Thesis

An exploratory study into the influence of last-mile home delivery innovations on consumer delivery service choices in the parcel and meal delivery markets

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TUDelft

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An exploratory study into the influence of last-mile home delivery innovations on consumer delivery service choices in the parcel and meal delivery markets

by

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Preface

This research was conducted as a graduation project at the Delft University of Technology for the master programme Transportation, Infrastructure, and Logistics. The research was carried out for the Future Mobility Network – a start-up company aiming to contribute to the improvement of mobility by means of real world implementation of (automated) transport innovations. The aim of this research is to identify the consumer value of parcel and meal home delivery service innovations, in order optimize market proposition, and to predict the impact of these innovations on the delivery market. Insights into this topic gained in this research will be used to advise companies on how to implement home delivery service innovations in a way that is of value to the consumer. With this thesis, I will conclude my master program *Transport, Infrastructure & Logistics* at the TU Delft.

Executive summary

Innovating the last mile of parcel and meal delivery Logistic service providers are looking for ways to innovate their delivery process in order to optimize their operations, lower operational cost, and to be able to meet growing consumer demands in terms of convenience, predictability, accuracy and flexibility in delivery time and place. Ordering products, produce and meals online, to be delivered at your door, is becoming increasingly common. This leads to an increase in demand for home deliveries. From the operational cost perspective of logistic service providers (LSP), the so called last mile of the delivery is very expensive. The last mile is the very last part of the journey. For parcel delivery, this is typically the trip from the LSP's distribution centre to the consumer home. LSP's are contracted to deliver parcels to the consumer. Therefore, retailers are in fact the customer from a LSP's perspective. **Improving cost and quality of delivery services is important for LSP's for two reasons. Firstly, to lower operational cost in order to improve their market position. Secondly, to leverage a better consumer experience to the retailers.** There are innovations – often involving aspects of automation – which may optimize this last mile, therewith potentially reducing the operational cost of delivery and enhancing flexibility and quality for the consumers, in theory making them interesting investments. **This research focusses on the consumer side of this topic, and looks into their preferences by means of discrete choice modelling in order to determine the consumer value of these innovations.** Preferences can be specific to a type of commodity. For example, different trade-offs may be made when ordering a book rather than ordering a pizza. To capture these differences to a certain extent, this research takes into consideration parcel delivery and meal delivery. The main research question is:

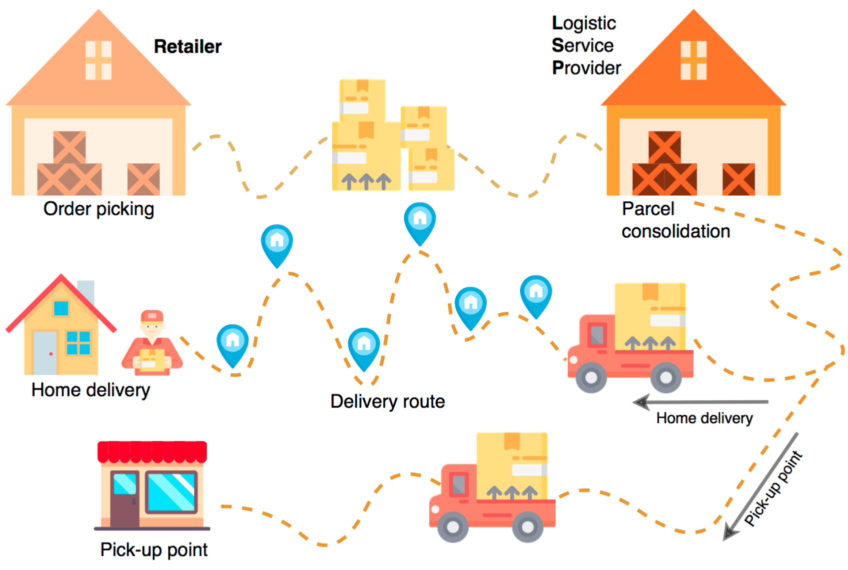
> "What is the effect of delivery service innovations on consumer delivery choices in the parcel and meal delivery market?"

Due to the fact that this research found that consumer delivery service choices – right now – are mainly driven by existing factors, their impact on consumer delivery choice is dependent on the extent to which they improve on these factors. This means that delivery innovations can be more attractive to consumers than current delivery services. This research looked into ways in which delivery innovations can best be implemented, by focussing on identified strengths of the different innovation types. The exact impact of changes in delivery services on consumer choice can be assessed with the choice prediction model this research yielded, enabling companies to optimize market propositions, and estimate the influence on hypothetical delivery service choices and market share. Hopefully paving the way to market implementation.

The delivery process For parcel delivery, when a consumer places an online order, the purchased products are picked and packaged in the retailers' warehouse. These parcels are then consigned to an LSP. The LSP plans and sorts the parcels in its distribution centre in order to deliver them as eficiently as possible in terms of delivery vehicle load factor and route planning. Consolidation allows for reduction of operational delivery cost, but does introduce complexity in terms of planning and logistics.
The meal delivery process is inherently different to that of parcel delivery due to its distinct characteristics. Meals are prepared fresh, locally and on demand, and must be consumed as soon as possible to ensure quality, therefore requiring a quick delivery. This means that this type of commodity does not allow for much consolidation, leading to a point-to-point delivery, mostly performed by scooter or bike.

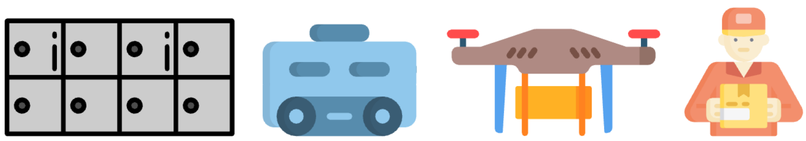
Current delivery services Currently, when ordering online, the consumer is commonly presented with a single delivery option. This so called standard delivery is typically (conditionally) free of charge and has a delivery time of two days (although some retailers are already shifting towards next day delivery, or weekend deliveries). Within this standard delivery, there are two options for the delivery location. Option one being home delivery –including the delivery to neighbours when not at home –, and option two being delivery at a parcel pick-up point. Home delivery offers the convenience of receiving the parcel at home, but requires the recipient to be present for the delivery. Pick-up point delivery offers the recipient the flexibility of the opening hours of the pick-up location – which can be a supermarket or post office -, but does require them to visit that specific location. Additionally, some retailers provide the consumer with the possibility to opt for extra features including (but not limited to) same day delivery, choosing the time slot, or delivery at irregular hours at extra cost. For meal delivery, it is simpler than parcel delivery. Restaurants offer delivery for orders above a certain minimum. Most restaurants then charge a small fee for the delivery, and indicate how long the delivery will take (sometimes based on current number of orders).

Figure 1: Parcel delivery process



Delivery innovations This research focusses on four delivery innovations. These are the *Self Driving Parcel Locker*, the *Small Curbside Delivery Vehicle*, *Delivery Drone*, and the *Small Scale Courier*. The Self Driving Parcel Locker is an automated moving parcel locker which can be placed anywhere in a neighbourhood. This concept offers the flexibility of the current pick-up point deliveries, and potentially brings it closer to consumer homes. The Small Curbside Delivery Robot is aptly named, and is a ground based last mile delivery vehicle, which can serve as a replacement of a delivery person. The delivery drone is air based, and similar to the small curbside delivery robot in the sense that it can be used for the last mile, and can potentially replace delivery persons. The Small Scale Courier is an innovation not involving automation consisting of a local network of on demand delivery persons. This can be compared to what Uber does for cabs, but then for the on demand delivery of commodities. This type of delivery service is able to provide same day (or even same hour) deliveries, and can be used to offer quick, local deliveries.

Figure 2: Delivery innovations



Delivery service characteristics In order to realistically model the consumer choice behaviour, it is necessary to know which characteristics consumers take into account. According to scientific literature and reports, consumers currently take into consideration the **price, location, speed and time window (and accessibility)** of a parcel delivery service. While keeping the characteristics of the current delivery methods, delivery innovations bring certain changes in the delivery process. Assuming that automated delivery services are also greener – as envisioned –, two extra characteristics noticeable for consumers are the interaction and the sustainability of the delivery. For meal delivery, the relevant characteristics were assumed to be **price, speed, guarantee, sustainability and method.**The characteristics that are assumed to be of influence on consumer delivery choices must now be tested on whether they indeed play a role, and how important they are.

The survey Two surveys were conducted in this research. One to identify consumer trade-offs for parcel delivery services, and one for meal delivery. This was done through a professional panel service named PanelClix, a panel service commonly used at the TU Delft for high quality data collection for statistical research. A total of 474 representative respondents participated, resulting in 4892 observations (each choice a respondent makes counts as one observation). The sample consisted of respondents living in urban areas of age 20 through 64. Through several analysis steps, among others by means of PythonBiogeme, the data was processed. This yielded detailed information including: which delivery characteristics play a role for consumers, willingness-to-pay, the relative importance of delivery characteristics, and differences between consumer groups. Lastly, the data was used to create a model which is able to predict consumer choices for different scenario's.

Relative importance of delivery characteristics The relative importance of the delivery characteristics indicates the influence of each characteristic on the attractiveness of delivery services to consumers. Insights into how many factors actually influence delivery choice, and knowing to which extend they do, indicates what the focus should be on for the market proposition of these delivery methods. This research yielded charts with the relative importance of delivery characteristics for parcel delivery, and one for the meal delivery market. The shares indicated in bold font apply to the general population, and the one is normal font only apply to the sample acquired in this research.

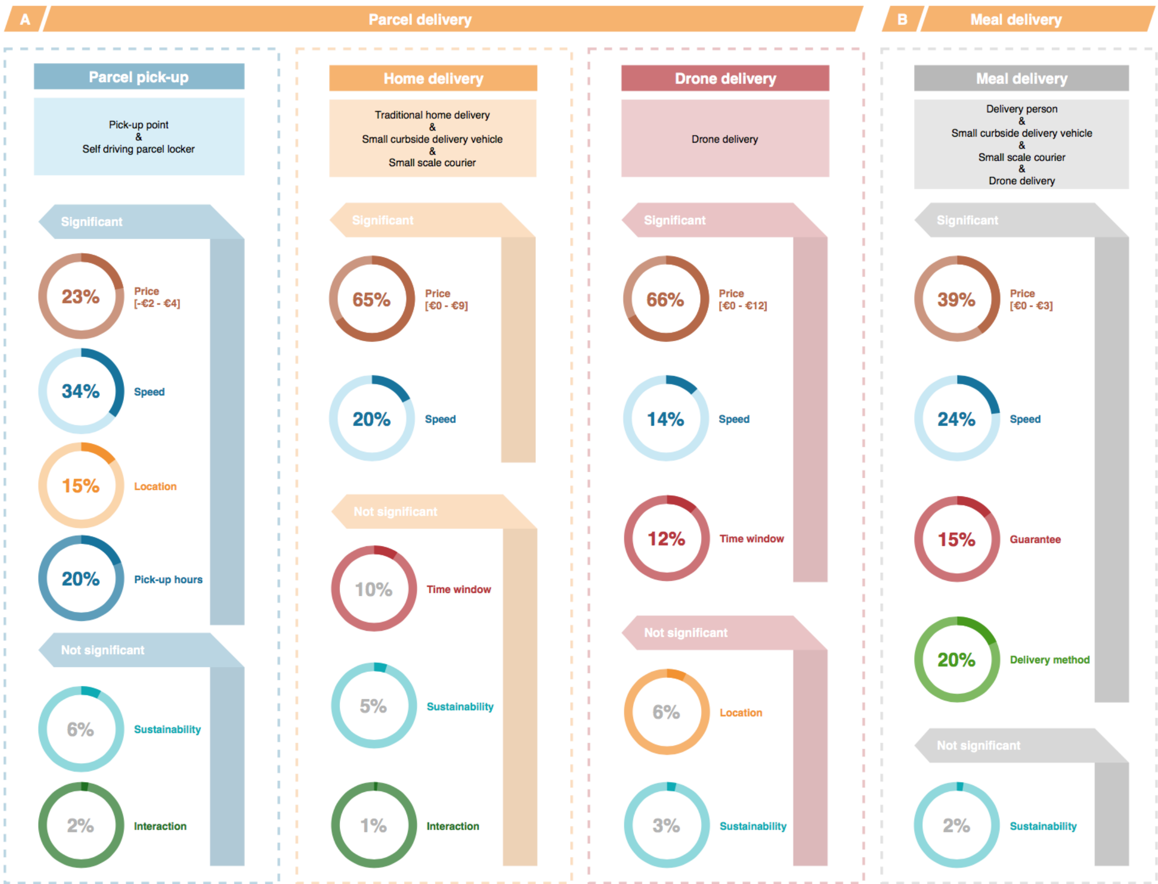
For home delivery, small curbside delivery vehicle and small scale courier, the delivery characteristics found to be of significant influence on consumer choice are **price (64%) and speed (20%).** Only two out of five factors turned out to be on influence on delivery choice. This tells that the focus of the market proposition of these delivery methods should mainly be on keeping prices low, and secondly on high delivery speed.

For parcel pick-up and the self driving parcel locker, price (23%), speed (34%), location (15%) and accessibility (20%) were found to be of influence on the delivery choice. Four out of six factors are of influence on the delivery choice. In this case, when implementing parcel pick-up or the self driving parcel locker, the focus should not mainly be on price, but also on speed, accessibility (opening hours) and location.

For drone delivery, price (64%), speed (14%) and time window (12%) are of influence on the delivery choice. This means that three out of six factors are indeed on influence on the delivery choice. When drone delivery are implemented, the main focus therefore should be on keeping the delivery price as low as possible. Offering high delivery speed, and a small time window is of value for consumers, but does not have as big of an influence on the attractiveness of drone delivery as price.

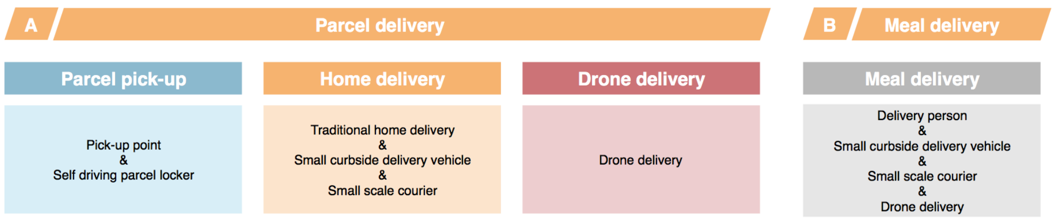
For **meal delivery**, four out of five factors are **of influence on the delivery choice: price (39%), speed (24%), guarantee (15%) and type (20%).** Price is of largest influence, but also delivery speed, type and guarantee are important. Within the delivery type characteristic, consumers rated delivery by person highest, followed by small curbside delivery vehicle, and rated drone delivery lowest. This factor accounts for 20% of the total influence on delivery choice. So, if small curbside delivery vehicles or drone would be used in the future, it is important to compensate trough price, speed or by guaranteeing an on time delivery.

Figure 3: Parcel & meal delivery key attributes and relative importance



Differences between consumer groups In this research, the results were also split in order to identify potential differences between consumer groups. This was done for age groups and a 'green group', containing respondents which were assigned to this group based on questions related to the importance of the environment. The representation of the delivery innovations can be seen in figure 4.

Figure 4: Representation of delivery services



Parcel delivery

From a market proposition and marketing perspective, the lowest **age group 20-34, is more open to drone deliveries, and value the environmental impact** of delivery services. This makes this group the most suitable for drone delivery, and implies that, underlining the sustainability aspect will have added value. **Age group 35-49 values parcel pick-up deliveries higher** than the other groups do, potentially making them the best candidate for this delivery innovation pilot. On the other hand, they are the only group that does not value sustainability. **Age group 50-64 assign great value to the home delivery type service, and value the sustainability aspect** of the service. This implies that age group 50-64 is a suitable group to test the greener home delivery innovations on.

Meal delivery
Except for the green group valuing the sustainability aspect of the delivery – indicating that there is indeed a sub group in the population which value sustainability –, and assigning more value (and there with higher willingness to pay) to the delivery guarantee, there were no substantial differences found between the consumer groups in this research.

The delivery choice prediction model Ultimately, the consumer choice shares can be predicted with the model constructed in this research. This tool can be used by parties to estimate the choice shares for a plethora of (hypothetical) delivery methods. **The model allows the user to construct delivery options – in terms of the delivery characteristics taken into this research – and then presents the choice share estimations.** The figure shows an example of a parcel delivery scenario in which drone deliveries compete with the two current delivery options (pick-up point and home delivery). The predicted share is now 10%, however the model allows the user to evaluate the impact of changes to the delivery options. For example, when changing the drone delivery price with increments of €1.-, the impact on delivery choice shares can be seen. This way, the model allows for the fine tuning of market propositions, and helps LSP's to make informed decisions on the way in which to conduct a real-world pilot, or market implementation. The same capabilities hold for the meal delivery choice model. This tool can be used to forecast the impact of delivery innovation on market shares, and can even optimize current delivery services.

Conclusion This research succeeded in capturing consumer delivery choice behaviour for parcel and meal delivery in choice models. With data collected by mean of survey, choice models were estimated, and insights into consumer preferences and trade-offs were gained. With these insights, guideline for the implementation of delivery innovations were given. Furthermore, the choice models constructed in this research can be used to predict choice shares of hypothetical delivery service choice situations, and can be used to fine tune market proposals.

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List of abbreviations

AV Automated Vehicle

CI Confidence Interval

DCM Discrete Choice Model

DR Drone delivery

HD Home Delivery

LSP Logistic Service Provider

MD Meal Delivery

PD Parcel Delivery

PP Parcel Pick-up

SCDV Small Curbside Delivery Vehicles

SCE Stated Choice Experiment

SDPL Self Driving Parcel Locker

SP Stated Preference

SSC Small Scale Couriers

UF Utility Function

WTP Willingness-To-Pay

Glossary

Online purchase An online purchase, as mentioned in the research scope, can include a broad range of purchases. The definition of an online purchase in this research involves a purchase via the internet at a webshop, online grocery service or a purchase via mobile phone. All these purchases require transportation to the consumer.

Consumer This thesis looks at the consumer perception of delivery innovations. Therefore the term consumer is defined as follows: the Cambridge dictionary [2] defines the term consumer as: a person who buys goods or services for their own use. This research defines the term consumer in a very similar way. The consumer is a person or entity that purchases (orders) goods that need to be transported to an address of their choice by means of goods delivery service.

Preferences A preference is defined as something that an individual prefers based on (economic) considerations. People's preference for example goes out to the choice that is of highest added value to them. One may choose same day delivery over next day delivery, because it is important to receive the item as quickly as possible. Logically, the speedier delivery type is preferred in this example.

Trade-off's Trade-off's expresses how much someone would trade from characteristic A to gain more of characteristic B. Value of time is a great example. How much money does one want to pay to save time. In transportation, less time - be it travel time or delivery time - equals higher cost. The amount of money one is willing to pay for shorter travel time is a perfect example of a trade-off.

Delivery innovation Delivery innovations are defined as new ways of delivering goods last mile to consumers. This entails that certain aspects of the delivery process will change from a consumers' perspective. The last mile refers to the last part of the transportation process of a product from a warehouse or consolidation centre to the consumers' home.

Stated choice experiment Stated choice experiments are a method used to capture preferences and trade-offs of respondents by means of survey. Carefully constructed, this method enables one to capture the effect of individual attributes (factors) on choice making. Respondents are asked to choose from a hypothetical choice situation between alternatives repeatedly, with the alternatives changing a little bit each time in terms of attributes (e.g. price or delivery time). The resulting preferences and trade-offs are used as input for the DCM.

Discrete choice model Discrete choice models (DCM) are used to predict consumer choices between alternatives. This method is used to assess the shift from current choices to a future (hypothetical) alternatives. The model is used to predict future choices. In this research this method is used te predict if consumer groups choose a new type of delivery for their purchased (distinct) product. If this is the case, the model confirms that there is indeed a match between customer, product and delivery service.

1 INTRODUCTION

This thesis is carried out for the Future Mobility Network (FMN). FMN is a start-up that aims to accelerate the implementation of automated vehicles, and aspires to push mobility forward into a more environmental friendly and safer form. FMN wants to gain insights into the potential of delivery service innovations (involving automation) in order to help their customers in the logistics field with their implementation. Among these customers are logistic service providers, food chains, and technology companies. Consumer value was chosen to be the centre of this research. Insights into consumer preferences and trade-off's, and how they differ between consumer groups and product types do not yet exist. This research approaches consumer value though discrete choice modelling techniques. This forms the foundation of this thesis research.

Logistic service providers are looking for ways to innovate their delivery process in order to optimize their operations, lower operational cost, and to be able to meet growing consumer demands in terms of convenience, predictability, accuracy and flexibility in delivery time and place. Ordering products, produce and meals online, to be delivered at your door, is becoming increasingly common. This leads to an increase in demand for home deliveries. From the operational cost perspective of logistic service providers (LSP), the so called last mile of the delivery is very expensive. The last mile is the very last part of the journey. For parcel delivery, this is typically the trip from the LSP's distribution centre to the consumer home. LSP's are contracted to deliver parcels to the consumer. Therefore, retailers are in fact the customer from a LSP's perspective. Improving cost and quality of delivery services is important for LSP's for two reasons. Firstly, to lower operational cost in order to improve their market position. Secondly, to leverage a better consumer experience to the retailers. There are innovations – often involving aspects of automation – which may optimize this last mile, therewith potentially reducing the operational cost of delivery and enhancing flexibility and quality for the consumers, in theory making them interesting investments. This research focusses on the consumer side of this topic, and looks into their preferences in order to determine the consumer value of these innovations. Preferences can be specific to a type of commodity. For example, different trade-offs may be made when ordering a book rather than ordering a pizza. To capture these differences to a certain extent, this research takes into consideration parcel delivery and meal delivery.

1.1. Problem identification

Home delivery demand is ever growing. Every year, more people are purchasing consumer products online, which have to be delivered to the consumer. In the first half year of 2017, the growth of the number of online purchases in the Netherlands was 15% according to market research performed by GfK[17]. The online expenditure grew by 14%. The total online retail growth in 2017 is expected to be 13% in terms of transactions, and 12% in terms of expenditure. Moreover, this steep growth is expected to continue. The Economic Bureau of ING bank[18] reports that e-commerce will represent 25% of the total retail market in 2025 as opposed to 12.5% in 2016. These products need to be delivered to the consumer, and given the growth of e-commerce in the Netherlands, leads to a large demand of home delivery.

The last mile is the last part of the journey of a product to the consumer. It most commonly refers to the transportation of goods from a distribution centre to the recipient. For meal delivery it refers to the trip from the restaurant to the consumer. In the transportation and logistics field, the last mile of transportation is known for its complexities and complications. This in turn translates into problems that can roughly be divided in three categories: societal problems (e.g. negative externalities), consumer problems (e.g. large variety in preferences and high demand), and logistic service provider problems (e.g. high operational cost). The main driver for companies to innovate their delivery services is logically the cost component. Therefore, automation is an interesting investment, due to its labour cost cutting nature.

Currently, there a several developments in the last-mile logistic market which aim to reduce the problems related to last-mile delivery, such as automated vehicles designed for delivery, delivery drones and small scale urban (first- and) last-mile couriers.

One of the barriers for market implementation of these delivery innovations is consumer acceptance. LSP's and restaurant food chains want to reduce operational delivery cost, while improving their customer service, therewith enhancing their market position. There is currently not much known about the consumer value of home delivery innovations, as some of them are still conceptual, and have yet to prove themselves in the real world, be it by means of a pilot. If it is possible to identify the value of these new delivery methods for the consumer, and know how to position them in the market, this will make decisions on investments in these innovations easier and more effective.

1.2. Research scope

In this research, the influence of last-mile home delivery innovations on consumer choices is determined by means of discrete choice modelling, a statistical modelling technique used to predict choices in hypothetical scenario's. This approach is based on the premise that choices are based on the relative value of choice alternatives. Each choice alternative's individual value is based on its characteristics (attribute values) and their importance (weight). This research will therefore yield the key drivers (factors) of consumer delivery choices, provide their relative importance, and deliver a model which can be used as a tool to predict delivery choices for specific hypothetical scenario's.

Current delivery services, and several delivery innovations are taken into account, in order to determine which delivery service characteristics matter to consumers, and if there are differences between them in terms of characteristics. Assumptions about the functional characteristics of the delivery innovations are made, as some still in the conceptual phase, and have not yet been developed. This project does not mainly focus on the details of the logistic aspects of the proposed delivery innovations such as: the changes in distribution, adaptation of hubs, optimization of route choice, etcetera. It does however dive explore aspects to get a sufficient understanding of the changes brought by these innovations that will be noticeable for consumers, in order to determine the value of these changes and therewith their influence on consumer choice.

There are four innovations taken into account in this research: **small scale couriers**, **self driving parcel lockers**, **drones**, and **small curbside delivery vehicles**. This is because the clients of TFMN are investing in these types of delivery innovation. More information on these innovations can be found in chapter 2.1.

The following **two delivery markets** are taken into account: parcel delivery (PD), and meal delivery (MD). These two categories make up for a large percentage of the e-commerce market, and they reflect the business of FMN customers.

Geographically speaking he research is centred around delivery service choices by **consumers living in urban areas in the Netherlands**. The sample data that is used to analyse consumer preferences and trade-off's will be collected from inhabitants of the Netherlands. Preferences and trade-off's can vary between countries, and therefore this research is focussed on the Netherlands only.

1.3. Research objective & research questions

The **objective** of this research is to identify the consumer value of parcel and meal home delivery service innovations, in order optimize market proposition, and to predict the impact of these innovations on the delivery market. Insights into this topic gained in this research will be used to advise companies on how to implement home delivery service innovations in a way that is of value to the consumer.
The **main research question** of this thesis is:

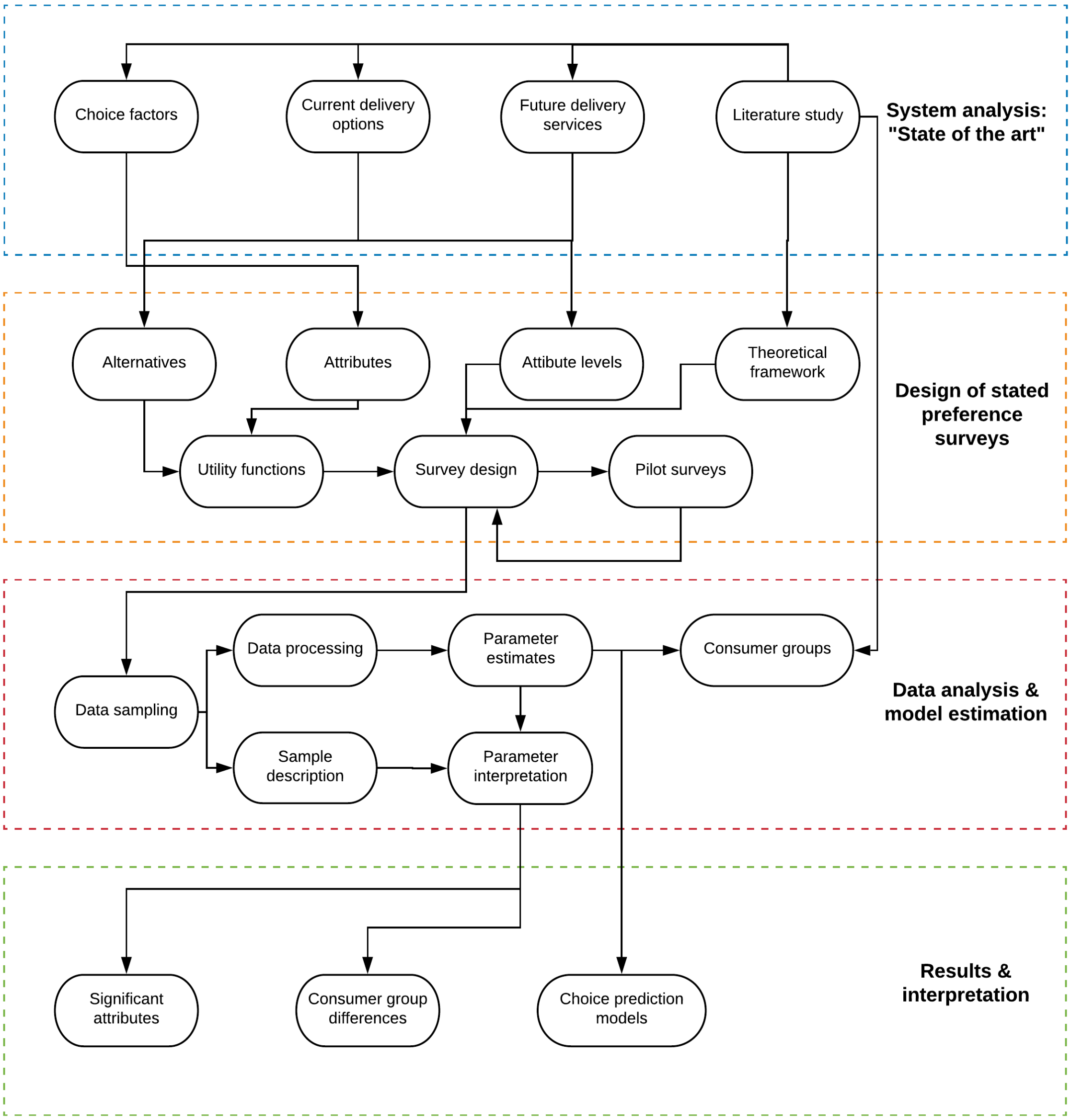
> *"What is the effect of delivery service innovations on consumer delivery choices in the parcel and meal delivery market?"*

1. Which factors (significantly) influence consumers' delivery service choice, and how strongly?
2. How does delivery choice making differ between parcel delivery and meal delivery?
3. How do delivery preferences vary between consumer groups?

1.4. Research methodology

The methodology used in this research is explained in this section. The methodology consists of four major parts: a system analysis (state of the art), the design of stated preference survey, data analysis and model estimation, and the model interpretation. An overview of how the input and output of each step flows is provided in figure ??.

Figure 1.1: Methodology flowchart



1.5. Research outline

Problem identification The problem and objective were defined in the initial phase of the project. Moreover, research questions were defined that will be answered in this study.

State of the art The function of this chapter is to gain the required knowledge about essential subjects that are needed to carry out this research. The system analysis looked into the delivery process, current delivery services, delivery innovations, factors of influence on delivery choice, and consumer groups. The findings in this step were used to construct the stated preference surveys.

Design of the stated preference survey This part of the research uses the input from the system analysis to define and detail the all components of the data collection instrument: the stated preference survey. The design of the surveys is an iterative process. First, the theoretical framework was discussed. Next, the choice alternatives, attributes and attribute levels were defined in order to construct the states preference surveys for both parcel and meal delivery.

Data analysis & model estimation When the data collection (via survey) was finished, it needed to be processed and interpreted. The choice models were estimated. This was done in several steps and with several methods. Eventually, this lead to an interpretation of the data and enables consumer choice prediction. This chapter yielded the parameter estimates.

Results and interpretation This section presented the significant attributes, consumer group differences and the delivery choice prediction model.

Conclusions, discussion and recommendations This chapter answered all the research questions, and provided a lengthy discussion regarding the limitations of the project and choices that were made. Lastly, recommendations are given for further research.

2 STATE OF THE ART

The state of the art chapter provides an elaborate description of the building blocks of this research. Therefore, this chapter dives into the state of the art of: **1)** the delivery process in section 2.1, **2)** current delivery services in section 2.2, **3)** delivery innovations in section 2.3, **4)** factors of influence on delivery choice in section 2.4, and **5)** consumer groups in section 2.5.

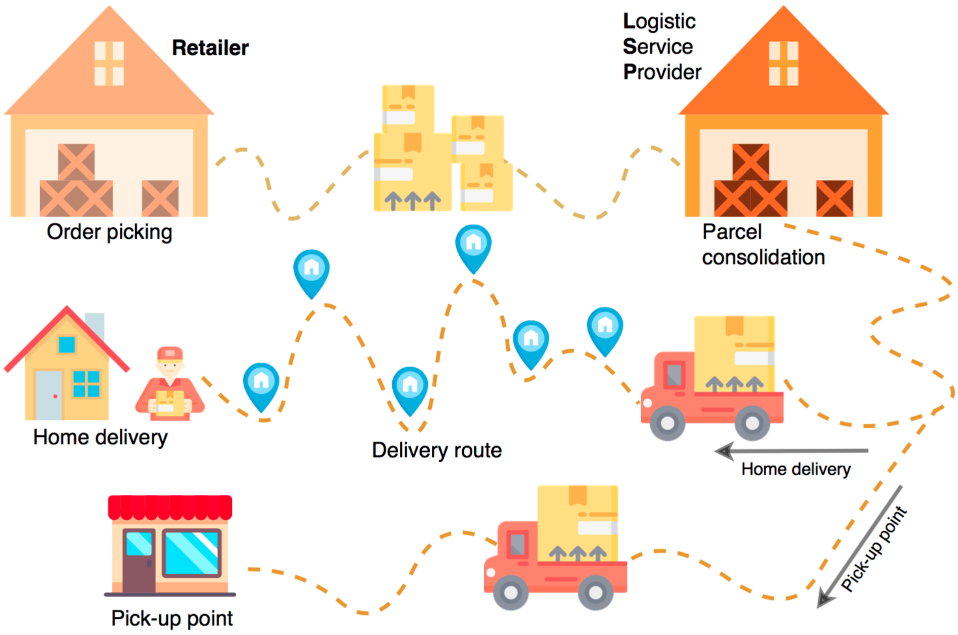
As this research main objective is to determine the influence of delivery innovations on consumer delivery choices in the parcel and meal delivery market by means of discrete choice modelling, the first step is to define the model input. The findings of the state of the art chapter will do just that, as the insights provided in this chapter are used as input for the next chapter, the survey design.

2.1. The delivery process

This section describes and discusses the delivery processes of parcel and meal delivery in order to gain a clear understanding.

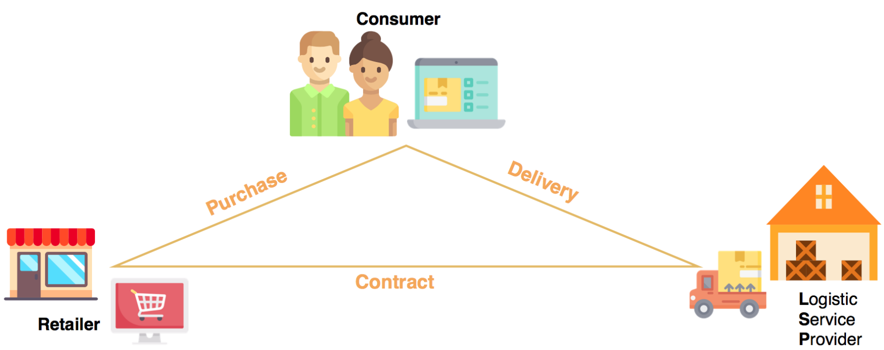
Parcel delivery process For parcel delivery, when a consumer places an online order, the purchased products are picked and packaged in the retailers' warehouse. These parcels are then consigned to an LSP. The LSP plans and sorts the parcels in its distribution centre in order to deliver them as efficiently as possible in terms of delivery vehicle load factor and route planning. Consolidation allows for reduction of operational delivery cost, but does introduce complexity in terms of planning and logistics. Due to consolidation, a delivery van can delivery many parcels in one route. A visual representation of this process can be seen in figure 2.1.

Figure 2.1: Parcel delivery process and steps



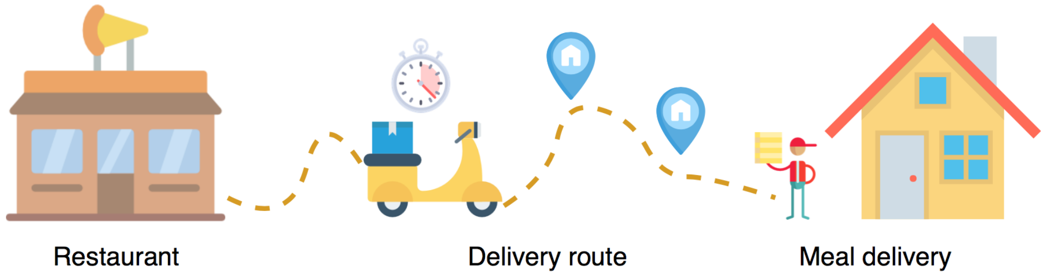
With parcel delivery - in the case of an online purchase -, the relationship between retailer, consumer and LSP is triangular: the purchase is between consumer and retailer, there is a contract between retailer and LSP, and the actual delivery is between the LSP and consumer, which makes the delivery market a bit more complicated than first meets the eye. This research focusses on the consumer and LSP interaction aspect of the triangle, (as shown in figure 2.2) with the goal being to improve the consumer experience while cutting the operational cost for the LSP. An important implication of this triangular relationship is that by improving home delivery services for the consumer, the LSP is able to offer retailers a better customer experience, leveraging the LSP's market position.

Figure 2.2: Triangular relationship between consumer, retailer and LSP



Meal delivery process The meal delivery process is inherently different to that of parcel delivery due to its distinct product characteristics. Meals are prepared fresh, locally and on demand, and must be consumed as soon as possible to ensure quality, therefore requiring a quick delivery. This means that this type of commodity does not allow for much consolidation, leading to a point-to-point delivery, mostly performed by scooter or bike. The process is visually represented in figure 2.3.

Figure 2.3: Meal delivery process and steps



This research focusses on delivery innovations in the last-mile of the aforementioned delivery processes. For parcel delivery this means the trajectory from the distribution centre of the LSP to the consumer, and for meal delivery this means the trajectory from the restaurant to the consumer.

2.2. Current delivery services

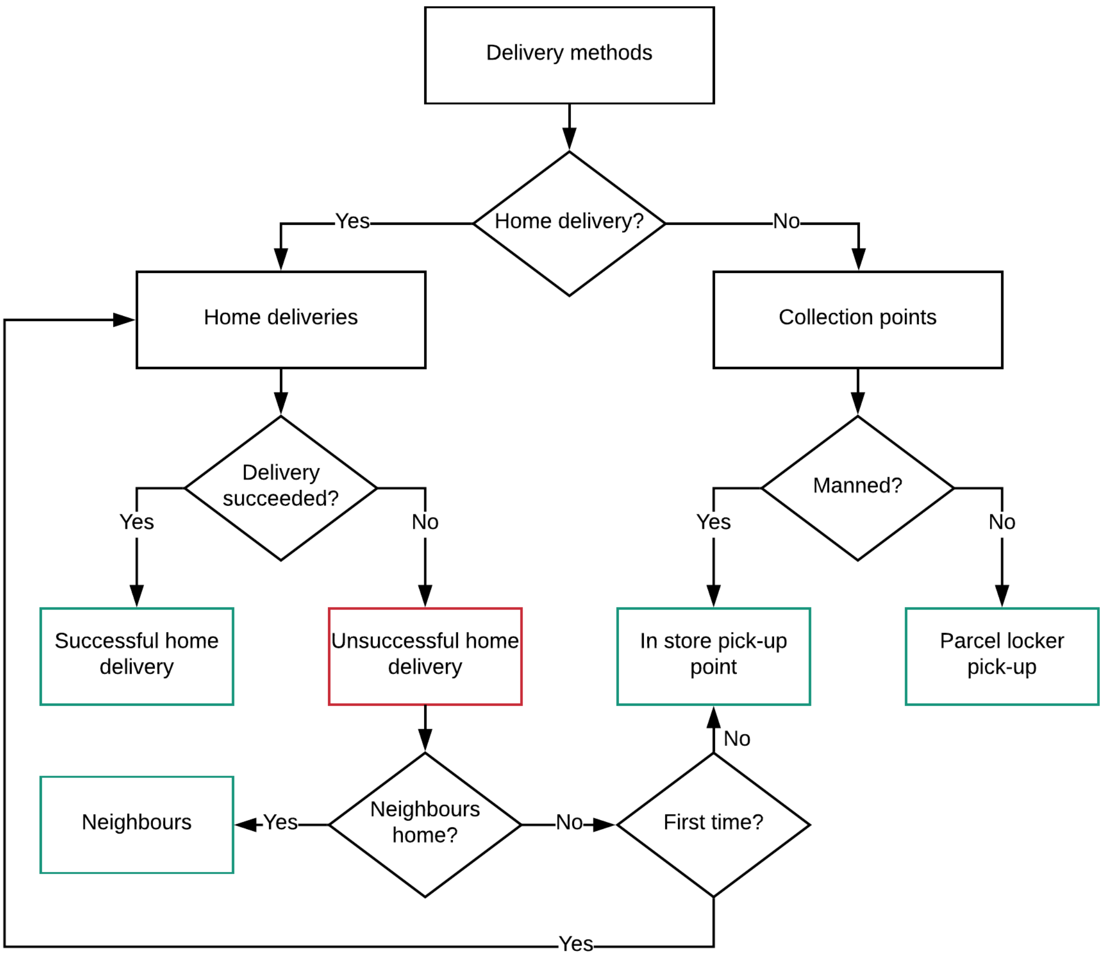
This section discusses the delivery service options, available today. Identifying the current delivery services serves as input for the selection of the factors which influence consumer delivery choices.

Parcel delivery services Currently, when ordering online, the consumer is presented with delivery options. There is great variation between retailers in terms of delivery options. Commonly, amongst these delivery services are options which are (conditionally) free of charge. The delivery speed differs between retailers, but is typically 'next day' or 'within two days'. Regarding location, there are two options: home delivery - including delivery to neighbours when not at home -, and delivery at a pick-up point. Home delivery offers the convenience of receiving the parcel at home, but requires the recipient to be present for the delivery. Pick-up point delivery offers the recipient the flexibility of the opening hours of the pick-up location – which can be a supermarket, post office or other store -, but does require them to visit that specific location. There is also an unmanned version of the pick-up point available in the form of parcel lockers which can be located at a train station for example. Additionally, some retailers provide the consumer with the possibility to opt for extra features including (but not limited to) same day delivery, choosing the time slot, or delivery at irregular hours at extra cost. An overview of the delivery options of the largest webshop can be found in the appendix, section **??**, table A.1. Overall, the current delivery services can be generalized into two options:

1. Home delivery
   - with varying speed
   - with varying time windows
   - with varying delivery moments
2. Pick-up point
   - manned or unmanned
   - with varying locations

These two delivery services have different last-mile trajectories. A visual representation if the delivery process for both (home and pick-up point) delivery services is provided in figure 2.4. Home deliveries suffer from the 'not at home' problem, which leads to extra effort for the LSP if the consumer is not at home when the delivery takes place. At first, LSP will try to delivery the parcel at a neighbour. If this fails, the LSP will make a new delivery attempt the next day, and if this happens repeatedly, the parcel will go to a pick-up point if suitable. Upon closer inspection, figure 2.4 shows that the pick-up point deliveries are much simpler for the LSP, as there is more room for parcel consolidation and no chance of the 'not at home' problem occurring.

Figure 2.4: Current parcel delivery process

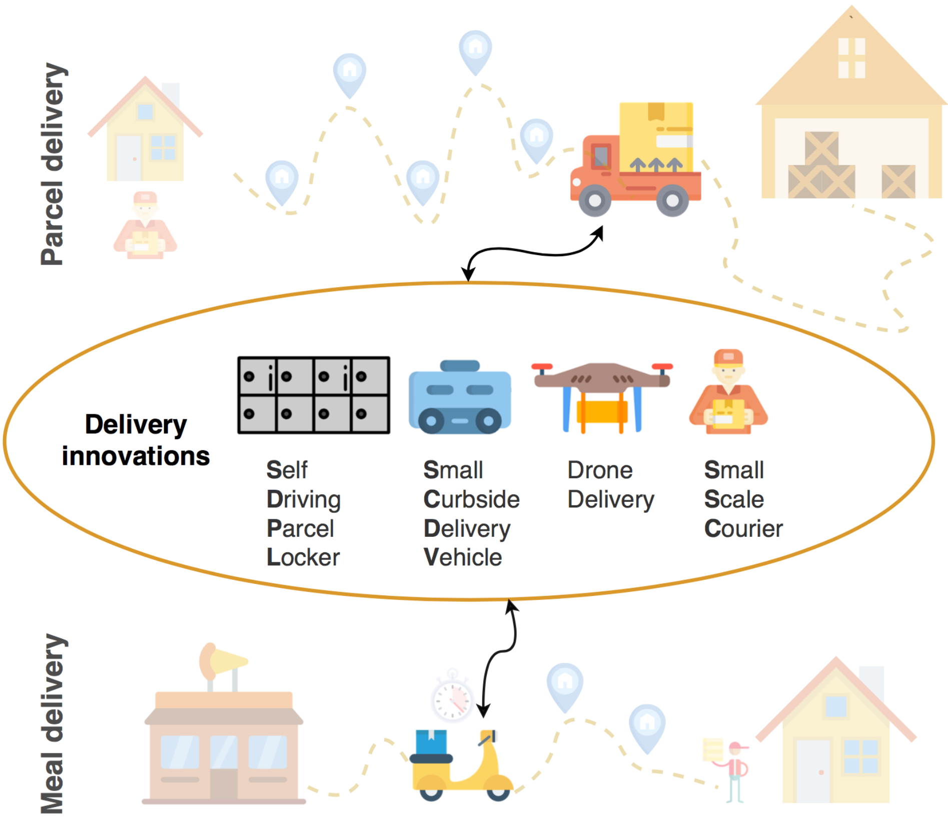


Meal delivery services For meal delivery, it is simpler than parcel delivery. Restaurants offer delivery for orders above a certain minimum. The minimum amount is typically around €10.-. Most restaurants then charge a small fee for the delivery, and indicate how long the delivery will take (sometimes based on current number of orders).

2.3. Delivery innovations

This section provides a description of the delivery innovations of which their impact on is evaluated in this research. These innovations are all concept delivery services from the customers of Future Mobility Network, for which this research is conducted. Most of these innovations are still ideas, and any functional description are based on how these concepts are envisioned. Each one of these innovations can potentially improve on current delivery problems as described in the literature study included in appendix A.2.1. When implemented, these innovations would substitute the current delivery methods, as depicted in figure 2.5.

Figure 2.5: Innovations for the last mile of parcel and meal delivery



This research focusses on four delivery innovations. These are the Self Driving Parcel Locker (SDPL) explained in section 2.3.1, the Small Curbside Delivery Vehicle (SCDV) explained in section 2.3.2, Delivery Drone explained in section B.3, and the Small Scale Courier (SSC) explained in section 2.3.4.

2.3.1. Self driving parcel locker

The self driving parcel locker (SDPL) is a concept of PostNL. This concept is specifically designed for parcel delivery, and is not suitable for the delivery of meals. The SDPL is, simply put, a parcel locker that can move in an automated fashion. Figure 2.6 shows a non-automated variant, ergo a parcel locker. The main characteristics of a parcel locker apply to the SDPL: its an unmanned pick-up point, which provides consumers with the flexibility to pick up their parcel at their convenience. On the flip side, the consumer must travel to the parcel locker location in order to do so. The automated nature of the SDPL can serve two purposes: cut cost for vehicle drivers if the parcel locker would drive from the distribution centre to the pick-up location, and another advantage could be to pick a location in order to minimize the distance to consumer's homes. For the LSP, the high consolidation possible with this concept - as is also the case with current pick-up points and lockers - is a big plus.

Figure 2.6: Parcel locker

Key characteristics:

- Potential advantages

  Automated version of a parcel locker

  High parcel consolidation

  Allows for pick-up 24/7

  May be stationed dynamically to minimize travel distance for consumer

- Potential disadvantages

  Consumers need to travel to the locker's location

  Not suitable for meal delivery

A more elaborate description of the SDPL is provided in appendix A.3.1.

2.3.2. Small Curbside Delivery Vehicle

The Small Curbside Delivery Vehicle (SCDV) is a small delivery robot which was designed for usage on the curbside. The vehicle was developed by a technology company named Starship Technologies. Figure 2.7 depicts the SCDV. This vehicle can delivery parcels up to a consumers' doorstep, and is suited for urban last mile deliveries. It is electrically driven, and is automated. The SCDV has a storage compartment which offers limited space, so there are practical limitations to the versatility of this vehicle. Due to this fact, this vehicle does not allow for much parcel consolidation. When used for parcel delivery, this vehicle would most likely operate on a point-to-point basis. This could make the SCDV very suitable for meal deliveries, if the vehicle allows for fast enough delivery.
Key characteristics:

- Potential advantages

  Automated, thus cost cutting for LSP

  Can drive up t consumer doorsteps

Figure 2.7: Small Curbside Delivery Vehicle

- Potential disadvantages

    Small capacity does not allow for much consolidation

    Possibility slow

A more elaborate description of the SCDV is provided in appendix A.3.2.

2.3.3. Drone delivery

This concept is a drone that is able to deliver to the consumer. This can potentially be done very quickly and efficiently (in terms of routing due to the freedom in airspace). This makes the drone delivery concept well suited for same day parcel delivery or last minute purchases. Assuming these drones are electrically driven, they could decrease the impact of same day deliveries drastically. Currently, same day parcel deliveries allow for much less consolidation due to the smaller planning window, increasing the per-parcel environmental footprint of the delivery. A noticeable downside of this concept may be radius and capacity. A variation on this concept is the drone that flies to a pick up point. This would require less infrastructure - ie.g. not a landing platform at each home, but one for a residential area - while still being able to quickly deliver goods. This operational characteristics of this delivery innovation makes it also very suitable for meal delivery, as meals require quick deliveries, and already operate on a point-to-point basis.

Figure 2.8: Drone delivery

Key characteristics:

- Potential advantages

    Potentially very quick

Automated, thus cutting cost for LSP

As a substitution for current quick deliveries potentially much more environmentally friendly

- Potential disadvantages

  Not certain which landing location is best

  Airspace regulation are a big obstacle

  Limited range

  Does not allow for much consolidation

A more elaborate description of the drone delivery concept is provided in appendix A.3.3.

2.3.4. Small Scale Courier

This concept is not automated and uses people to perform the delivery. Its innovation lies in the fact that the deliveries can be tailored to the needs of the consumers. This concept is based on bun.run, a local delivery start up operational in The Hague. The delivery is performed by couriers (so called runners) which operate in the vicinity of the city. Their delivery platform is able to pick-up and deliver goods on-demand. Currently, this has opened up the possibility for consumers to ask the courier to pick-up a product locally, and delivery it to them. In the future, the small scale courier service may also be used for same hour deliveries from local stores. If retails chains partner up with local delivery couriers, this opens up the way for in store pick-up and same hour delivery at the consumer. Moreover, in cooperation with LSP's they serve as spare capacity during the busiest delivery days in the year. The delivery is commonly performed by bike, which makes it a sustainable solution from an emission perspective. This convenience does come at a higher consumer price than the normal deliveries performed by LSP's, starting at €5.75 **??**.

Figure 2.9: Small Scale Courier

Key characteristics:

- Potential advantages

  Speedy delivery

  On-demand

  As a substitution for current quick deliveries much more environmentally friendly

  Local pick-ups

- Potential disadvantages

  More expensive

  Limited range

  Does not allow for much consolidation

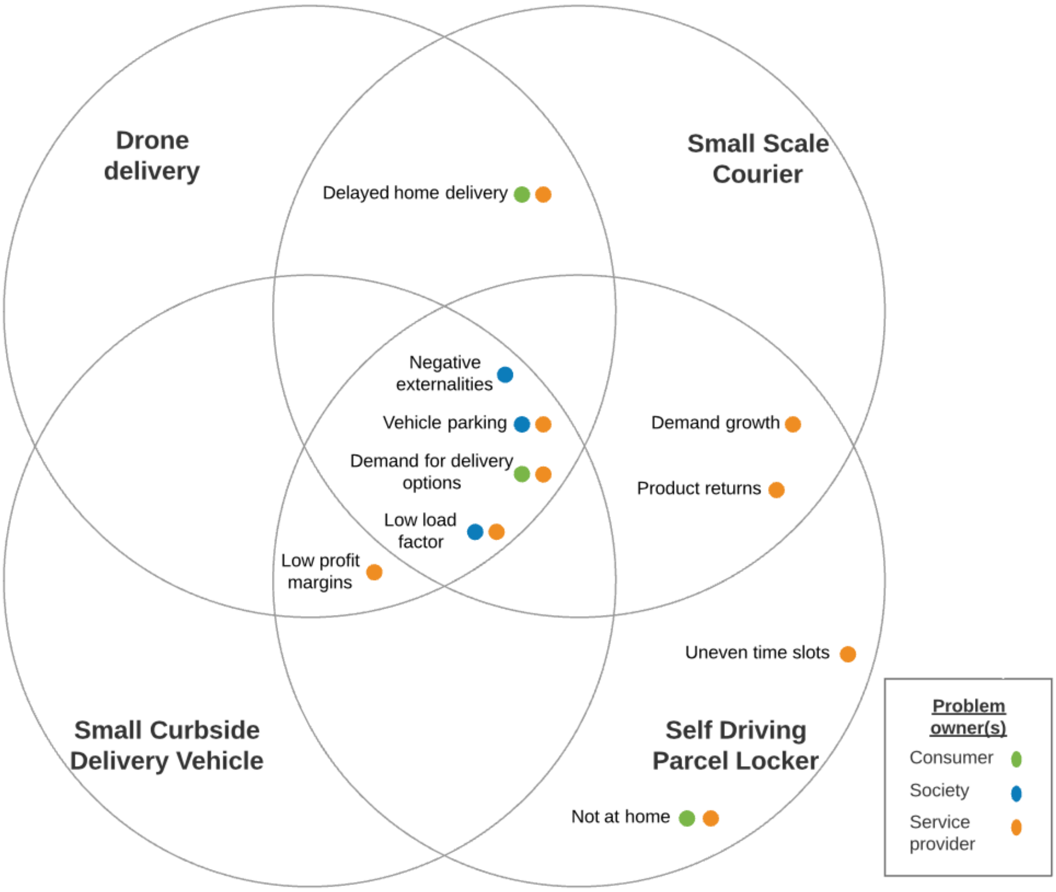
A more elaborate description of the small scale courier concept is provided in appendix A.3.4.

2.3.5. Innovations and last-mile problems

In the literature study, which can be found in appendix A.2.1, a comprehensive list of problems in last mile-delivery was extracted from the studied literature. Problems in the last mile delivery included: **delivery delays, the "not at home problem", uneven timeslot demands, seasonal peak demands, negative externalities of the transportation of the parcels** and more. Moreover a few of the most important trends included: the **growing number of urban distribution centres, protective environmental zones in inner cities, an increase in zero-emission vehicles, and an incentive to invest in safer delivery vehicles.** The delivery innovations that are included in this research can potentially address these problems and may even solve them. Also, the increase of urban distribution centres is a relevant development for the last mile innovations to be able to operate, as some og them have low load capacity and are designed for point-to-point deliveries.

The relationship between the delivery innovations and the problems they solve is depicted in figure 2.10. Each circle represents the domain of one of the four concepts. All problems that are located in a circle are potentially solvable by that concept. Some problems can only be solved by one concept, others can be solved by two, three or even all four concepts. Please note that this figure does not imply that these problems can only be solved by these concepts. The visualization of the relationship between the four innovations and the problems they can solve does not necessarily indicate the directly added consumer value of a delivery innovation, but does shed light on the extent to which they can solve problems of a more societal nature which might become all the more relevant in the future.

Figure 2.10: Problems, problem owners & concepts



2.4. Factors of influence on delivery choice

This section focusses on identifying the most important factors consumers take into account when choosing a delivery service for their products, and identifies any new factors introduced by the the innovations. First, important factors for consumers are discussed. These findings come from a variety of sources, including: papers, articles, reports and websites. These identified factors serve as input fro the survey that will be constructed in the next chapter.

Parcel delivery Based on the assessment of important factors for consumers when choosing a delivery service (which can be found in appendix A.4), a list of the factors which are likely to be of influence on delivery choices was constructed. These factors are: *cost, speed, flexibility, reputation, service, location, environmental friendliness, transparency, and the number of delivery options.* Not all factors can be taken into the model due to model size constraints, and practical reasons. For example, reputation may be an important factor, but falls outside of the scope as it is not something delivery innovations can directly solve. The reputation of a LSP or restaurant may change due to delivery innovations, but is not one of its characteristics. Transparency is also important for consumers. However, the innovations that have been discussed in paragraph 2.3, do not inherently change the transparency of the delivery process. The new service around the innovations may increase transparency - for example by adding more advanced forms of tracking -, but this could also be applied to any other (existing) delivery service. The factor 'service ' is most likely composed of several factors, which may include transparency, flexibility and more. Because this factor is hard to grasp, and is probably implicitly represented by other attributes, this will not be taken into the model. The same holds for 'more delivery service choices', because this is implicitly part of this research, as this research is looking into how to offer consumers more choices. Due to aforementioned reasons, some factors falls outside of the model scope. **The remaining relevant factors are: cost, flexibility (including time window and opening hours), location and environment.**

Meal delivery For the meal delivery market, the delivery options are much simpler. Thuisbezorgd.nl[9], a platform for meal delivery, provides a nice overview of the different delivery conditions.The delivery **price** commonly ranges between zero and €4.-. The delivery can be free of charge when exceeding a certain order value. There is always a minimum order value. There are mostly no promises regarding **delivery speed,** only an indication is given. A client of FMN has also expressed interest in exploring the consumer value of **delivery guarantee**, which basically is a promise to the consumer for the meal to be delivered in the time span that was indicated, at a small fee.

2.4.1. Factors introduced by delivery innovations

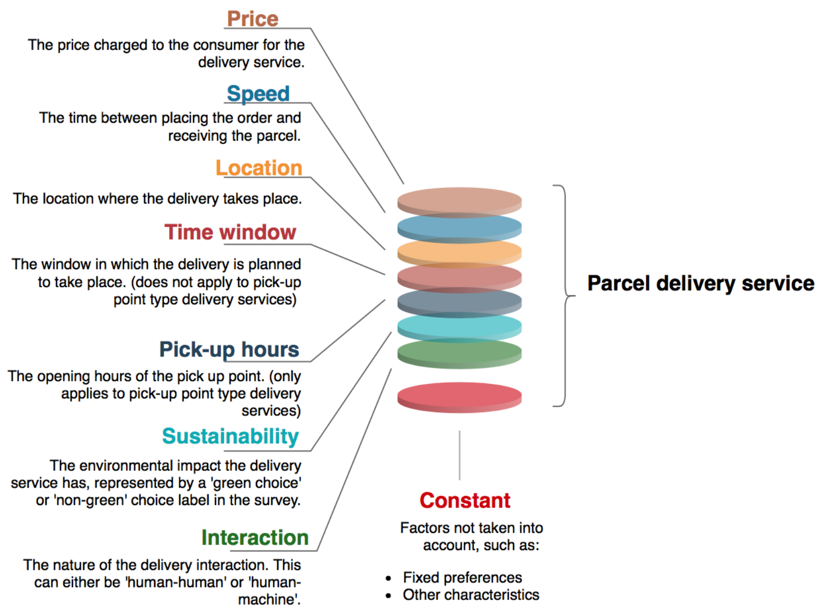
The delivery innovations introduce change to the delivery process which may also be noticeable for the consumer, therefore potentially influencing consumer delivery choice making. Delivery innovations have the same characteristics as current delivery services: price, speed, flexibility, location and environmental impact. However, one major difference is the change from a delivery person to a delivery robot. This means that consumers do not interact with a person any more when picking up their parcel, but with a machine. Presumably, the transaction of the parcel or meal from the automated delivery vehicle to the recipient will involve some digital step such as a QR code, or other type of verification. This change is represented in the model as the **interaction** variable.

2.4.2. Selected delivery choice factors

This presents discusses the selected factors representing the delivery services, current and innovation.

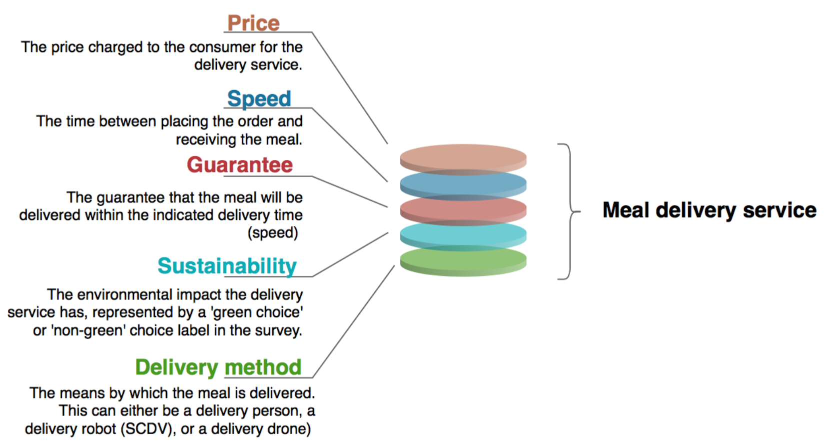
Parcel delivery In order to realistically model the consumer choice behaviour, it is necessary to know which characteristics consumers take into account. According to scientific literature and reports, consumers currently take into consideration the price, location, speed and time window (and accessibility) of a parcel delivery service. While keeping the characteristics of the current delivery methods, delivery innovations bring certain changes in the delivery process. Assuming that automated delivery services are also greener – as envisioned –, two extra characteristics noticeable for consumers are the interaction and the sustainability of the delivery.

Figure 2.11: Parcel delivery attributes and explaination



Meal delivery For meal delivery, the relevant characteristics were assumed to be price, speed, guarantee, sustainability and method. The 'method' characteristic is new, but was introduced for model technical reasons which will be further explained in chapter 3. Using this variable allows for a simpler model, and thus it was included. The characteristics that are assumed to be of influence on consumer delivery choices must now be tested on whether they indeed play a role, and how important they are.

Figure 2.12: Meal delivery attributes and explaination



2.5. Consumer groups

The analysis of consumer preference and trade-off's based on the data collected by means of the stated preference surveys will first and foremost be performed for the whole dataset. However, differences between demographics of the respondents are expected. Age groups are expected to have different preferences and willingness to pay. Consequently, it is of importance to know the differences between several consumer groups. This can be done through data segregation. This lead to the following question: which consumer groups should be analysed? The ways in which this can be done is nearly infinite, and it is impossible to do it all. So, the challenge here is to choose which consumer groups to analyse within given time.

Potential consumer groups Among the most obvious and logical customer groups are those based on socio-demographic characteristics of the respondent. These include, but are not limited to: *age, ethnicity, gender, home ownership, disabilities, education, employment status, children, location, marital status, savings and IT skills.* Not all factors have to be analysed. For example, only consumers from urban areas will be surveyed in this research, and therewith factors out the differences between urban and rural consumers. These characteristics are most likely to have an impact on delivery choices. Age goes hand in hand with IT-capabilities which most likely will make a big difference in accepting automated versions of LMGD services. Education correlates with societal awareness, and in part with income. Income influences the willingness to pay. And lastly, location alters the context in which a consumer makes a delivery choice. For example, in an urban area, delivery at your neighbour is no problem because their doorstep is a mere 10 metres away, whereas a neighbouring house in rural areas can be more than a couple of hundreds of meters away.

Selected consumer groups

- **Age**: Age is considered to be an important characteristic of respondents. Differences in age can entail cultural differences, differences in income, life phase, and views on societal matters. Age groups 20-34, 35-49 and 50-64 are analysed in this research, as they represent different generations, and different life phases.
- **Green minded consumers:** sustainability can play a large role with the delivery innovations. Also, according to a study performed for the European Commission [15], 55% of the Dutch participants indicated that environmental impact plays a role in online shopping decisions. It is therefore interesting to see how preferences and trade-off's differ for this sub group.

2.6. Conclusion

This chapter explored the building blocks on which the modelling of consumer choice will be based. The chapter covered **1)** the delivery process in *section 2.1*, **2)** current delivery services in *section 2.2*, **3)** delivery innovations in *section 2.3*, **4)** factors of influence on delivery choice in *section 2.4*, and **5)** consumer groups in *section 2.5*. Figure 2.13 provides a visual overview of the parcel and meal delivery services and their process, while also depicting the delivery innovations.

The delivery process For the parcel market, the delivery services can generally be divided into two categories: home delivery (which delivers parcels at the consumer's home), and pick-up point (which delivers at a pick-up point). The delivery process involves consignment from the retailer to the logistic service provider (LSP) to the distributions centre. At this point, consolidation of parcels and route planning takes place. Generally, more available time for this step leads to more efficient planning, higher vehicle load factors, and lower operational cost per parcel for the LSP. Depending on the type of delivery (home, or pick-up point), the delivery vehicle either drives to consumer homes, or to parcel pick-up locations. The meal delivery process is inherently different to that of parcel delivery due to its distinct product characteristics. Meals are prepared fresh, locally and on demand, and must be consumed as soon as possible to ensure quality, therefore requiring a quick delivery. This means that this type of commodity does not allow for much consolidation, leading to a point-to-point delivery, mostly performed by scooter or bike. The delivery process for parcel and meal delivery is visualised in figure 2.13. The delivery innovations are to substitute the delivery vehicles/means used in the current delivery process.

Current delivery services The current delivery services for parcel delivery are divided into two categories: 1) *home delivery*, and 2) *pick-up point delivery*. The home delivery and pick-up point delivery characteristics can differ between retailers. Generally, the delivery is conditionally free (i.e. subject to a minimum order), and flexibility (e.g. in terms of time window) or higher delivery speed comes at additional cost. An overview of the delivery services of a list of large online retailers can be found in appendix A.1. For meal delivery, it is simpler than parcel delivery. Restaurants offer delivery for orders above a certain minimum order. The minimum amount is typically around €10.-. Most restaurants then charge a small fee for the delivery, and indicate how long the delivery will take (sometimes based on current number of orders).

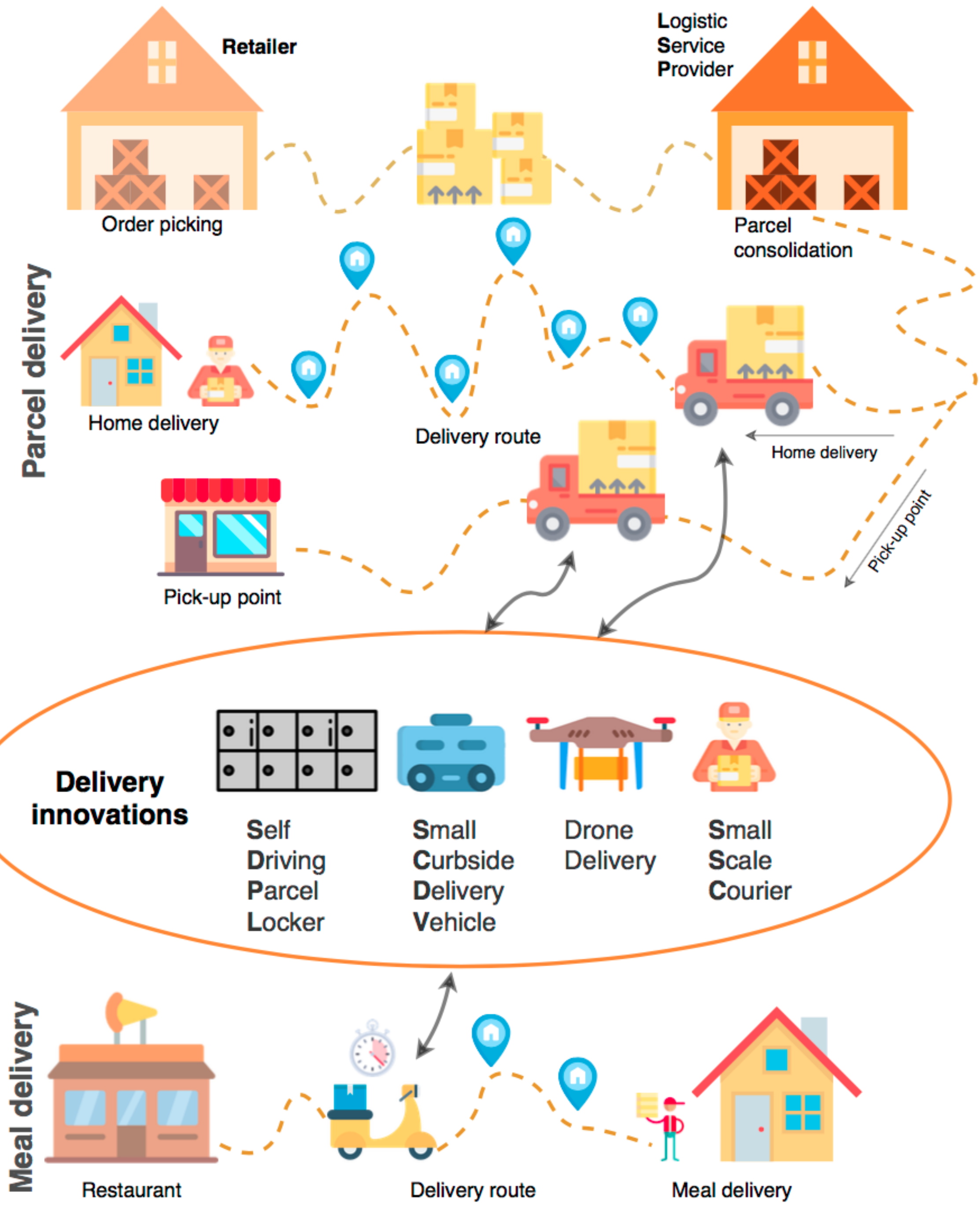
Delivery innovations This research focusses on four delivery innovations. These are the *Self Driving Parcel Locker* (SDPL), the *Small Curbside Delivery Vehicle* (SCDV), *Delivery Drone*, and the *Small Scale Courier* (SSC). The Self Driving Parcel Locker is an automated moving parcel locker which can be placed anywhere in a neighbourhood. This concept offers the flexibility of the current pick-up point deliveries, and potentially brings it closer to consumer homes. The Small Curbside Delivery Robot is aptly named, and is a ground based last mile delivery vehicle, which can serve as a replacement of a delivery person. The delivery drone is air based, and similar to the small curbside delivery robot in the sense that it can be used for the last mile, and can potentially replace delivery persons. The Small Scale Courier is an innovation not involving automation consisting of a local network of on demand delivery persons. This can be compared to what Uber does for cabs, but then for the on demand delivery of commodities. This type of delivery service is able to provide same day (or even same hour) deliveries, and can be used to offer quick, local .

Factors of influence on delivery choice The delivery service factors - which are likely to be of influence on delivery choices - selected in this chapter are different for parcel and meal delivery. For parcel delivery the factors are: *price, location, speed, accessibility, time window, interaction and sustainability*. For meal delivery this is: *price, speed, guarantee, sustainability and method*.

Consumer groups The consumer groups which were selected are: *age groups 20-34, 35-49, 50-64*, and a so called *'green-minded' group* which will be based on additional questions in the survey.

Altogether, the current delivery services, the delivery innovations, the delivery service factors and consumer groups will be used as input for chapter 3: design of the stated preference survey.

Figure 2.13: Delivery process, current services and innovations



3 DESIGN OF THE STATED PREFERENCE SURVEYS

In this chapter, the stated preference surveys are constructed. This chapter covers the following: **1)** the theoretical framework of stated preference surveys and discrete choice modelling in *section 3.1*, **2)** the parcel delivery survey design in *section 3.2*, **3)** the meal delivery survey design in *section 3.3*, and **4)** the survey construction steps (including two pilots) in *section 3.4*, and ends with a chapter conclusion in *section 3.5*.

The method for determining the influence of delivery innovations on consumer delivery choices in the parcel and meal delivery market consists of a data collection technique named *stated preference survey* and a modelling technique called *discrete choice modelling*. Within this framework, the assumption is made that consumers make choices based on the attribute value of choice options (alternatives), and the importance (weight) of these attributes. The alternatives were determined in chapter 2.2 and 2.3, and the attributes (factors) were selected in chapter 2.4. This chapter used this input to design the stated preference surveys. In turn, the analysis of the survey output in chapter 4 will determine the weights of the attributes, which serve as input for choice modelling.

3.1. Stated Choice Experiments & Discrete Choice Modelling

This part of the design chapter goes into the techniques used to construct the stated preference surveys and the associated choice model. The data collection is done through a survey in which respondents are presented with a hypothetical choice situation in which they chose between (typically) two or three options. In this case, the respondents will be asked which delivery service they would choose. The choice options each consist of several factors (or attributes) like price, speed, etcetera. These properties are varied between questions. The respondent chooses the option that best reflects their needs, and therewith state their preference. Theoretically, when enough of these choices are observed for one respondent, it would be possible to determine exactly how important each factor was when making the choices. In this case however, the number of choices that need to be observed grows exponentially when increasing the number of attributes or the amount of variation for each attribute (attribute levels). As it is utterly impossible to ask a respondent hundreds even thousands of choice questions. This is where stated choice experiments come in. This technique allows for complex choice modelling while keeping the survey size relatively small. All knowledge regarding the theoretical framework of stated preference surveys and discrete choice modelling used in this research is based on the extensive lecture slides[26] of course SEN1221, which is given at the TU Delft.

3.1.1. Stated Preference surveys

Stated preference surveys are a data collection method used to estimate choice models which are specifically designed for choices within hypothetical scenario's. As the delivery innovations do not yet exist - with the exception of the small scale courier -, choice data from hypothetical scenario's are needed. The underlying principle is simple: present people with a hypothetical scenario containing multiple options and ask them to state their preference. Each option is represented by a set of characteristics (e.g. price, speed, sustainability). Asking the same respondent to choose a delivery service for different scenarios (with varying sets of values for the delivery option characteristics), yields information on how that person makes their choices. When a sufficient amount of these choices is collected, the value that the respondent assigns to the delivery characteristics can be derived through choice model estimation. When obtaining this information from a large enough representative group these findings can be generalized to the population. Insights into consumer trade-offs can then be used with the 'discrete choice model' to predict consumer choices in hypothetical scenarios.

When using choice modelling techniques to predict choices and learn about preferences and trade-off's, data input is needed. This data (or observations) needs to be captured. In this case: choices need to be observed. Stated choice experiments is a data collection method in which choice alternatives are constructed by the researcher. Each respondent is presented with a choice set and must choose between an finite number of alternatives. The respondent does this multiple time, with varied choice options characteristics. By analysing the choices a respondent makes (estimating the choice model), trade-off's can be observed.

Stated preference vs Revealed preference There are two types of data collection to be distinguished: stated and revealed. **Stated preference** is, as the name suggests, the preference that a respondent states when confronted with a **hypothetical** choice situation. On the other hand, **revealed preference** is a preference for an option in an existing choice situation. The delivery innovations discussed in chapter 2.3 are not yet available to the market. Hypothetical choice situation are needed, and therefore stated preference data is collected in stead of revealed preference.

3.1.2. Discrete Choice Modelling

The more value a delivery service has for consumers, the more likely they are to choose that new delivery service. The following question arises: how to know if a consumer would choose a new hypothetical delivery method over current ones? One way to find out is by utilizing a technique that can predict hypothetical consumer choices. This technique is called 'discrete choice modelling'. To predict consumer choices, it is key to learn how people make choices. According to the discrete choice modelling theory, people make choices based on the characteristics (attributes) of their choice options, and the importance (weights) of those characteristics. A characteristic of a delivery service can be its price, or its speed. The weights determine how important these characteristics are relative to each other. So, to predict consumer delivery service choices, it is necessary to identify which delivery characteristics a consumer takes into consideration, and how important these characteristics are to them (for parcel and meal delivery).

The basics Discrete choice modelling is a technique used to predict future choices made by consumers. Often, this technique is used to assess the impact of infrastructure and transportation changes on mode or route choices: e.g. a new metro line is being planned, and it is important to know how many people will switch from current existing travel options (bus, car, bike, train, taxi, etcetera) to the new (hypothetical) metro line. To do this, first, peoples choices are observed (by means of survey). Second, choices, preferences and trade-off's are inferred. Third, based on these trade off's, future choices are predicted as well as the benefits of transport policies. So why not ask people directly? The main reason is that people are poor analysts of their own behaviour.

Random Utility Maximization and the Multinomial Logit Model This paragraph covers the Random Utility Maximization (RUM) and Multinomial Logit Model (MNL) theory. In classic economics utility (U) is considered to be a measure of preference or satisfaction that consumers try to maximize. When confronted with a choice set of goods or services, the consumer will purchase the one that offers him or her the largest U. In other words: consumer choices are influenced by the U of goods (or alternatives) in a choice set. The **utility of alternative *i*** is defined mathematically as follows:

$$U_i = v_i + \varepsilon_i = \sum_m (\beta_m * x_{im}) + \varepsilon_i$$

For the **RUM model**, alternative i is chosen if:

$$\sum_m (\beta_m * x_{im}) + \varepsilon_i > \sum_m (\beta_m * x_{jm}) + \varepsilon_j \quad , \quad \forall j \neq i$$

Alternatives:	i, j
Attributes:	x
Tastes/weights:	β
Randomness:	ε

The total utility consists of: **systematic utility** (v_i) + **error term** (ε). The error term represents variability in the utility of the alternative. This means that for certain individuals, the utility will be different because of preferences, tastes or personal situations. The varying utility is called **unobserved utility**. This can lead to a difference in choice e.g. the chosen alternative is not the one with the highest systematic utility. When error term ε is independent and identically distributed (i.i.d.) with variance $\pi^2/6$, then the **probability of alternative *i*** being chosen can be captured in the **MNL model** :

$$P(i) = \frac{\exp(v_i)}{\sum_{j=1...j} \exp(v_j)}$$

3.2. Parcel delivery survey design

The first step in constructing a survey is the model specification. In this step much of the content of the stated choice experiment is defined: the alternatives, the attributes, the characteristics of the attributes - generic or alternative specific -, model type, utility function, whether interaction effects are included and the desire to test for non-linearity.

3.2.1. Choice alternatives

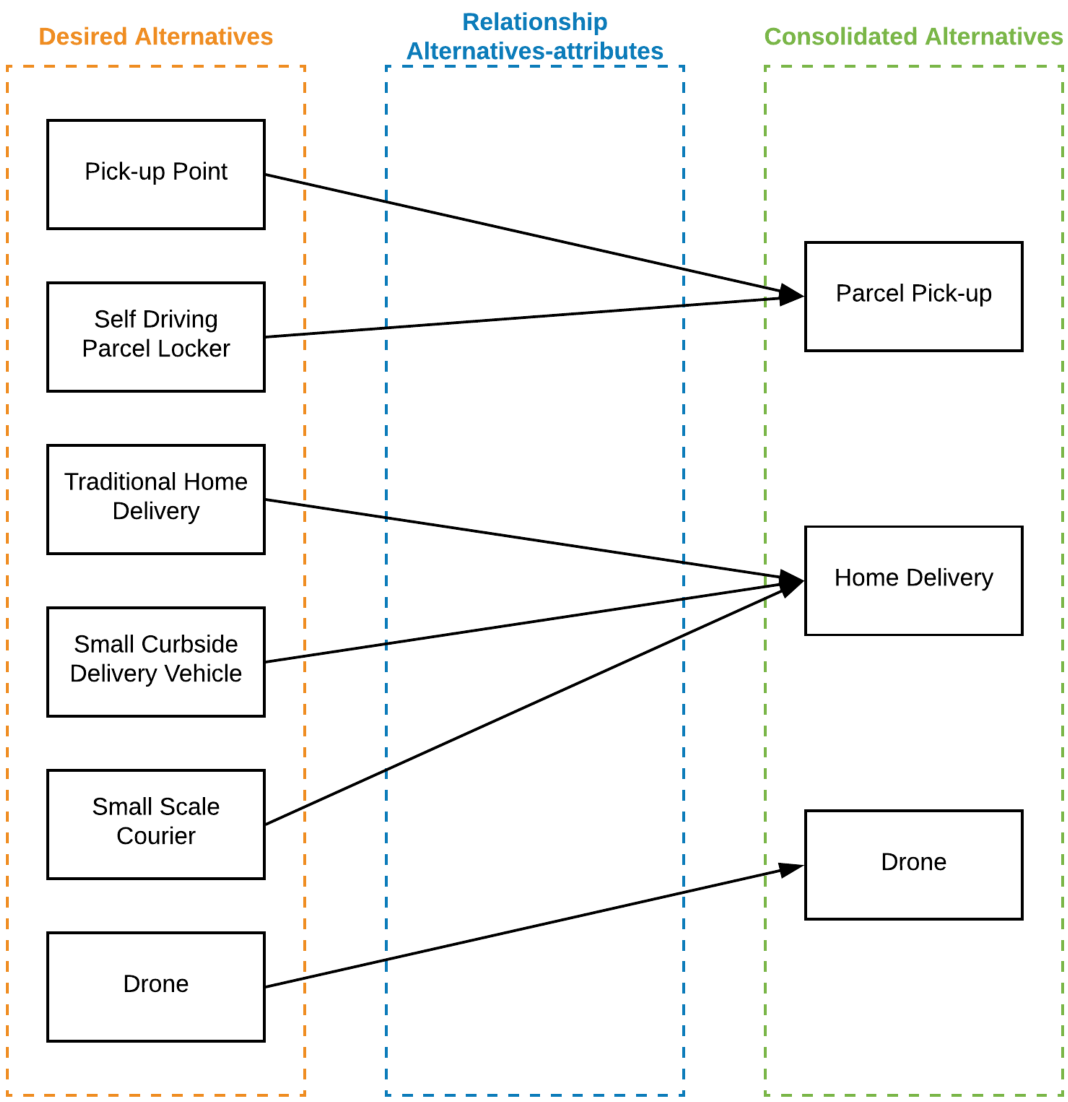
In a choice experiment, it is important for the choice set to be exhaustive - meaning that all choice options in real-life should be represented in the experiment. For the choice set should realistically represent a choice situation. All four of the previously found innovation types - drone, SCDV, SDPL and SSC - are included in the list of alternatives. It is important to learn about all these concepts. Moreover, two (base) alternatives are included to be able to compare the performance of the innovations with the current delivery types. The two current delivery types that are included are: traditional home delivery, and pick-up point.

1. **Drone**
2. **Small curbside delivery vehicle**
3. **Self driving parcel locker**
4. **Small scale courier**
5. **Traditional home delivery**
6. **Pick-up point**

This amount of alternatives leads to a very extensive number of choice sets and therefore, the number of alternatives should be decreased. In a consolidation step the number of alternatives was reduced by half.

Consolidation of alternatives Because of the properties of the chosen research method - Stated Choice Experiments -, six alternatives are likely to be too much for respondents. Ideally, this number would be reduced. The six alternatives were brought back to just three, by consolidation based on shared attributes. There are now three remaining alternatives: the parcel locker, home delivery, and drone. The process by which this was done can be seen in appendix **??**. Table 3.1 illustrates which alternatives were combined.

Figure 3.1: Consolidating the alternatives



3.2.2. Attributes

Next, the attributes that - together - adequately describe an alternative, are specified. This yields a list of 7 attributes, as found in chapter 2. These attributes are not necessarily included with every alternative. Moreover, the attributes may be alternative specific in the sense that each alternative has its own range of values for this attribute.

1. **Price**: the cost charged to the consumer when choosing the delivery service
2. **Location**: the delivery location expressed in terms of distance from the ideal location (home, work, etcetera)
3. **Speed**: the time between the moment of ordering and moment of delivery
4. **Window**: the time interval in which the delivery is planned
5. **Accessibility**: the time interval in which the parcel can be extracted up from the pick-up location
6. **Sustainability**: the environmental impact of the delivery
7. **Interaction**: the nature of the transition of goods, either involving a person or not

Model type The Multinomial Logit Model (MNL) is used as the model type, as this is the most simple model type and is the most proven model type. Due to the exploratory nature of this research - as this is (one of the) first time this model is applied to the delivery market - the MNL is most likely the most advanced model than can be applied within the time span of the research. Moreover, two models need to be estimated as both the parcel and delivery market are covered.

3.2.3. Attribute levels

The right amount of attribute levels should be chosen for several reasons. First, the levels must be representative of real life choice situations. Second, the number of attribute levels enable testing for linear, quadratic or s-curve relationships. The values are based on current delivery service parameters.

Table 3.1: Alternatives, attributes and attribute levels (1)

Attribute \Alternative	*Parcel pick-up*	*Home delivery*	*Drone delivery*
Delivery price	-€2	€0	€0
	€0	€3	€4
	€2	€6	€8
	€4	€9	€12
Delivery location	street	-	home
	neighbourhood	-	street
	station	-	neighbourhood
	pick-up point	-	pick-up point
Delivery speed	same day	same hour	same hour
	same evening	same day	within 2 hours
	next day	next day	within 4 hours
	2 days	2 days	same day
Delivery time window	-	1/2 hour	1/4 hour
	-	2 hours	1/2 hour
	-	3 1/2 hours	3/4 hour
	-	5 hours	1 hour
Pick-up accessibility	12:00-17:00	-	-
	09:00-18:00	-	-
	09:00-21:00	-	-
	00:00-00:00	-	-
Delivery sustainability	green choice	green choice	green choice
	non-green choice	non-green choice	non-green choice
Delivery interaction	human	human	-
	machine	machine	-

3.3. Meal delivery survey design

3.3.1. Choice alternatives

The delivery of meals brings about different requirements for delivery services. Obviously, the pick-up point and self driving parcel locker are not suitable for the delivery of meals because of its high dependence on delivery speed to guarantee food quality. For that reason, the selection of alternatives is limited to just four out of the original six alternatives.

1. **Drone**
2. **Small curbside delivery vehicle**
3. **Small scale courier**
4. **Traditional home delivery**

3.3.2. Attributes

As a basis for determining the attributes for the meal delivery survey, the same attributes as with the parcel delivery survey are take into account. However, not every attribute applies to the meal delivery market. Four attributes remained from the parcel delivery survey. Also, new attributes that apply to the meal delivery market were included. Table B.4 in appendix B.3 shows which attributes apply to the meal delivery market.

The original attributes

1. **Price**: the cost charged to the consumer when choosing the delivery service
2. **Location**: the delivery location expressed in terms of distance from the ideal location (home, work, etcetera)
3. **Speed**: the time between the moment of ordering and moment of delivery

4. **Window**: the time interval in which the delivery is planned
5. **Accessibility**: the time interval in which the parcel can be extracted up from the pick-up location
6. **Sustainability**: the environmental impact of the delivery
7. **Interaction**: the nature of the transition of goods, either involving a person or not

New attributes

1. **Guarantee**: the guarantee that your order is delivered within the indicated delivery time
2. **Type**: the type of vehicle/entity that performs the delivery (relevant if the survey is unlabelled)

3.3.3. Attribute levels

The right amount of attribute levels should be chosen for several reasons. First, the levels must be representative of real life choice situations. Second, the number of attribute levels enable testing for linear, quadratic or s-curve relationships. The attribute levels are based on pricing and delivery speeds that are common today.

Table 3.2: Alternatives, attributes and attribute levels (2)

Attribute \Alternative	*Option 1*	*Option 2*
Delivery price	€0 €1 €2 €3	€0 €1 €2 €3
Delivery speed	15 minutes 30 minutes 45 minutes 60 minutes	15 minutes 30 minutes 45 minutes 60 minutes
Guaranteed within time?	yes no	yes no
Delivery sustainability	green choice non-green choice	green choice non-green choice
Delivery type	drone small curbside delivery vehicle person	drone small curbside delivery vehicle person

3.4. Constructing the surveys

3.4.1. Pilot survey 1

The pilot was conducted via Google forms. A total number of 10 respondents participated in the pilot. There were special questions included in the survey to assess the context definition. Its main goal was to test if the respondents interpreted the questions as intended. The design and details regarding the initial pilots for both parcel delivery as well as meal delivery can be found in appendix B.4.

3.4.2. Pilot survey 2

This section gives an elaborate overview of the design process involved with the orthogonally designed pilot survey. Orthogonal designs are commonly used to determine prior values. These prior values are needed to construct the final survey which is a D-efficient design. The prior value provides information on the direction and magnitude of the parameter estimates, and allows for the optimization of the survey. In practical terms: the final survey will be more compact than the pilot survey, which makes data collection easier and more reliable.

3.4.3. Final survey

This section describes the design process of the final surveys. A D-efficient design for the final survey was chosen. This was due to a number of reasons. Firstly, due to the fact that two surveys are conducted in this research, the available number of respondents will divided over both surveys. This leads to smaller sample sizes, which is unfavourable. Secondly, the number of choice sets for the two surveys when using a traditional orthogonal design is 32 and 24 respectively (as seen in the orthogonally designed pilot for prior values). These choice sets would both have to be split - or blocked - into two segments to prevent fatigue among respondents which might influence the data negatively. Having four survey blocks would increase the required amount of respondents when maintaining the same number of replications. Given that the budget for the data collection is fixed, this means a lower number of replications. Lastly, opting for a D-efficient design is likely to increase the reliability of the parameter estimates and leading to smaller standard errors.

Construction steps The design of the states choice experiment consists of deciding which alternatives, attributes and attribute levels should be taken into account, and the corresponding utility functions. The construction of the survey is done by a programme named Ngene. When specifying all aforementioned aspects of the design, Ngene returns a file with choice sets, describing the attribute levels for each choice situation. Next, these choice sets need to be processed into choice tables, in order to be presented to the respondents in a neat and readable fashion. An online survey platform is used to distribute the surveys, and to present the choice tables to the respondents.

Ngene The Ngene scripts were changes in order to specify an efficient design. The *(MNL,d)* indicates the model type and the type of efficient design. The biggest change is the addition of prior values. Moreover, all nominal variables are now effect-coded, allowing for specifying the priors on an indicator-variable level. The attributes that needed to be be effect-coded due to their "nominal" nature are: location, speed, time window, accessibility, sustainability and interaction. These variables cannot necessarily be described as a linear function, and need to be explained using indicator variables. This will be explained more thoroughly in the final survey data analysis part in the next chapter.
Ngene returns the choice set combinations are output. These tables can be seen in appendix B.4.4.

Survey format After constructing the surveys, the choice sets were translated into tables presenting the choices to respondents. An example is given for the first choice set - first row - of the PD survey in table B.7. The survey platform that was used is named Survey Gizmo. The software was provided by a member of the TPM faculty at the TU Delft. Survey Gizmo is an online survey tool that allows the user to build and execute their survey. The survey platform offers a plethora of functions amongst which are: support for multiple browser types for mobile and desktop, branching, and screening/opt-out questions. After execution, Survey Gizmo allows the user to export the collected data.

Screening & profiling The final survey was executed through a professional panel. The company behind the panel routers the survey to the target group that was agreed on. However, for more advanced screening, to access a more advanced group of respondents, additional screening questions needed to be implemented in the survey. The respondents need to fall into the following category: between age 20-64, living in an urban area or inner city, and have experience with parcel delivery and/or food delivery. A series of questions was asked at the start of the survey. In order to prevent bias among the respondents, the parcel delivery/food delivery experience questions were integrated in a broader question, as shown in figure B.10. If the question was more direct - i.e. do you have experience with x? - the respondent knows which answer to give in order to be selected for the survey.

3.5. Conclusion

In this chapter, the stated preference surveys were constructed. This chapter covered the following: **1)** the theoretical framework of stated preference surveys and discrete choice modelling in *section 3.1*, **2)** the parcel delivery survey design in *section 3.2*, **3)** the meal delivery survey design in *section 3.3*, and **4)** the survey construction steps (including two pilots) in *section 3.4*.

Stated Preference Surveys & Discrete Choice Modelling The influence of delivery innovations on consumer delivery service choices in the parcel and meal delivery market is determined through discrete choice modelling. Choice modelling requires data input - in the form of observed choices - order to estimate the model. The delivery innovations discussed in chapter 2.3 are not yet available in the market - except for the smalls scale courier. Stated preference surveys are used in this research due to the fact that they allow for *hypothetical choice scenario's*.

Discrete choice modelling is a technique used to predict future choices made by consumers. This research uses Random Utility Maximization (RUM) and Multinomial Logit Model (MNL) theory. In classic economics utility (U) is considered to be a measure of preference or satisfaction that consumers try to maximize. When confronted with a choice set of goods or services, the consumer will purchase the one that offers him or her the largest U. In other words: consumer choices are influenced by the U of options (or alternatives) in a choice set. The *utility of alternative i* is defined mathematically as follows:

$$U_i = v_i + \varepsilon_i = \sum_m (\beta_m * x_{im}) + \varepsilon_i$$

Alternatives:	i, j
Attributes:	x
Tastes/weights:	β
Randomness:	ε

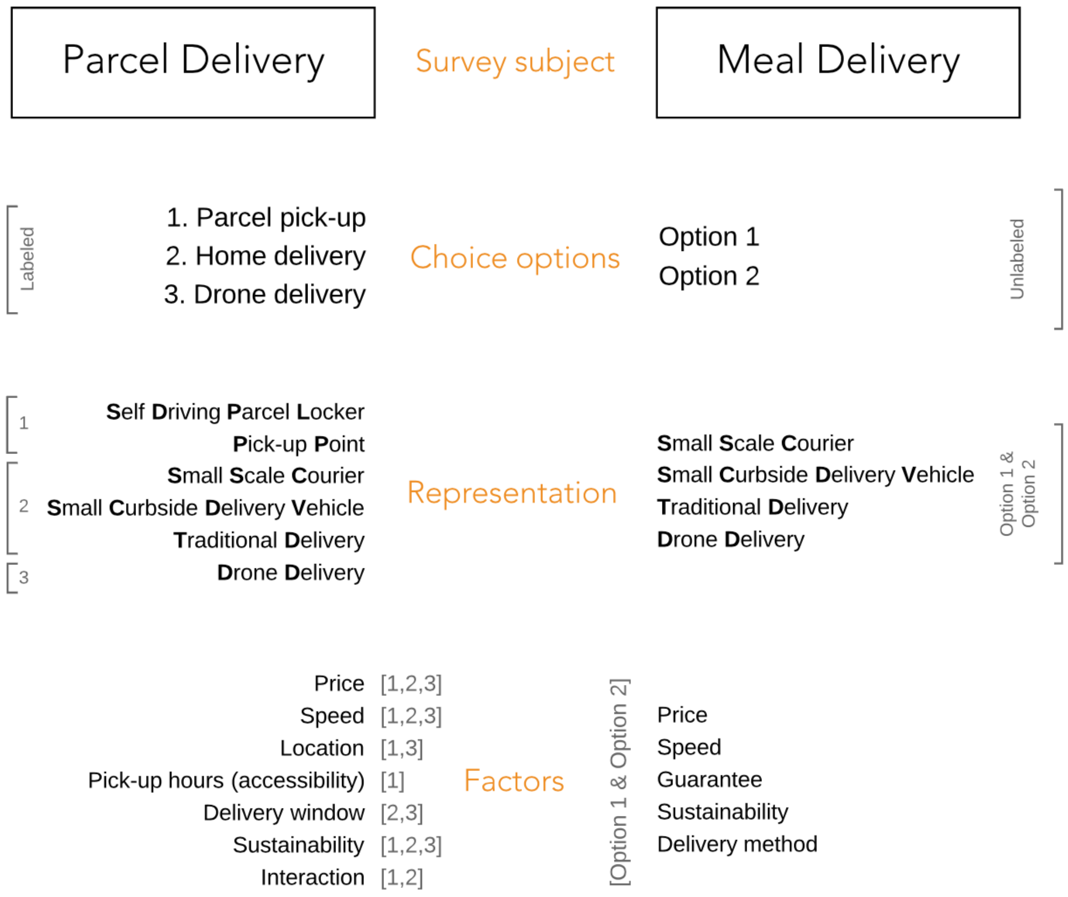
The *probability of alternative i* being chosen can be captured in the *MNL model*:

$$P(i) = \frac{\exp(v_i)}{\sum_{j=1...j} \exp(v_j)}$$

Parcel delivery survey design The parcel delivery survey has to represent four innovations: the *self driving parcel locker*, the *small curbside delivery vehicle*, the *small scale courier*, and the *drone delivery*. Moreover, the two current delivery services (home delivery and pick-up point delivery) also need to be represented as reference points of the performance of the delivery innovations. Incorporating six delivery services in the survey - in correct terms six *alternatives*- would lead to a large number of survey questions, making the data collection more difficult. Therefore, based on shared characteristics, the six alternatives were nested accordingly into three choice options: parcel pick-up, home delivery and drone delivery. Figure 3.2 shows the way the parcel delivery was designed: choice options and their corresponding attributes, and which innovations they represent. A full overview of the attribute levels can be found in chapter 3.2.3. For more information on these design choices, please go to chapter 3.2.

Meal delivery survey design The meal delivery survey has to represent only three delivery innovations, as the self driving parcel locker is not suitable for meal delivery. Moreover, the current delivery service is also taken into the survey design as a reference point for the performance of the new delivery services. Figure 3.2 shows the way in which the meal delivery survey was designed. Note that the choice options are *unlabelled* as 'option 1' and 'option 2'. This was done to bring the size of the design back, and was possible due to the fact that the delivery services all share the same characteristics. Therefore, the delivery method attribute was introduced to represent the different delivery innovations. For more information on these design choices, please refer to chapter 3.3.

Figure 3.2: Surveys: nested alternatives & attributes



Constructing the surveys The surveys were constructed in a number of steps: **1)** the surveys were constructed with Ngene, a specialized software tool designed to construct stated preference surveys. This step required input of the survey design in terms of *choice alternatives, attributes and attribute levels.* Ngene yields choice sets as output, which basically means that Ngene determines which way the choice set characteristics are varied with each question. **2)** these choice sets were transformed into table format for them to be implemented in an online survey software platform.

The construction of the final surveys (both for parcel delivery and for meal delivery) was preceded by two pilot surveys. The *first pilot* was conducted on a small scale and its purpose was to check if the respondents would interpret the survey as intended. The *second pilot* was conducted on a somewhat larger scale to obtain *prior values*, which is data needed to construct an efficient design. Efficient designs allow for a smaller number of choice sets, which reduces the survey size. With the decision to use a d-efficient design, the number of choice sets (survey questions) was reduced from 32 to 20 for the parcel delivery survey, and from 24 to 12 for the meal delivery survey.

Chapter 4, data analysis, will discuss the data collection method in section 4.1, the data sample analysis in section 4.2, and the data analysis steps for the choice model estimation in section 4.3.

4
DATA ANALYSIS

In this chapter, the stated preference data is analysed and the choice model is estimated. This chapter contains the following sections: **1)** sampling method, describing the data collection process in section *section 4.1*, **2)** descriptive statistics, *section 4.2* in which the data sample characteristics are analysed , **3)** the model estimation, *section 4.3*, in which the choice models for parcel and meal delivery are estimated for the total sample, and the segregated samples (to determine consumer group differences), and ends with a chapter conclusion in *section 4.4*.

This chapter covers the data analysis process of the stated preference data. First, the sampling method is discussed and includes the data collection method, sample size, criteria for the respondent, and target group split for data segregation. Second, the pre model estimation outcomes of the survey are discussed. By means of descriptives and frequencies, the sample is evaluated. These properties give information on the distribution of respondent demographics and the distribution of choices. Moreover, filtering of outliers to ensure sample quality is discussed. Third, the data sets of the final survey are segregated and processed in order to obtain parameter estimations, standard errors and levels of significance. This is done for the whole sample, and the sub groups, for the parcel delivery survey, and for the meal delivery survey.

4.1. Sampling method

For the main data collection - by means of the final survey - a professional panel named PanelClix was used. PanelClix is the largest online panel in the Netherlands and is also operational in Germany, Belgium and France. The company has been building their panel since 1999. As of today, the panel has over 120.00 members in the Netherlands.

PanelClix was recommended by the TU Delft, as they have used their services before. There are many advantages to using a professional panel. Firstly, speed: a vast amount of data collection is possible in mere days. Data collection in the pilot phase took almost two weeks for a relatively small number of respondents. Secondly, a tight control over survey quotas: the large panel size enables the researcher to select specific target groups and allows for precise quotas. Lastly, using a panel results in a sample that is more evenly distributed over the population. Especially compared to data collection within ones own network or environment.

On the other hand - due to the fact that PanelClix works with a monetary incentive for their panel - odds are that some respondents will only participate to earn money. This may lead to speeding (unrealistically quick completion times), and decreased attention when filling out the survey. Overall, this implies that a fraction of participants may give a random data input. This phenomenon makes it more difficult to achieve significant parameters. Unfortunately, filtering these respondents - and accounting for these errors - is difficult. Which is why - when interpreting the results - this potential flaw must be kept in mind. Last but not least, using a panel for the data collection is quite costly. PanelClix works with a fixed tariff for each project, and charges an amount per respondent.

For this research, respondents were selected based on three criteria: experience with parcel or meal delivery services, between the age of 20-64, and living in the Nielsen 1 area in the Netherlands (Amsterdam, Rotterdam, and The Hague, including neighbouring cities) as the geographical scope of this research was set on urban areas.

Given the available budget for data collection,the sample size will be approximately 450 respondents.
The sample size requirements and data segmentation for consumer groups can be found in appendix C.1.1 and C.1.2.

4.2. Descriptive statistics

This section goes into the characteristics of the respondents' answers. This gives insight into the quality of the respondents, their attitudes and demographics. A total of 548 respondents participated in the surveys. The full sample analysis can be found in appendix C.2.

4.2.1. Outliers

First, the sample was checked for speeders - respondents which filled in the survey as quickly s possible, just for the reward, rendering the data useless. Based on reference completion times from the pilots, the responses with a completion time lower than 180 seconds were removed. This lead to the removal of 74 responses, resulting in a remaining sample size of 474 respondents. More details on the removal of outliers can be found in appendix C.2.1.

4.2.2. Frequency distribution

Table 4.1 displays the frequency distribution for the age bins over the different survey segments. The PD survey has [58, 58, 56] respondents and the MD survey returned [31, 39, 36] respondents. This means that the sample size for the PD age bin data sets are on the low side. However, the MD data set falls neatly in the above 30 respondents category.

Table 4.1: Frequency distribution age bins

		Respondent age group				
		20-34	*35-49*	*50-64*	Total	
Distribution over surveys	*PD 1*	**58**	**58**	63	179	37,8%
	PD 2	74	59	**56**	189	39,9%
	MD	31	39	36	106	22,4%
	Total	163	156	155	474	
		34,4%	32,9%	32,7%		

The green-minded bin consists of all respondents that filled in "I agree" or "I strongly agree" for the statement "I am willing to pay more for a more sustainable delivery service". As can be seen in table 4.2. For the PD survey, 61 fall in this category, and for the MD survey 34 do, which makes this bin is large enough for data analysis.

Table 4.2: Frequency distribution green-statement

		"I am willing to pay more for a more sustainable delivery service."					
		Strongly agree	*Agree*	*Neutral*	*Disagree*	*Stronly disagree*	*Total*
Distribution over surveys	*PD 1*	10	57	81	24	7	179
	PD 2	**8**	**53**	76	39	13	189
	MD	**6**	**28**	39	24	9	106
	Total	24	138	196	87	29	474

Fixed preference Some respondents may have a fixed preference for one of the alternatives. This means that non of the attributes and their values change the delivery choice. These statistics for the PD survey can indicate a certain familiarity with an alternative. If this is not the case, it might be a sign of a respondent choosing the same service from each choice set in order to finish as quickly as possible. The latter is however not very likely, due to the filtering of outliers with a very low completion time. Table 4.3 shows that there were 7 respondents with a fixed preference for the parcel pick-up delivery service, a whopping 42 of the respondents have a fixed preference for home delivery. This is possibly because respondents are most familiar with this delivery service. Out of all PD respondents, 4 had a fixed preference for drone delivery. The MD statistics show that only 3 respondents have a fixed preference for option 1. But due to the choice sets being generic,

Table 4.3: Fixed preferences among respondents

	Fixed preference PD
PP	7
HD	42
DR	4

	Fixed preference MD
Option 1	3
Option 2	0

this given no information on the preferences of the respondents. The occurrence of fixed preference is within the MD survey is most likely due to coincidence, or because of speeding.
Moreover, the demographic characteristics and attitudes of the respondents was analysed, the results of which can be viewed in appendix C.2.3 and C.2.4 respectively. Also the choice frequency was assessed, which provides insights into choice distribution and fixed preference (a respondent who chose the same option for every question) in appendix C.2.5.

4.3. Model estimation

The model estimation section contains a detailed overview of all steps taken during the data analysis from data output until the parameter estimation.

4.3.1. Analysis steps

Data preparation

The output from Survey Gizmo is an excel file. This sheet contains a lot of information - a lot more than needs to be used. This vast amount of data must ultimately be processed into a format which can be read and solved by the software programme that estimated the parameters. Two files are needed to prepare the dataset for parameter estimation: a matrix containing choice data, and a matrix containing the attribute values of the design and all the parameters which need to be estimated. This means that every effect-coded variable needs to be translated into indicator variables in this file.

A step-by-step overview of the data preparation:

1. Filter choice data until a matrix remains that contains the respondent ID and the choices made per choice set represented by integers - i.e. parcel pick-up is translated to "1", home delivery to "2" and drone delivery to "3";
2. Construct a matrix containing all parameters - including indicator variables - and parameter values for each choice set;
3. Transform the two matrices into one file containing the information on the respondents' choice, and the properties of the corresponding choice set - this was done by means of a Matlab script.
4. Output the matrix as a tab delimited file (.dat) in order to be legible for pythonbiogeme.

Together, these two files provide information on which choice which respondent made in which choice set, and also provide information on what the respondent chose between - in the form of a parameter specification. Table 4.4 provides a small example of such file.

Table 4.4: Example choice data file

Respondent	Choice set	Choice	Delivery price (PP)	Delivery speed (PP)	
1	**1**	2	**1**	**15**	...
1	**2**	3	3	60	...
1	**3**	1	3	45	...
1	**4**	2	1	30	...
2	1	1	**1**	**15**	...
2	2	1	3	60	...
2	3	3	3	45	...
2	4	2	1	30	...
3	1	3	**1**	**15**	...
3	2	3	3	60	...
3	3	1	3	45	...
3	4	2	1	30	...
...	...	...	...	...	

For both surveys, data files were constructed for the total dataset, for all age bins, for the green minded respondents and the early adopters. This results in six different datasets per experiment, which means a total amount of twelve datasets.

Pythonbiogeme
Pythonbiogeme requires two files to solve the parameters: a dataset in correct format (as already discussed), and a model specification script containing details like model type, prior values, utility functions and parameter properties. The most important aspects of the python script are discussed. Equations 4.3.1, 4.3.2 and 4.3.3 represent the utility functions of the three alternatives from the PD survey. Every one of the nominal variables were effect-coded. This can be seen in the utility functions as numerical extensions [1,2,3]. An example of a coding scheme can be seen in table 4.5.

Table 4.5: Coding scheme for the location attribute for the parcel pick-up alternative

Location (PP)	**PPL1**	**PPL2**	**PPL3**
Street	1	0	0
Neighbourhood	0	1	0
Station	0	0	1
Pick-up point	-1	-1	-1

$$\begin{aligned} Vpp = ASC_{PP} + PPC * Beta_{PPC} + PPL1 * Beta_{PPL1} + PPL2 * Beta_{PPL2} + PPL3 * Beta_{PPL3} \\ + PPS1 * Beta_{PPS1} + PPS2 * Beta_{PPS2} + PPS3 * Beta_{PPS3} + PPSS * Beta_{SS} \\ + PPA1 * Beta_{PPA1} + PPA2 * Beta_{PPA2} + PPA3 * Beta_{PPA3} + PPI * Beta_{I} \end{aligned} \tag{4.3.1}$$

$$\begin{aligned} Vhd = ASC_{HD} + HDC * Beta_{HDC} + HDS1 * Beta_{HDS1} + HDS2 * Beta_{HDS2} + HDS3 * Beta_{HDS3} + HDW1 \\ * Beta_{HDW1} + HDW2 * Beta_{HDW2} + HDW3 * Beta_{HDW3} + HDSS * Beta_{SS} + HDI * Beta_{I} \end{aligned} \tag{4.3.2}$$

$$\begin{aligned} Vdr = ASC_{DR} + DRC * Beta_{DRC} + DRL1 * Beta_{DRL1} + DRL2 * Beta_{DRL2} + DRL3 \\ * Beta_{DRL3} + DRS1 * Beta_{DRS1} + DRS2 * Beta_{DRS2} + DRS3 * Beta_{DRS3} + DRW1 \\ * Beta_{DRW1} + DRW2 * Beta_{DRW2} + DRW3 * Beta_{DRW3} + DRSS * Beta_{SS} \end{aligned} \tag{4.3.3}$$

4.3.2. Model fit

Model fit parcel delivery After running the script, along with the parameter estimates, the model characteristics are being output by Pythonbiogeme. The model fit - a performance measure indicated by the log likelihood and rho-square - can be observed from these numbers. In table 4.7, the model fit for the PD survey is compared across all datasets. The higher the log-likelihood (LL) of a model is, the better the fit. However, in order to evaluate the model fit in relative terms, the Rho-square statistic is needed. The Rho-square is calculated by subtracting the ratio between the LL of the estimated model and the LL of the model when all beta's are zero from 1. $(1-(LL_{model}/LL_{zero}))$. Therefore, the higher the Rho-square value, the more the estimated parameters have increased the model fit. Model 5 - as shown in table 4.6 - is the best model due to the lowest final LL, and the most realistic representation of the variables.

Table 4.6: Estimated models parcel delivery

Model	**Price**	**Time window**
1	Linear (alt spec)	Effects coded
2	Linear (alt spec)	Generic
3	Linear (alt spec)	Alternative specific
4	Linear (alt spec)	Quadratic (gen)
5	Quadratic (gen)	Effects coded
6	Quadratic (gen)	Generic
7	Quadratic (gen)	Alternative specific
8	Quadratic (gen)	Quadratic (gen)

Table 4.7: Model fit comparison PD survey

Model	Parameters	Sig. params.	% sig. params.	LL(final)	Rho-bar	AIC	BIC
1	31	14	45%	-3.414	0,141	6889	7081
2	26	14	54%	-3.416	0,142	6883	7044
3	27	13	48%	-3.415	0,142	6885	7052
4	27	13	48%	-3.415	0,142	6884	7051
5	30	10	33%	-3.412	0,142	6884	7070
6	25	12	48%	-3.418	0,141	6886	7041
7	26	12	46%	-3.417	0,141	6886	7047
8	26	12	46%	-3.417	0,141	6886	7048

Model fit meal delivery For the MD survey, a model with and without a quadratic component for the price attribute was estimated. The quadratic component was not significant. Therefore, it can be concluded that price behave linearly for meal delivery. Moreover, the best model is the one with the linear price component, as marked in green in table 4.8.

Table 4.8: Model fit MD survey

Model	Parameters	Sig. params.	% sig. params.	LL(final)	Rho-bar	AIC	BIC
Linear price	6	4	67%	-822,375	0,06	1657	1688
Quadratic price	7	3	43%	-822,367	0,059	1659	1695

4.3.3. Parameter estimates

This subsection contains all parameter estimates for the parcel delivery and meal delivery model estimates. Each one of these parameter outcomes was analysed extensively, and the following aspects were discussed:

1. **Parameter significance:** the parameters' statistical significance determines if the parameter value can be generalized to the population - within the profile of the respondent in this research. A parameter is statistically significant at the 5% interval if the p-value is lower or equal to 0.05, and the t-statistic is higher or equal to 1.96. If a parameter is not statistically significant, the value only applies to the observed sample. The null-hypothesis is accepted (parameter value = 0 for the population) and does not need to be described any further.

2. **Parameter value & attribute utility** the parameter values represent the weight of an attribute level. When multiplied, it represent the utility contribution of an attribute level. This value indicates to which extend an attribute level contributes positively or negatively to the total utility of the choice option.

3. **Curve characteristics:** the curve gives a visual overview of the utilities of different attribute levels. It is important to check if the curve has the expected characteristics.

4. **Utility range & ratio:** the utility range is the difference between the highest and lowest utility of an attributes' levels. This range represents the extend to which its variation can influence the total utility of an alternative. The utility ratio is the utility range of an attribute divided by the total sum of utility ranges for an alternative. The ratio represents the relative influence of attribute for choosing an alternative.

5. **Interpretation:** lastly, an interpretation is given for each of the attributes and its estimated parameters. This is only done in detail for the significant parameters, as these describe the population and not only the sample.

This analysis was very thorough, and helped with the interpretation of the outcomes. Furthermore, it helped a great deal with determining if the outcomes are logical or plausible, as there is no reference material available. Most of the parameter estimates behave as expected, with a few small exceptions which are different than expected on the parameter level, but behave logically in the bigger picture. The full analysis is omitted in the main text, but can be found in appendix C.3.

Parameter estimates parcel delivery The parameter estimates for the parcel delivery survey can be viewed in table 4.9. Visualization and an in depth discussion on all the parameter outcomes can be found in appendix C.3.

Table 4.9: Parameter estimates parcel delivery survey

Name	**Value**	**Std err**	**t-test**	**p-value**	**5% significance**	**Expected sign?**
Parcel pick-up constant	0,00	-	-	-	-	-
Home delivery constant	0,83	0,13	6,36	0,00	Yes	Yes
Drone constant	-0,06	0,12	-0,47	0,64	No	Unknown

Name	**Value**	**Std err**	**t-test**	**p-value**	**5% significance**	**Expected sign?**
Price parameter 1 (linear)	-0,05	0,03	-1,80	0,07	No	Yes
Price parameter 2 (quadratic)	-0,02	0,00	-6,69	0,00	Yes	Yes

Name	**Value**	**Std err**	**t-test**	**p-value**	**5% significance**	**Expected sign?**
Parcel pick-up: Speed 1	0,06	0,08	0,77	0,44	No	Yes
Parcel pick-up: Speed 2	0,14	0,08	1,72	0,08	No	Yes
Parcel pick-up: Speed 3	0,30	0,07	4,20	0,00	Yes	Unknown
Home delivery: Speed 1	0,13	0,15	0,87	0,38	No	Yes
Home delivery: Speed 2	0,30	0,09	3,20	0,00	Yes	Yes
Home delivery: Speed 3	-0,15	0,09	-1,61	0,11	No	Yes
Drone delivery: Speed 1	-0,26	0,12	-2,25	0,02	Yes	No
Drone delivery: Speed 2	-0,20	0,10	-2,03	0,04	Yes	No
Drone delivery: Speed 3	0,06	0,09	0,62	0,53	No	No

Name	**Value**	**Std err**	**t-test**	**p-value**	**5% significance**	**Expected sign?**
Parcel pick-up: Location 1	0,21	0,08	2,65	0,01	Yes	Yes
Parcel pick-up: Location 2	0,02	0,08	0,27	0,79	No	Unknown
Parcel pick-up: Location 3	-0,15	0,08	-1,83	0,07	No	Yes
Drone delivery: Location 1	-0,15	0,11	-1,37	0,17	No	No
Drone delivery: Location 2	0,12	0,10	1,17	0,24	No	Unknown
Drone delivery: Location 3	0,03	0,09	0,28	0,78	No	Unknown

Name	**Value**	**Std err**	**t-test**	**p-value**	**5% significance**	**Expected sign?**
Parcel pick-up: Accessibility 1	-0,29	0,08	-3,80	0,00	Yes	Yes
Parcel pick-up: Accessibility 2	0,18	0,08	2,42	0,02	Yes	No
Parcel pick-up: Accessibility 3	0,04	0,08	0,47	0,64	No	Yes

Name	**Value**	**Std err**	**t-test**	**p-value**	**5% significance**	**Expected sign?**
Home delivery: Window 1	0,17	0,12	1,41	0,16	No	Yes
Home delivery: Window 2	-0,05	0,09	-0,53	0,60	No	No
Home delivery: Window 3	-0,11	0,12	-0,86	0,39	No	No
Drone delivery: Window 1	0,11	0,09	1,26	0,21	No	Yes
Drone delivery: Window 2	-0,14	0,11	-1,33	0,18	No	No
Drone delivery: Window 3	0,30	0,11	2,73	0,01	Yes	No

Name	**Value**	**Std err**	**t-test**	**p-value**	**5% significance**	**Expected sign?**
Interaction	0,02	0,02	0,88	0,38	No	Yes

Name	**Value**	**Std err**	**t-test**	**p-value**	**5% significance**	**Expected sign?**
Sustainability	0,07	0,06	1,29	0,20	No	Yes

Parameter estimates meal delivery The parameter estimates for the meal delivery survey can be viewed in table 4.10. Visualization and an in depth discussion on all the parameter outcomes can be found in appendix C.3.

Table 4.10: Parameter estimates meal delivery

Name	**Value**	**Robust Std err**	**Robust t-test**	**p-value**	**Significant?**	**Expected sign?**
Price	-0.377	0.0695	-5.42	0	Yes	Yes
Name	**Value**	**Robust Std err**	**Robust t-test**	**p-value**	**Significant?**	**Expected sign?**
Guarantee	0.213	0.0604	3.52	0	Yes	Yes
Name	**Value**	**Robust Std err**	**Robust t-test**	**p-value**	**Significant?**	**Expected sign?**
Speed	-0.0154	0.00557	-2.76	0.01	Yes	Yes
Name	**Value**	**Robust Std err**	**Robust t-test**	**p-value**	**Significant?**	**Expected sign?**
Sustainability	0.0304	0.0595	0.51	0.61	No	Yes
Name	**Value**	**Robust Std err**	**Robust t-test**	**p-value**	**Significant?**	**Expected sign?**
Delivery method 1	-0.261	0.0486	-5.37	0	Yes	No
Delivery method 2	-0.0434	0.0496	-0.88	0.38	No	No

4.4. Conclusion

In this chapter, the stated preference data was analysed and the choice models were estimated. This chapter covered the following subjects: **1)** sampling method, describing the data collection process in section *section 4.1*, **2)** descriptive statistics, *section 4.2* in which the data sample characteristics are analysed , **3)** the model estimation, *section 4.3*, in which the choice models for parcel and meal delivery are estimated for the total sample, and the segregated samples (to determine consumer group differences).

Sampling method The data was collected via an online data collection panel named PanelClix, which is the largest panel in the Netherlands and is operational in multiple countries. Respondents are compensated for filling in the survey. PanelClix provided quick data collection, and allowed for the selection of respondents. For this research, respondents were selected based on three criteria: experience with parcel or meal delivery services, between the age of 20-64, and living in the Nielsen 1 area in the Netherlands (Amsterdam, Rotterdam, and The Hague, including neighbouring cities) as the geographical scope of this research was set on urban areas. One of the downsides of this type of data collection is the risk of speeders (respondents who will out the survey as quickly as possible just for the money).

Descriptive statistics The total sample size, containing the parcel and meal delivery data was 548 respondents. Of these 548 respondents, 74 were identified as speeders, and were removed based on their survey completion time. Lastly, in the parcel delivery sample, there were 42 respondents with a fixed preference (meaning that the respondent chose this option for every question) for home delivery, 7 respondents with a fixed preference for parcel pick-up, and 4 respondents with a fixed preference for drone delivery. This indicates that there is a large group which is not sensitive to the delivery service attributes, but only for the delivery service.

Model estimation Through several analysis steps, among other things by means of PythonBiogeme, choices models were estimated based on the stated preference data. First, the model fit was compared between several model specifications, and the best fitting model for parcel and meal delivery were selected. The model estimation was performed several times: once for the parcel delivery data, once for the meal delivery data, and eight times for the segregated data (3 age groups, and one green group) for both parcel and meal delivery. For the parcel delivery model, a quadratic price component was used (and was significant), for the meal delivery model both price and speed were estimated as linear (this yielded the best model fit). *This means that the price attribute behaves quadratically for parcel delivery, and linearly for meal delivery.*

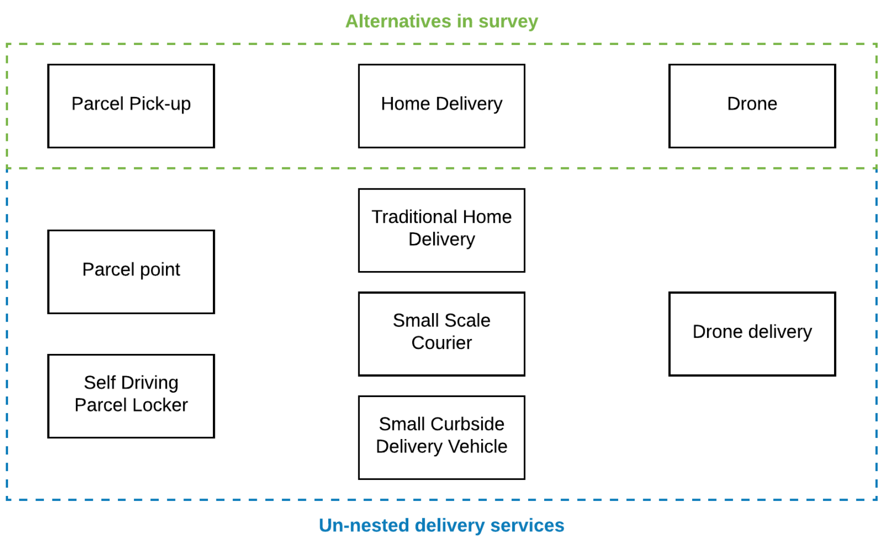
Concluding, the data analysis yielded parameter estimates for the parcel and meal delivery choice model. These outcomes will be interpreted in the next chapter, chapter 5, and will shed light on which delivery characteristics play a role for consumers and their relative importance in section 5.1, the willingness-to-pay in appendix D.2, and differences between consumer groups in section 5.2. Next, the choice prediction model, which can be used as a tool to assess the market propositions of delivery innovations is featured in section 5.3. Moreover, implementation advise for delivery innovation is given in appendix D.4.

5

RESULTS & INTERPRETATION

This chapter gives an extensive overview of the results and findings in this research, and what they imply for delivery innovations in the parcel and meal delivery market. The following outcomes are presented and discussed for parcel delivery, and for meal delivery: 1) key attributes, 2) consumer group differences, 3) delivery choice prediction model, 4) implementation advise. In section 5.1 the key attributes are discussed, in section 5.2 the differences between consumer groups are highlighted, and in section 5.3 the choice prediction model is explained. The willingness to pay and implementation advises are included in appendix D.2 and D.4 respectively.
With the design of the parcel delivery survey, six delivery methods were nested into three alternatives to decrease the size of the survey drastically. This entailed that the alternatives in this research represented several delivery services and innovations. The three alternatives (PP, HD and DR) represented: parcel point, self driving parcel locker, traditional home delivery, small scale courier, small curbside delivery vehicle, and drone delivery. This is depicted in figure 5.1.

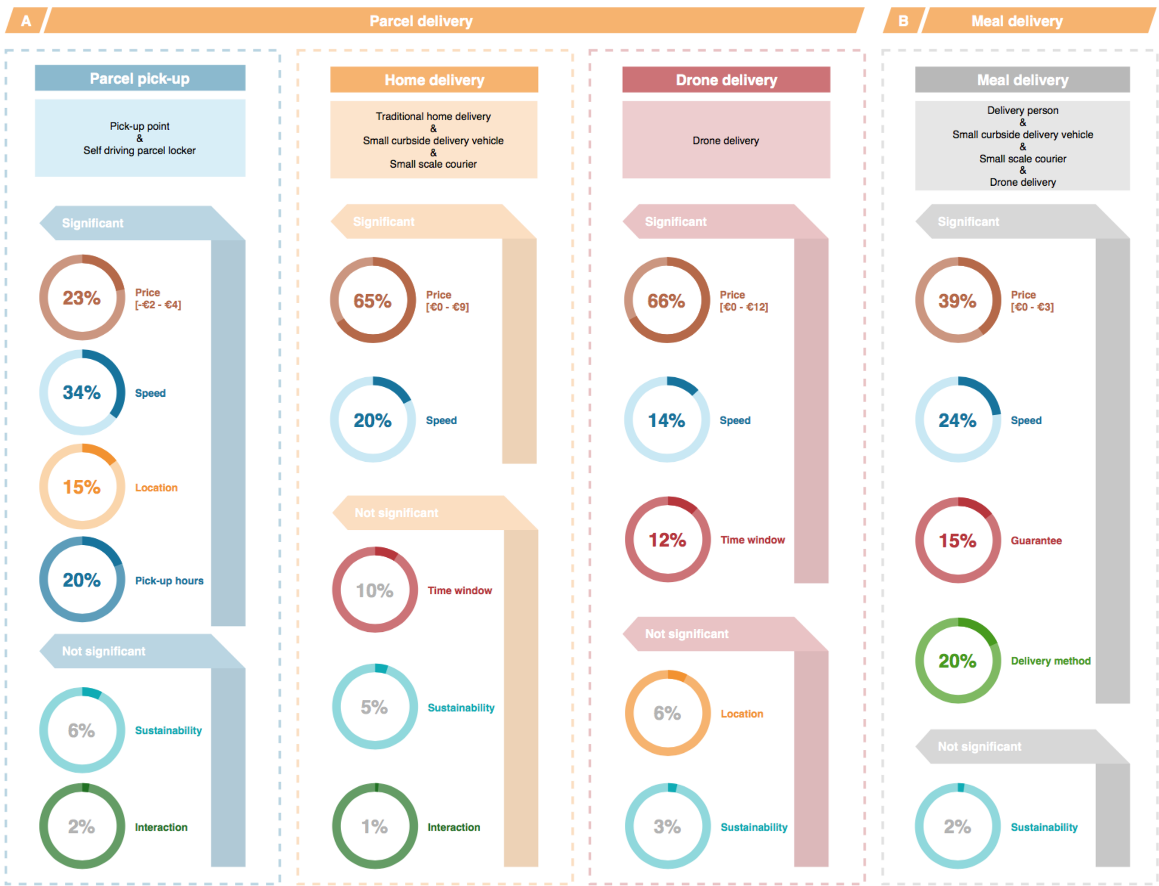
Figure 5.1: Representation delivery services parcel delivery



5.1. Key attributes & relative importance

The relative importance of the delivery characteristics indicates the influence of each characteristic on the attractiveness of delivery services to consumers. Insights into how many factors actually influence delivery choice, and knowing to which extend they do, indicates what the focus should be on for the market proposition of these delivery methods. This research yielded three sets of attribute importance, due to choice for nested alternatives in the survey design: 1) Home delivery, containing traditional home delivery, small curbside delivery vehicle, and small scale courier, 2) Parcel pick-up, containing the pick-up point, and the self driving parcel locker, 3) drone delivery, representing only the drone delivery.

Figure 5.2: Parcel & meal delivery key attributes and relative importance



Parcel delivery 1) For home delivery, small curbside delivery vehicle and small scale courier, the delivery characteristics found to be of significant influence on consumer choice are price (64%) and speed (20%). Only two out of five factors turned out to be on influence on delivery choice. This tells that the focus of the market proposition of these delivery methods should mainly be on keeping prices low, and secondly on high delivery speed.

2) For parcel pick-up and the self driving parcel locker, price (23%), speed (34%), location (15%) and accessibility (20%) were found to be of influence on the delivery choice. Four out of six factors are of influence on the delivery choice. In this case, when implementing parcel pick-up or the self driving parcel locker, the focus should not mainly be on price, but also on speed, accessibility (opening hours) and location.

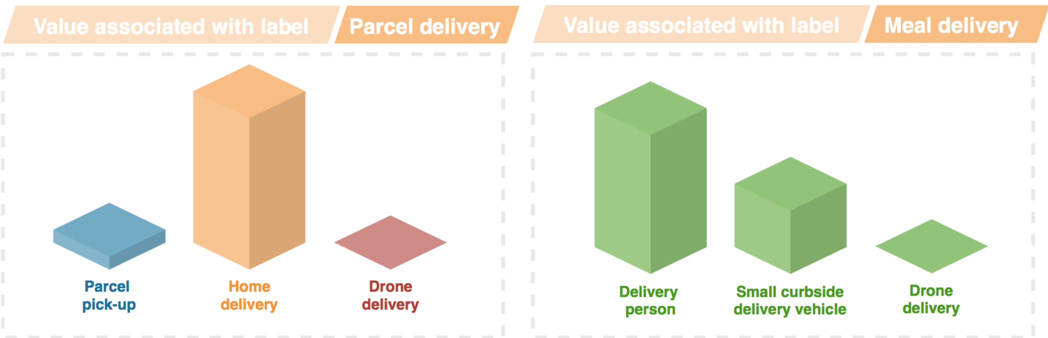
3) For drone delivery, price (64%), speed (14%) and time window (12%) are of influence on the delivery choice. This means that three out of six factors are indeed on influence on the delivery choice. When drone delivery are implemented, the main focus therefore should be on keeping the delivery price as low as possible. Offer-

ing high delivery speed, and a small time window is of value for consumers, but does not have as big of an influence on the attractiveness of drone delivery as price.

Meal delivery For meal delivery, four out of five attributes are of influence on the delivery choice: price (39%), speed (24%), guarantee (15%) and type (20%). Price is of largest influence, but also delivery speed, type and guarantee are important. Within the delivery type characteristic, consumers rated delivery by person highest, followed by small curbside delivery vehicle, and rated drone delivery lowest. This factor accounts for 20% of the total influence on delivery choice. So, if small curbside delivery vehicles or drone would be used in the future, it is important to compensate through price, speed or by guaranteeing an on time delivery.

Value associated with label The data analysis of the survey yields which characteristics play a role in choosing the delivery service, and how important they are relative to each other. However, delivery services might have value to the consumer independent of the set characteristics by which they are represented in the survey. This may be due to other influences which have not been taken into account, such as other characteristics (not included in the survey), or preferences based on familiarity. In order to capture these phenomena, extra variables were added. These variables serve two purposes: from a technical standpoint, this makes the models' predictions more accurate; and from a practical standpoint, this enables the model to assign value to influences beyond the (potentially incomplete) finite set of characteristics included in this research.

Figure 5.3: Value associated with label

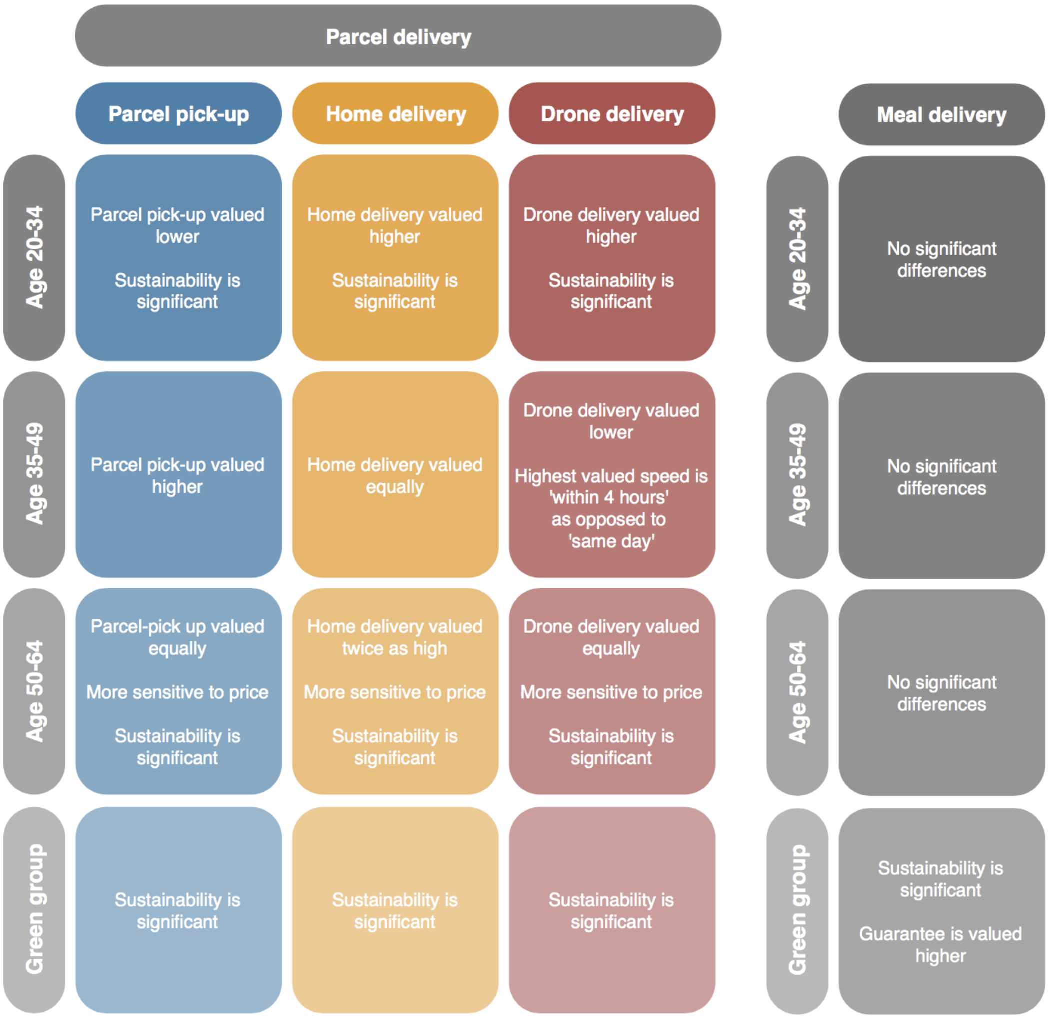


For parcel delivery, the current home delivery, delivery by small scale courier and curbside delivery – nested in 'home delivery' – were ranked highest. Parcel pick-up, self driving parcel locker – nested in 'parcel pick-up' – and drone delivery were ranked lower. This means that consumers associate these delivery methods with higher value. **For meal delivery**, three delivery types were presented to the respondent: delivery by drone, delivery by small curbside delivery vehicle, and delivery by person. Of these different delivery types, delivery by person was ranked highest, curbside robot was ranked second (right in between), and drone delivery was ranked last.

5.2. Consumer group differences

In this research, the results were also split in order to identify potential differences between consumer groups. This was done for age groups and a 'green group', containing respondents which were assigned to this group based on questions related to the importance of the environment. The noteworthy results can be seen in the infographic 5.4. The full analysis can be seen in appendix D.1.

Figure 5.4: Differences between consumer groups for parcel and meal delivery



Parcel delivery From a market proposition and marketing perspective, the lowest age group 20-34, is more open to drone deliveries, and value the environmental impact of delivery services. This makes this group the most suitable for drone delivery, and implies that, underlining the sustainability aspect will have added value. Age group 35-49 values parcel pick-up deliveries higher than the other groups do, potentially making them the best candidate for this delivery innovation pilot. On the other hand, they are the only group that does not value sustainability. Age group 50-64 assign great value to the home delivery type service, and value the sustainability aspect of the service. This implies that age group 50-64 is a suitable group to test the greener home delivery innovations on.

Meal delivery Except for the green group valuing the sustainability aspect of the delivery – indicating that there is indeed a sub group in the population which value sustainability –, and assigning more value (and there with higher willingness to pay) to the delivery guarantee, there were no substantial differences found between the consumer groups in this research.

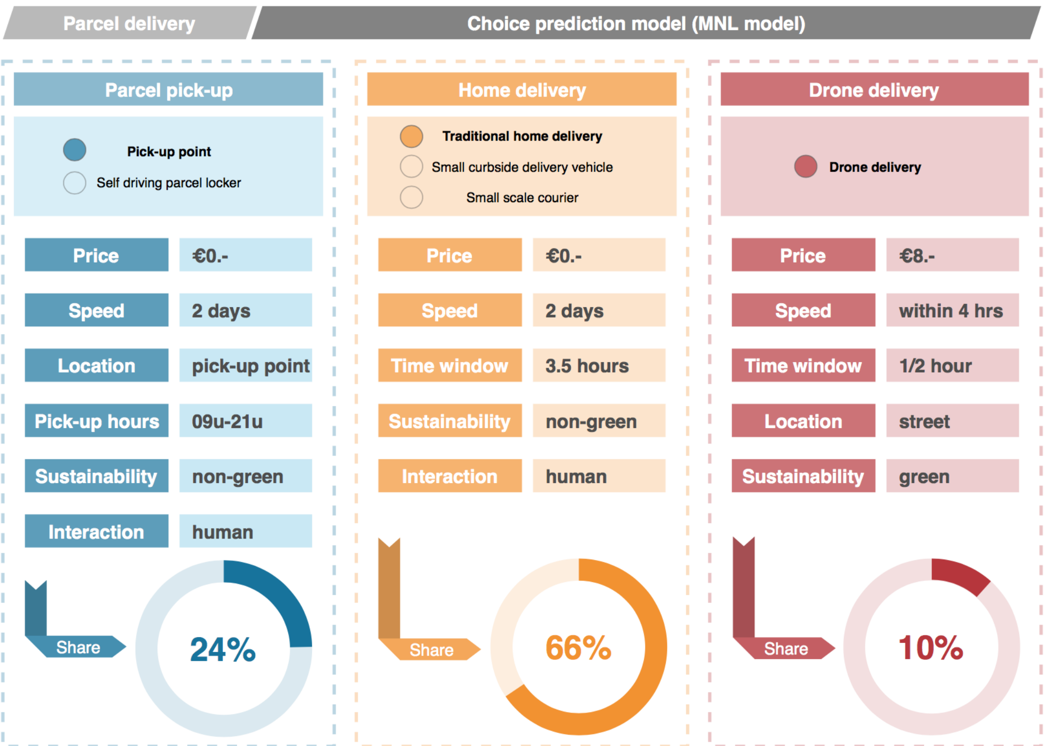
5.3. Delivery choice prediction model

One of the main features of the MNL model is its forecasting abilities. The utility functions describing the total attractiveness of an alternative is comprised of factors and weights. The sum of which equals the total utility. The factors are in this case the delivery service features and characteristics such as price, speed and sustainability. The weights describe the relative importance of these factors and were estimated in the data analysis phase based on the survey data. When applying these outcomes to the MNL model, a choice share can be calculated with equation 5.3.1.

$$P(i) = \frac{\exp(v_i)}{\sum_{j=1...j} \exp(v_j)} \tag{5.3.1}$$

Choice prediction model parcel delivery The parcel delivery MNL model can be seen in figure 5.5. This table is the result of a parametric implementation of all factors and weights in equation 5.3.1. The delivery service characteristics can be altered within the model boundaries, and the predicted choice share will show accordingly. This MNL tool can be used to assess the impact of changes in delivery services on choice shares, or it can be used to compare the performance of new delivery services to that of current ones. The MNL model can compare up to three delivery services. One of each nested alternative (PP, HD, and DR).

Figure 5.5: MNL model for consumer parcel delivery choice prediction

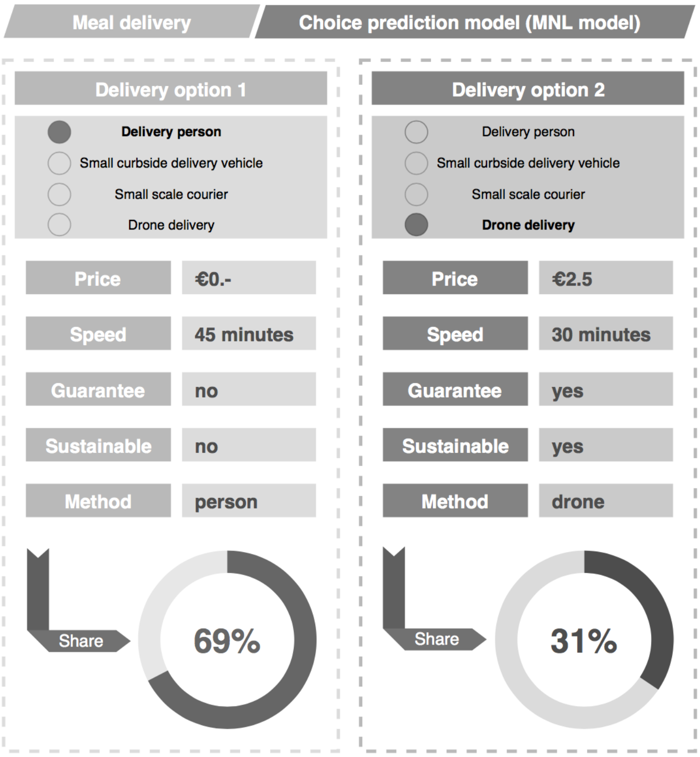


Example 1: *Figure 5.5 depicts the way in which the MNL model can be used to compare choice share predictions. This instance, pick-up point, home delivery (as they are currently), and the drone delivery innovation are compared. The model output is **24%** choice share for the pick-up point, **66%** choice share for the traditional home delivery, and **10%** choice share for the drone delivery.*

Example 2: *another scenario - which can be viewed in appendix D.3.2, table D.13 - is a variation on example 1, and swaps the pick-up point for the self-driving parcel locker. Due to the higher value of the self driving parcel locker, the choice shares shift to **30%** for the SDPL, **61%** for the traditional home delivery, and **9%** for drone delivery.*

Choice prediction model meal delivery The meal delivery MNL model can be seen in figure 5.6. The tool allows for a comparison of up to three delivery services. Because the model uses unlabelled choices, the delivery options are just named option 1 , and option 2. The factors price, speed, guarantee, sustainability, and delivery method can be adjusted. Different combinations yield different choice share predictions.

Figure 5.6: MNL model for consumer meal delivery choice prediction



Example 1: *Figure 5.6 depicts the way in which the MNL model can be used to compare choice share predictions. This instance, a delivery by delivery person is compared to a quicker drone delivery. The model output is **69%** choice share for delivery option 1, and **31%** choice share for delivery option 2.*

Example 2: *another scenario - which can be viewed in appendix D.3.3, table D.20 - compares choice shares of three delivery options 1) delivery by person at a price of €2.-, 2) delivery by small curbside delivery vehicle for free with quicker and guaranteed delivery, and 3) drone delivery for free with quicker and guaranteed delivery. Assuming that right now, all delivery are done by person (option 1), the effect of offering better performing delivery innovations (option 2, and option 3) alongside the current delivery method is a shift of delivery choices shares to **15%**, **47%**, and **38%** respectively.*

5.4. Conclusion

This chapter gave an extensive overview of the results and findings in this research, and what they imply for delivery innovations in the parcel and meal delivery market. In section 5.1 the key attributes were discussed, in section 5.2 the differences between consumer groups were highlighted, and in section 5.3 the choice prediction model is explained. The willingness to pay and implementation advises are included in appendix D.2 and D.4 respectively.

Key attributes & relative importance The statistically significant attributes in for parcel delivery are price, speed, location, accessibility and time window. More specifically, when split into the three nested alternatives in the survey, the significant factors for *parcel pick-up are: price, speed, location, and accessibility.* For *home delivery this is only price and speed.* For *drone delivery its: price, speed, and time window.* For meal delivery the significant parameters are *price, speed, guarantee, and delivery type.*

Delivery choice prediction model In this chapter, the MNL model application on the parcel delivery and meal delivery market was discussed and demonstrated. A parametric tool was built for both product types. These models can be adjusted to reflect a number of choice situations. Either two or three delivery services can be compared at the same time. For each of these services, each service component can be adjusted. Both the parcel delivery and meal delivery service propositions can be evaluated in terms of market share. These predicted choice shares give an indication of the market potential of different delivery services.

Consumer group differences The most significant finding for *parcel delivery* is that age group 20-34, 50-64 and the 'green' group turned out to be sensitive for the delivery sustainability, which means that the greener delivery innovations have an edge over current non-green delivery services, if all other aspects are equal. Age group 20-34 has the highest value for drone delivery. Age group 35-49 values pick-up point highest. Age group 60-64 is more sensitive for price, and values home delivery highest. For *meal delivery,* there were no significant differences between age groups. The green group is the only group which is sensitive to sustainability, which means that there is indeed a sub group which values the sustainability of a meal delivery service.

Delivery choice prediction model Ultimately, consumer choice shares can be predicted with the model constructed in this research. This tool can be used by parties to estimate the choice shares for a plethora of (hypothetical) delivery methods. The model allows the user to construct delivery options – in terms of the delivery characteristics taken into this research – and then presents the choice share estimations.

6
CONCLUSIONS, DISCUSSION & RECOMMENDATIONS

The **objective** of this research was to identify the consumer value of parcel and meal home delivery service innovations, in order optimize market proposition, and to predict the impact of these innovations on the delivery market. Determining the influence of delivery innovations on consumer choice was done by means of choice modelling in order to understand consumer preferences and trade-offs. This final chapter starts with the conclusions for this research in section 6.1, in which the research questions are answered. The second part of this chapter, section 6.2 contains a critical discussion regarding the findings and the research as a whole. Lastly, in section 6.3 provides guidelines and suggestions for science.

6.1. Conclusions

This section provides answers to all research questions (main and sub). Section 6.1.1 answers the first sub question, section 6.1.2 answers the second sub question, section 6.1.3 answers the third sub question, and section 6.1.4 answers the main research question.

6.1.1. Factors of influence on consumer delivery choice *(sub question 1)*

The first sub question was:

> *"Which factors significantly influence consumers' delivery choice, and how strongly?"*

For home delivery, small curbside delivery vehicle and small scale courier, the delivery characteristics found to be of significant influence on consumer choice are **price (64%)** and **speed (20%)**. Only two out of five factors turned out to be on influence on delivery choice. This tells that the focus of the market proposition of these delivery methods should mainly be on keeping prices low, and secondly on high delivery speed.

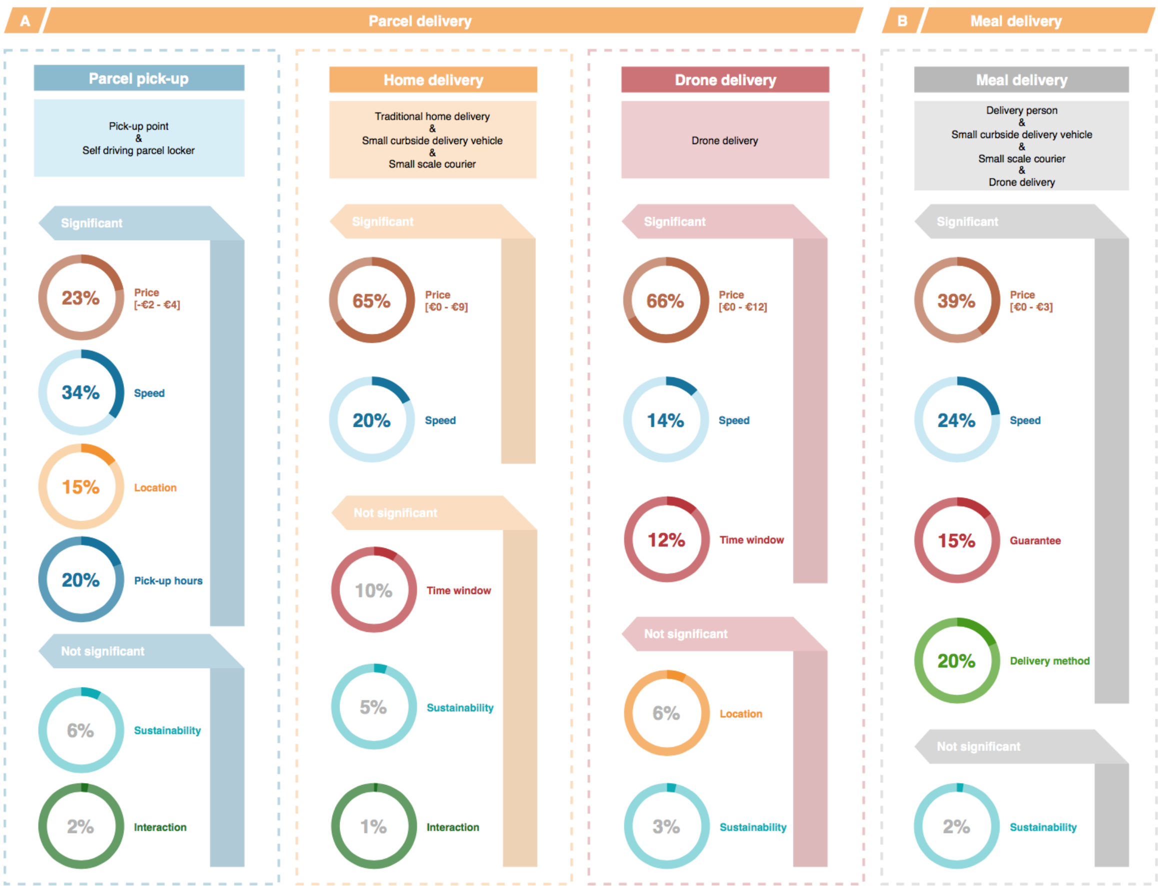
For parcel pick-up point and the self driving parcel locker, **price (23%)**, **speed (34%)**, **location (15%) and accessibility (20%)** were found to be of influence on the delivery choice. Four out of six factors are of influence on the delivery choice. In this case, when implementing parcel pick-up or the self driving parcel locker, the focus should not mainly be on price, but also on speed, accessibility (opening hours) and location.

For drone delivery, price (64%), speed (14%) and time window (12%) are of influence on the delivery choice. This means that three out of six factors are indeed on influence on the delivery choice. When drone delivery are implemented, the main focus therefore should be on keeping the delivery price as low as possible. Offering high delivery speed, and a small time window is of value for consumers, but does not have as big of an influence on the attractiveness of drone delivery as price.

For meal delivery, four out of five factors are of influence on the delivery choice: **price (39%), speed (24%), guarantee (15%) and type (20%)**. Price is of largest influence, but also delivery speed, type and guarantee are important. Within the delivery type characteristic, consumers rated delivery by person highest, followed by small curbside delivery vehicle, and rated drone delivery lowest. This factor accounts for 20% of the total influence on delivery choice. So, if small curbside delivery vehicles or drone would be used in the future, it is important to compensate through price, speed or by guaranteeing an on time delivery.

A full overview of the significant attributes and their relative importance can be seen in figure 6.1

Figure 6.1: Parcel & meal delivery key attributes and relative importance



6.1.2. Differences between parcel delivery and meal delivery choice making *(sub question 2)*

This part answers the second sub question:

How does delivery choice making differ between parcel delivery and meal delivery?

There are a few general differences found between the preferences and trade-off's of the two product types. Firstly, the price attribute has a significant quadratic component for parcel delivery, and only a linear component for meal delivery. This means that **consumers are more sensitive for price increase with parcel delivery services, than with meal delivery services.**

Parcel delivery choice making and meal delivery choice making are subject to different sets of attributes. Of the significant attributes, **price and speed play a role in both delivery markets**. There are also significant attributes which are unique to parcel and meal delivery. **For parcel delivery location, accessibility, and time window are unique factors. For meal delivery, delivery guarantee and the delivery method are unique factors.**

The consumer group outcomes show that only the 35-49 age group does not take sustainability into consideration when choosing a delivery service. Vice versa, age groups 20-34, 50-64 and the green group do take sustainability into consideration. For meal delivery, only the green group takes sustainability into consideration. **This implies that, when choosing a parcel delivery service, a larger share of consumers care about sustainability than with choosing a meal delivery service.**

6.1.3. Differences between consumer groups *(sub question 3)*

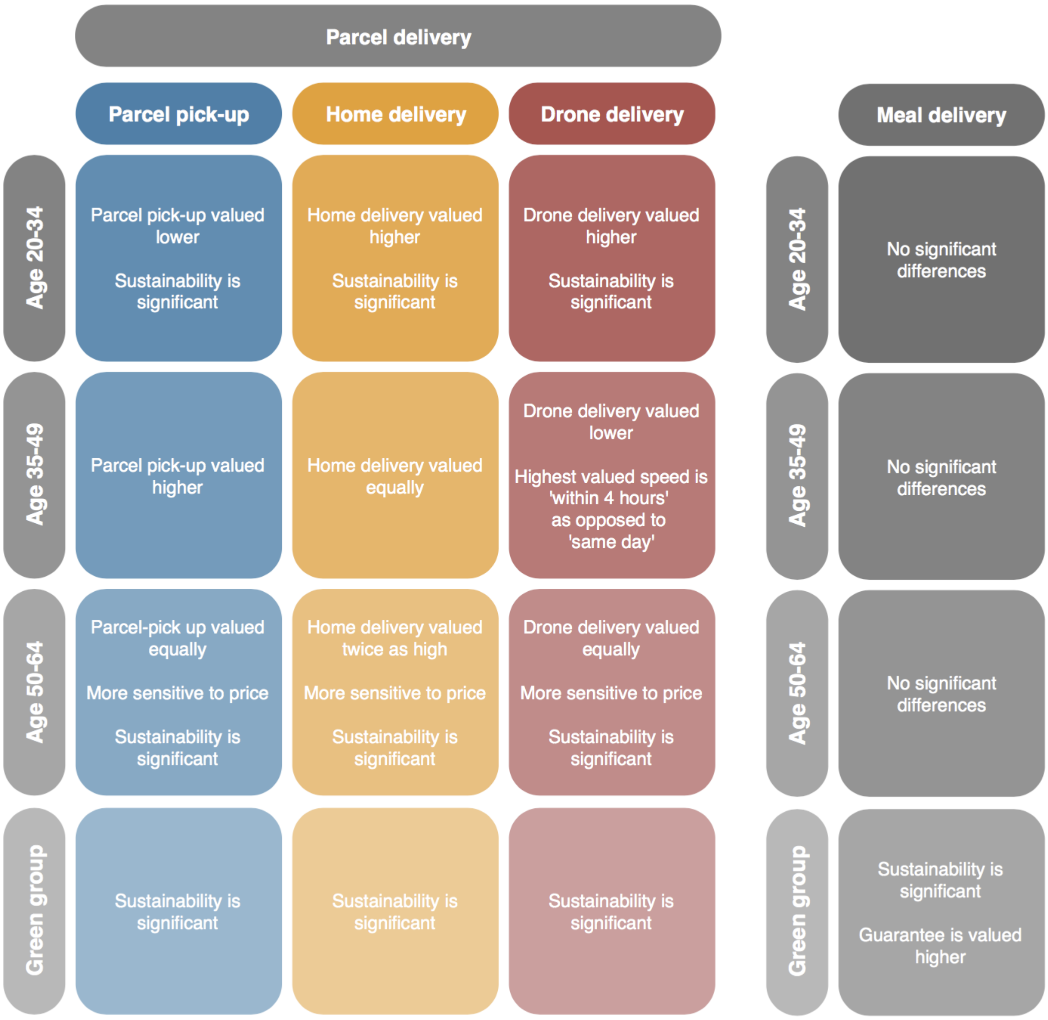
This part answers the third sub question:

How do delivery preferences vary between consumer groups?

Parcel delivery From a market proposition and marketing perspective, the lowest **age group 20-34, is more open to drone deliveries**, and value the environmental impact of delivery services. This makes this group the most suitable for drone delivery, and implies that, underlining the sustainability aspect will have added value. **Age group 35-49 values parcel pick-up deliveries higher** than the other groups do, potentially making them the best candidate for this delivery innovation pilot. On the other hand, they are the only group that does not value sustainability. **Age group 50-64 assign great value to the home delivery type service, and value the sustainability** aspect of the service. This implies that age group 50-64 is a suitable group to test the greener home delivery innovations on.

Meal delivery Except for the green group valuing the sustainability aspect of the delivery – indicating that **there is indeed a sub group in the population which value sustainability** –, and assigning more value (and therewith higher willingness to pay) to the delivery guarantee, there were **no substantial differences found between the consumer groups in this research**.

Figure 6.2: Differences between consumer groups for parcel and meal delivery



6.1.4. The effect of delivery service innovations on consumer home delivery choices *(main question*

This part answers the main question:

> *What is the effect of delivery service innovations on consumer delivery choices in the parcel and meal delivery market?*

The answer to this question depends on several factors. One of the most important aspects lies in which delivery service characteristics influence consumer delivery choice, and how strongly their influence is. This differs for the parcel and meal delivery markets. Ultimately, an LSP or restaurant has to decide if the implementation of (automated) delivery innovations is feasible, all things considered. However, this research does illuminate the consumer perspective on these innovations, and is therefore able to provide guidelines to optimize their market propositions, and yields a tool to predict consumer choice shares (which has a parallel with market shares).

There is a distinction to be made between delivery characteristics which already exist in current delivery methods, and the ones introduced by delivery innovations: the interaction and sustainability of a delivery service. For parcel delivery, the interaction aspect – the change from a delivery person to a delivery robot – was found not to play a role. Sustainability on the other hand, does play a role, except for age group 30-49.

Parcel delivery: parcel pick-up type deliveries Parcel pick-up type deliveries include: pick-up point (current), and self-driving parcel locker (innovation). When implementing this type of innovation, the market proposition focus should be on price, speed, location and pick-up hours. If the self driving parcel locker is able to improve on the delivery location, speed, it will be more attractive to consumers than the current pick-up point service. Combining this with the preferred pick-up hours solidifies the market position of this delivery service type. Sustainability should be emphasised, as this innovation probably allows for the largest reduction of environmental impact, and there are sub groups which value the sustainability of delivery services.

Parcel delivery: home delivery type deliveries The home delivery type – representing traditional home delivery, small curbside delivery vehicles, and small scale couriers – remains a very attractive delivery type. This is emphasized by the large 'default' value for this delivery type – assumedly partly related to familiarity – as found in this research. The focus for market implementation should be on price and speed. Therefore, if the delivery innovations are able to improve adequately on either speed or price, they will be able to compete with – and potentially improve on - current delivery methods. The small curbside delivery method would be the cheaper to operate and greener innovation. The small scale courier would be the more expensive, but also much quicker delivery method. The exact impact of differences in speed and price should be assessed with the choice prediction tool.

Parcel delivery: drone delivery Drone delivery can potentially compete with current delivery methods by offering fast deliveries. However, drone deliveries seem to suffer from a negative bias as the default value is lowest. This can in part be due to the unfamiliarity with this delivery method. More research is needed to properly identify the reasons behind this phenomenon. Fast deliveries are associated with higher delivery prices, and unfortunately, high pricing easily overshadows the speed advantages of drone deliveries in terms of consumer value. When implementing this delivery service, it can only be marginally more expensive than the competing services. Moreover, the (potentially large) differences in emission should be emphasized, as drones are zero emission, and current express deliveries have a very high per parcel emission. Age group 20-34 seems to value drone delivery higher than, implying that a younger audience may be more open to drone deliveries.

Meal delivery For meal delivery, consumers seem to prefer the current delivery service (by person) to the delivery innovations (small curbside delivery vehicle (SCDV), and drone). If restaurants and food chains insist on implementing these automated delivery services – due to operational cost reductions, or marketing related motives –, the innovations should have least one of the following four aspects: lower price (€1.- lower for SCDV, and €1.50 lower for drone), higher speed, or offering a delivery guarantee, to be equally attractive to consumers.

Due to the fact that consumer delivery service choices – right now – are mainly driven by existing factors, their impact on consumer delivery choice is dependent on the extent to which they improve on these factors. This means that delivery innovations can be more attractive to consumers than current delivery services. This research yields ways in which delivery innovations can best be implemented, by focussing on identified strengths of the different innovation types. The exact impact of changes in delivery services on consumer choice can be assessed with the choice prediction model, enabling companies to optimize market propositions, and estimate the influence on hypothetical delivery service choices and market share. Hopefully paving the way to market implementation.

6.2. Discussion

6.2.1. Fundamentals

To the knowledge of te author, there was only very little prior research available for literature review. Most last mile delivery papers discuss operational aspect such as routing, or the negative externalities expressed in Euro per parcel. The consumer centred papers were mostly qualitative researches. There was not much prior research done on the topic of delivery service choice modelling. Moreover, to the knowledge of the author, this is the first time that discrete choice modelling was applied to the topic of urban last mile deliveries. This also introduces uncertainty, as it becomes more difficult to validate the model outcomes with reference material, as there is none. Also, in the first phase of this research a lot assumptions had to be made in the light of a lack of guidelines from prior research.

6.2.2. The survey

Attributes The list of attributes which were modelled for parcel and meal delivery was derived from literature, current delivery service information on websites, and from conversations with customers of FMN. However, there may be other attributes which influence the consumer delivery choice making, which were not taken into account.

Improvement on visuals of survey for better respondent engagement The survey was quite basic in terms of visuals. There is a chance that the survey would have been more appealing when it was visualised, or when the design was more playful. This could have increased the attention respondents paid to the questions, and might have increased the quality of the data.

Quality of data due to speeders there was a large percentage of speeders among respondents. This was compensated by filtering out the outliers, and supplementing the data with new respondents. Nevertheless, all respondents got an reimbursement for their effort. It is therefore legitimate to wonder how many of the total respondents rushed through the survey, or filled in out with minimal attention only for the money.

Representation of the interaction variable The interaction variable in the parcel delivery survey was used to indicate the difference between a delivery by person and a delivery by a machine. The differences were not clearly defined in the survey context, in part because this would differ too much between the nested alternatives in order to come up with a comprehensive instruction. Moreover, for a few of the concepts, how the interaction works exactly is not yet known. Therefore, the interaction variable was defined as "either an interaction with a person, or with a machine, requiring a digital transaction step such as scanning a bar code. When this interaction aspect becomes more clear for different innovations, it becomes easier de determine the consumer value of this variable because respondents have a clearer picture of what is meant by 'interaction with a machine'. The interaction variable was not of significant influence on the parcel delivery service choice right now, but this may change over time.

Representation of the sustainability variable The sustainability factor was defined as 'green choice' and 'non-green choice'. This was an elegant way to incorporate this attribute into the survey in a fashion which did not potentially confuse the respondent - as happened in the pilot survey when presented with the sustainability attribute expressed in grams CO2 emission per parcel-, but it does not provide much information in the real value for consumers, as attribute levels were superficial. The results of this research imply that, especially for parcel delivery, there are consumers with sensitivity for sustainability. The extend to which this is should be further investigated.

Representation of the price parameter It is difficult to grasp the price component in this research. The delivery price was quantified, and varied within certain ranges within the surveys. However, in practice consumers mostly do not pay for deliveries. This does not mean that the transportation of these goods to the consumer is free of cost, as the delivery expenses are compensated for in the product price. However, it does make it more difficult to capture the pure effect of price. When consumers are used to a price of €0.-, the penalty of a higher price can become very high. This means that it is possible that the price parameter value is overestimated. An option was to leave out the price components, in which case the price of all delivery services automatically become €0.-. However, the reason why this was not done is because the price component was essential to determine the willingness to pay. It would be interesting what a similar survey without price attribute would yield in terms of differences.

Representation of the location parameter The location parameter in the parcel delivery model represented the delivery location. One of the options for drone delivery was 'home'. Now, this home delivery can take a different form in real life, as the consumer might live in a terraced house, or an apartment building. This research did not have a way to accommodate these differences.

Nested alternatives he survey had three alternatives. These three alternatives represented a total of six delivery methods. In order to evaluate all delivery services, the nesting step was necessary to prevent the survey becoming too long and impractical. However, one may ask how much detail was lost with these simplifications. For example: the traditional home delivery and SCDV are assigned practically the same utility at similar specifications. This implies they are equal, whereas there is good reason to assume that there are indeed differences in terms of consumer value. These were not captured in this research.

6.2.3. The model choice

The MNL model limitations The MNL model is the simplest form of discrete choice modelling. This does not automatically mean that it represents the data best. MNL assumes heterogeneity in tastes and preferences. If an ML model was used, it could have been tested if there is variance in taste and preference within the sample. Moreover, this model would also have allowed for a pairwise comparison of the nested alternatives for the choice share prediction, which is now not possible.

Latent classes There is reason to assume that there are latent classes in the data set, as the basic data segregation performed in this research revealed that some parameters are only significant for certain sub sections. It would be interesting to fit the data to other model types to get the most out of the dataset. Ultimately, a latent class analysis was not performed in this research due to time constraints and the extensive nature of the research scope.

Regret minimization The ASC outcomes for parcel delivery, and the delivery method outcome for meal delivery were both in favour of existing delivery services. The ASC value of the home delivery type was highest, and the 'delivery person' delivery method was valued highest for meal delivery. This might be due to the familiarity with these delivery means, which leads to a higher appreciation as people might not want to take the risk of trying a new delivery type. Random regret theory, which focusses on the minimization of regret, in stead of the maximization of utility (as is the cast with the RUM model used in this research) might lead to a better model fit, and therewith a better representation of the data.

6.2.4. Simplifications and limitations of this research

Nesting of choice alternatives Due to the exploratory nature of this research, its scope was quite broad. Firstly, four delivery innovations needed to be taken into the research. Secondly, due to the fact that there was no prior research of this nature on the subject of delivery choice making, a relatively large number of attributes was taken into the survey design. This makes the choice task more straining on the respondent, possibly deceasing the data quality.

Alternative specific constants The parcel delivery model used three nested alternatives to represent a total of six delivery services. The choice options were labelled due to alternative specific attributes, and this lead to the incorporation of alternative specific constants which represent the value of a choice alternative if all attribute values are zero. Thus this variable represents the value respondents assign to choice alternatives which does not stem from the attributes which represent the alternative. For the nested alternatives, such as home delivery, one ASC was determined. This means that 'traditional home delivery', ' small scale courier', and 'small curbside delivery vehicle' all have the same 'default value'. This is unlikely due to the vast differences between the delivery services.

Sample size A total of 474 respondents participated in the survey (after filtering out the speeders). This is a respectable amount of respondents, however, this dataset needed to be split into parcel delivery data and meal delivery data. Moreover, to determine consumer group differences, the sample was split in much smaller bins. Generally, the more respondents, the higher the chances are of reaching parameter significance. In other words: for some of the sub groups, certain parameters might turn out to be significant when more data is available.

Determining differences between consumer groups In this research, the dataset was split into sub sets based on age and responses to a question regarding sustainability (to determine the green group). However, there are more advanced (and more complex) ways to determine the differences between consumer groups. This method involves adding personal characteristics to the utility function and would have allowed to distinguish more characteristics than just age and green group.

6.3. Recommendations

6.3.1. Science

Apply more advanced models to data It is recommended to apply more advanced models such as the ML model, Panel MNL, latent class,or even a whole different approach like Regret Minimization to the data, in order to see if the model fit improves. This can increase the accuracy of the model.

No nested alternatives If possible, it would be of great value to perform the survey again, but then for four non-nested choice alternatives for parcel delivery. This way, the ASC can be determined per delivery innovation, leading to more accurate insights.

Compare model prediction to known statistics In order to determine the model accuracy, the model predictions should be compared to statistics of current LSP's. This should be done with a choice share prediction for the existing delivery methods like home delivery and parcel point.

Qualitative research into drone bias The drone delivery was quite consistently ranked lowest based on the ASC for parcel delivery, and 'delivery method' parameter outcomes for meal delivery. More research is needed to determine where this negative bias comes from, and how this can be tackled.

Sustainability importance over time The sustainability parameter was significant for certain consumer groups. This parameter might be very relevant on the long haul, and it would be very interesting to see how the value of this parameter changes over time. If this part of the research is conducted periodically, it is possible to see to which extent the importance of this attributes grows.

Different data samples The target group for the data collection were respondents living in urban areas. This was done because delivery innovations are likely to be implemented in the higher density urban areas. However, as some delivery innovations (like drone) have also potential for deliveries outside of the city, it would be interesting to see how the parameter outcomes differ when a sample is taken among rural respondents.

6.3.2. Real world testing

Feasibility study A feasibility study should be done in cooperation with restaurants or LSP's in order to determine which market propositions are feasible. This research focuses on consumer choice making, and market share predictions. Ultimately, it is up to the LSP or restaurant to determine which proposition is financially feasible. It is recommended to perform such a study using the choice model together with the insights of the LSP or restaurant.

Interaction with delivery machines The interaction variable was not significant in this research, However, it can be expected that this might change when the interaction between the delivery machine and the consumer is more clearly defined. Therefore, real world testing, and the development of this interaction should be performed. Its goal should be to design this interaction as conveniently as possible for the consumer. Only this way is it possible to pinpoint the consumer value of the delivery interaction.

A

APPENDIX:STATE OF THE ART

A.1. Current delivery options

Table A.1: Customers e-tail shipping options

Company	Delivery service	Cost
Bol.com[6]	- Single shipment	Free (<€20 purchase), else €2.49
	- Evening delivery	€0.99 supplement
	- Sunday delivery	€1.99 supplement
	- Same day delivery/collection	€2.49 supplement
	- Install large home appliences	€14.99 supplement
	- Install televisions exceeding 43"	€29.99 supplement
Wehkamp[11]	Home delivery:	
	- Order before 23:00	
	- Next day delivery	
	- Choice morning/afternoon/evening	
		Free (<€20 purchase) else €2,95
	DHL collection point:	
	- Order before 23:00	
	- Collect from 14:30 (within 7 days)	
	- SMS or email notification	
Zalando[12]	- Standard shipment (2-4 workdays)	Free
	- DHL express shipment (next day)	€9.99
	- PostNL pick-up point (within 14 days)	Free
Coolblue[7]	- Standard shipping (next day, incl. Sundays)	Free
	- Timed delivery (2 hour windows)	€9.95
	- Same day (order before 3 pm)	€9.95
	- Evening delivery (6-9.30 pm)	Free
	- In store collection	Free
	- PostNL pickup point (within 14 days)	Free
Amazon[4]	- Standard delivery (2-3 workdays, small items)	Free
	- Standard delivery (2-3 workdays, others)	€3.99 + €0.50 per kg (<€29 purchase), else free
	- 2 Day delivery	€7.00 + €0.60 per kg
	- Next day delivery	€11.00 + €3.00 per kg
Albert Heijn[1]	Home delivery	Cost:
	- At least €70 worth of produce	Depending on time window €3.95-€12.95
	- Time windows of 2 hours	Under purchase €100, €1 extra service charge
	- 'Green' time windows of 4-5 hours	Bonus offers that waive the delivery fee
Van Dijk[10]	Standard delivery (within 5 workdays)	Free (for subsidised books)
		€2.95 (1-3 items)
		€5.25 (4-10 items)
		€7.50 (11 items)
H&M[3]	- Standard delivery (2-3 days)	€4.99
	- Next day delivery	€6.99
	- UPS access point (2-3 days)	€4.99
	- Next day UPS access point	€6.99
Media Markt[8]	Home delivery	
	- Order before 22.30	€1.99 (<€20 purchase), else free
	- Next day delivery (excl. Sundays, holidays)	
Blokker Holding[5]	- Standard delivery (before 10 pm, next day)	€3.99 (<€25 purchase), else free
	- In-shop delivery	Free
	- Big/heavy items	€9.99 (plus-sized items), €30 (heavy items)

A.2. Literature study

A.2.1. Literature review

This section dives into the current state of (scientific) research on this topic. Any findings useful for this research will be used, and everything that is still unknown in relation to this research is seen as a knowledge gap. These gaps - in turn- can be used to answer this thesis' main and sub questions by solving them.

Problems associated with last-mile logistics Morganti et al.[27] find that home delivery services lead to atomization of parcel flows thus causing problems in urban areas. Furthermore, they state that home delivery – the most preferred option - constitutes the most problematic delivery method in terms of operational cost and planning. The last mile requires relatively complex planning and a lot of vehicles – which translates into high loan costs. Due to the relatively large number of addresses that one delivery van must visit, the load factor is generally quite low.

Cardenas et al.[14] have found that the average cost of the negative externalities per parcel is between €0.26 and €0.37 per parcel in Belgium. The majority of which takes place in dense urban areas. However, the highest cost per parcel (€0.37) is in rural areas due to the low density, and thus longer trips. Not only does the last mile contribute immensely to the total trip kilometres of a delivery, it also causes congestion, accidents, air pollution, noise pollution and climate change according to Cardenas et al. These problems are all societal.

Figure A.1: External cost per parcel. Cardenas, I. et al. 2017. [14]

	Average cost per parcel (Euro/parcel)	Share of total costs
Urban	0.26	50.07%
Semi-urban	0.33	20.39%
Rural	0.37	29.54%

Consumer preferences In their 2008 paper, Xu et al.[30] confirm that e-shoppers experience a high degree of inconvenience. The 'not at home problem' is one of the major contributors. A large percentage (43%) experienced re-arranging the failed delivery as inconvenient. Xu et al.[30] have found that home delivery was the preferred delivery method for the majority of respondents. Making time to be at home for the delivery was a problem for 53%. Moreover, respondents indicated their willingness to pick up their parcel from a local collection point if it is within reasonable distance from their house. Interestingly, the respondents indicated that they would be more likely to buy at a webshop if there offer more delivery options. Last, Xu remarks that most working families prefer off-office hours or weekend deliveries. This poses challenges for the LSP because of the uneven demand curve.

Morganti et al.[27] have found – in their own literature review – that 39% of the e-consumers have experienced problems with online shopping. Problems mentioned are: not being at home, delay in delivery, too high delivery cost, no tracking, and having to go to a distant collection point.

Lemke et al. [21] researched the usability of parcel lockers from a consumer perspective. The research was conducted in Poland. The three criteria rated most important when choosing parcel locker services are price, speed and 24/7 availability.

The European Commission[15] mapped the consumer trust in environmental claims when purchasing online. They reported in 2016 that the perceived reliability of environmental claims in the Netherlands is 48.8%, with the highest trust being amongst the age group 18-35. The percentage of respondents indicating that environmental impact actually plays a role in their decision in online shopping is 55.2%. This means that more than half of the e-shoppers in the Netherlands takes the environmental impact of their purchase into perspective when buying online. The highest indicated impact is amongst respondents in the age group 35-54 with a high education and high income.

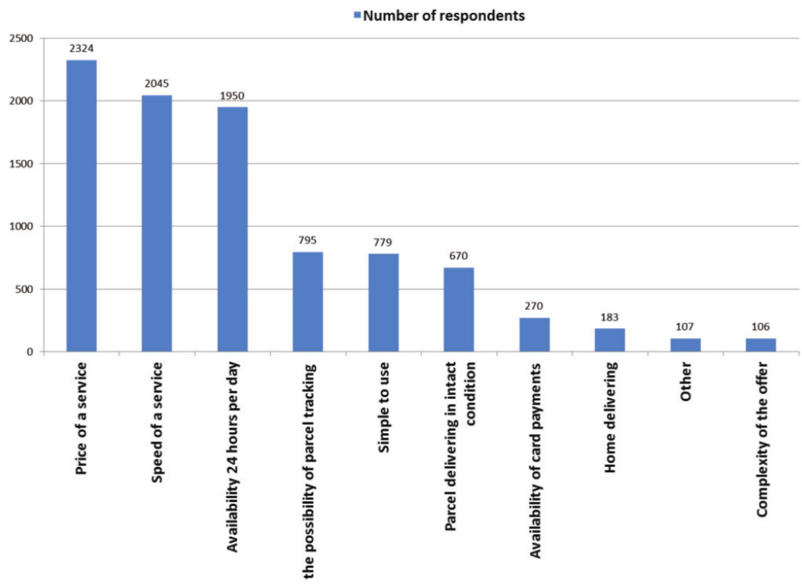
Innovation and the implementation of new last-mile solutions According to Xu et al.[30], the usage of local collection points is preferred by both e-tailers and e-shoppers. Also, Xu claims that reviewing current delivery practice in the face of changing consumer behaviour and emerging technology for improvement is key.

Figure A.2: Consumers' perception on delivery isses, Xu, M. 2008 [30]

		Paired sample t-test (t value, df = 124)			
Items	*Mean†*	*A*	*B*	*C*	*D*
A. I believe there is a need for online delivery tracking, with hourly accurate delivery information.	4.20				
B. Willing to collect the item from a local convenient collection point within a reasonable distance of my house.	3.57	–4.581*			
C. I am more likely to buy a product from a store that offers more delivery options.	3.54	–5.405*	0.299		
D. I would like to be offered the chance to leave a safe box on my premises that the goods could be delivered to.	2.43	–11.898*	9.394*	8.048*	
E. Current delivery processes are satisfactory to me.	2.42	–12.714*	–10.996*	–9.461*	–0.134

Notes: †1–5 Scale, 1 – Strongly disagree, 5 – Strongly agree; * $P < 0.01$.

Figure A.3: Criteria for choosing parcel locker service. Lemke, J., et al. 2016.



As solutions for the complex problems in home delivery, Morganti et al. [27] discuss a few innovative solutions. Both solutions require the recipient to collect their parcel outside of their home. The first solution is automated parcel stations, which is basically a pick-up locker. The second solution is a pick-up point, as we know it today in the form of a PostNL point or its equivalent. They state that, while not being the preferred delivery choice for customers, parcel lockers and pick-up point have the benefit of being lower in operational cost for the LSP, enable the optimization of delivery rounds, and increase the number of successful first-time deliveries.

Lemke et al. [21] found that between 39.44% and 42% of all parcel locker users are between the age of 25 and 35. This hints at the possibility that millennials are tended to use new delivery solutions more than the older generations. Moreover, lower shipping cost and better location are mentioned as two of the main criteria to consider a more frequent use of parcel lockers. Interestingly, a 88% correlation was found between using IT on a regular basis and using parcel lockers.

A.2.2. Trends

As stated in the problem definition, e-commerce demand is ever growing. Every year, more people are purchasing consumer products online. In the first half year of 2017, the growth of the number of online purchases in the Netherlands was 15% according to market research performed by GfK[17]. The online expenditure grew by 14%. The total online retail growth in 2017 is expected to be 13% in terms of transactions, and 12% in terms of expenditure. This steep growth is expected to continue. The Economic Bureau of ING bank[18] reports that e-commerce will represent 25% of the total retail market in 2025 as opposed to 12.5% in 2016.

According to an article authored by Walter Ploos van Amstel [28], who is a well known Dutch expert in the field of city logistics, there are 10 important and major trends in the logistics business right now. The full list can be found in the appendix. The most interesting and relevant trends are discussed in this paragraph.

Because of service companies adapting to the will of the consumer, there is an**increase in delivery services**: same day, different time windows, alternative locations, parcel lockers and more. Moreover, consumers want real time information on their parcel. To keep the operational cost balanced, companies are forced to look at the delivery operational cost on consumer level. Which customers bring in money, and which do not? This way, companies can offer alternative delivery networks for cluster of customers to **optimize their revenue**. They might even use dynamic pricing as an revenue management tool. **Automation** will be key in the supply chain. Self driving vehicles will follow the postmen. Moreover, **unmanned deliveries** by robots and drones will play a role in the future. **Protected environmental zones in inner-cities** force delivery companies to invest in zero-emission vehicles. This is a push for cleaner vehicles. With the e-mobility trend in inner cities, in part because of the aforementioned protected zones, comes an **increase in zero-emission vehicles**. These may also come in the form of e-bikes, or co-modality transportation of goods by trams or over water. Right now, the focus in transport planning is on minimizing the vehicle mileage. However, most of the time and cost lies in finding a parking place for the delivery vans. With **new planning systems, more advanced information** like real-time parking vacancy will play a central role. To tend to the needs of consumers' same day delivery demands, a **growing number of urban distribution centres** is being developed. This enables delivery company to deliver goods even more quickly. City hubs and micro hubs are playing an increasing role in the transition of slow transportation on large geographical scale to personal transportation on a small scale. **Visualization and tracking** is of increasing importance. Data that can proof the delivery of a parcel, and tracking information are of great importance when the delivery goes wrong. Heavy trucks and delivery vans are involved with a large share of traffic accidents. This leads to an incentive to invest in **safer vehicles** and to improve infrastructure and safety measures. Lastly, social innovation is key in city logistics innovation. On a strategic level, delivery companies need to work together (with local delivery parties) to be able to offer more costumer centred delivery solutions.

Overall, a growth in delivery demand, delivery options and a call for safer and more sustainable solutions and the role of automation are the key takeaways from the trend analysis. From the consumer perspective, the delivery options are most relevant. From a societal perspective, the safety and sustainability increase are most important. And for the LSP, the search for more profitable delivery services is the most urgent and relevant.

A.2.3. Problems

In this section, the current problems in last mile logistics are identified. These problems give insights into the requirements and capabilities of the innovations that could solve them.

Delayed delivery: Delays are a common problem within the delivery process of on-line purchases. The reason behind the phenomenon can range from simple things as congestion on the road to complex issues like misplaced parcels at consolidation centres. On behalf of the European Commission, a research on consumer attitude towards parcel delivery was conducted. The study found that just under a third (30%)[29] of al respondents in the 2012 survey have experienced a delay in the delivery of a product. This is a steep increase from the 20%[29] reported in 2011. In the Netherlands, the percentage of people with on-line purchase experience that have experienced a delay in the delivery process is 34%[29].

Not at home problem: The not at home problem occurs when a package is delivered but cannot be received due to the absence of the recipient. This is a big problem from the logistics providers' point of view due to the fact that it is costly to need multiple delivery attempts. Allen et al.[13] states that retailers and carriers have lost £771 million in 2014 due to the not at home problem. From the consumer perspective this problem leads to dissatisfaction and inconvenience. The delivery takes longer and the consumer may need to be at home yet another day. According to research at the University of Portsmouth[30], some consumers even perceive on-line shopping as taking longer than traditional shopping due to delays or failed delivery. They concluded that inconveniences by current delivery options undermine the convenience of on-line shopping. This problem also may limit e-commerce growth.

Uneven time slots: One of the problems also stated in the research by the University of Portsmouth[30] is the uneven timeslot demand problem. When looking at consumer preference for timed delivery, the majority of people will prefer between 6 pm and 8 pm Thursday through Sunday. This distribution is challenging from a logistics company perspective due to the fleet requirements to cover the peak moments, and the idle capacity at off-peak moments.

Negative externalities: The University of Antwerp[14] looked into the external cost of parcel delivery in Belgium. They concluded that the majority of negative externalities are taking place in dense urban areas. More specifically, in the last mile that contributes on average a whopping 83.6% of the 'vehicle kilometres travelled' in a tour. To calculate the external costs they looked into several types of negative externalities: congestion, accidents, air pollution, noise and climate change. The external cost per parcel (€/parcel) differed per morphology: urban, semi-urban and rural. As displayed in figure **??** this resulted in an average cost of €0.26 per parcel in urban areas, €0.33 per parcel for semi-urban areas and €0.37 per parcel for rural areas. Due to the higher demand, the share of total cost is highest in urban areas.

High delivery costs: Delivery costs are an important factor in on-line purchasing. Consumers prefer home deliveries at low prices. The Eurobarometer report found that 7%[29] of on-line consumers have experienced a price that was too high. Fortunately for consumers, most of the bigger on-line retailers offer free standard delivery. This is in part due to their strong negotiation positions. A report from the Autoriteit Consument & Markt (ACM) states that large retailers benefit hugely from their leverage over logistics companies, being able to negotiate steep discounts on delivery tariffs[25]. Moreover, these huge retailers also get better service than smaller businesses. This leads to another problem: a weaker position for small businesses in the on-line retail market.

Growth of demand: Ever growing e-commerce implies a growth in goods delivery demand. The factors that stimulate growth identified in the UK are: older people becoming more regular on-line shoppers, young people using it for the majority of purchases, closure of physical shops that are unable to compete, growth of on-line grocery shopping and the increasing use of smart phones[13]. E-commerce growth potentially amplifies all aforementioned problems.

Peak pressure: Retailers are focussed on sales peaks during the holidays or special occasions. Christmas shopping is a prime example of this phenomenon. Logistic companies face great challenges because of the huge capacity demand in these peak periods.

Overcapacity in the sector: The Royal Mail in the UK has estimated that there is around 20% of spare space capacity in the market[13]. New platforms such as Uber, or Picnic may increase this capacity surplus.

Impact of 'free' deliveries: Many retailers offer free delivery as a service to stay competitive in the on-line market. For the service provider however, this means that there is a great demand for low pricing models from retailers. This decreases the profit margin of the delivery service and increases the need for operational cost reduction.

Managing product returns: Product returns in the on-line retail business are much more common. Around 20-30% of purchases in the clothing and footwear category is returned according to a paper by J. Allen et al.[13]. Estimates are that between 50-75% of the returns is paid for by the retailer instead of the customer.

Traffic conditions: Finding suitable curb space to park delivery vehicles is increasingly difficult to find due to the rise in traffic, posing a greater challenge in on-time delivery. In the city of London, the average traffic speeds had declined by 2-9%, and the average vehicle delay has increased by 17-31%[13]. This development impacts retailers and customers.

Overall, there are a lot of problems with current delivery systems that stem from a combination of high peak hour demands, shorter planning, homogeneous delivery moment preferences, disruption of the delivery price perception for consumers due to big webshops offering free deliveries, and high operational cost for re-tries of failed deliveries. There are obviously may ways to deal with these problems. Delivery innovations are not exclusively capable of solving them, but do have the potential to solve parts of these problems.

Conclusion In general, most research is conducted on the topic of societal impact of LMGD, or the growing demands for parcel delivery. Moreover, several papers conclude that a shift towards pick-up points would in the end benefit consumer and LSP. These papers all imply that innovation is necessary to make tend to consumer needs and to make the LMGD market more sustainable. Unfortunately, there is currently no research on the topic of the trade-off's consumers make when choosing a delivery service of which the author is aware. This leaves opportunities for new findings, but at the same time leaves a lot up to assumption.
The problem owners are also included in the figure by means of colour coding. Green represents consumers, blue represents society, and orange represents the LSP's. Knowing who owns the problem provides information on which stakeholders can undertake action, or would benefit from these developments. For example, solving consumer inconveniences is beneficial for webshops, solving societal problems is beneficial for government entities and solving LSP problems is - of course - beneficial for the LSP.

A.3. Delivery innovations

A.3.1. Self driving parcel locker

Concept description The self driving parcel locker (SDPL) is a concept of PostNL. The SDPL is, simply put, a parcel locker that can drive itself. Currently, the delivery service which most resembles this concept would be the unmanned parcel lockers at several train stations in the Netherlands. A parcel locker holds parcels at one central place, and offers the consumer the flexibility to collect their parcel at any convenient time. Just as with a pick-up point like the current PostNL locations, parcel lockers enable a great amount of consolidation in distribution centres, increasing the load factor of delivery vehicles and decreasing external negative cost. There is no chance of a "not at home problem" occurring, and the delivery van which brings the parcels to the pick-up point can have a much higher load factor than average. The "self driving" aspect of the SPDL implies that this locker can either position itself according to the most favourable location for the consumers in that area, or may imply that the locker drives itself from a distribution point to the pick-up location itself. This may happen at night, to release the road from high traffic pressure at peak hours. A disadvantage is that this locker would have to serve multiple consumer in one area at once, so it is most likely that one has to walk a bit to reach the parcel locker. This concept can be seen as a PostNL pick up point with variable location.

Logistics The self driving parcel locker has the high consolidation characteristic of the current pick-up point delivery service, and also rids the not at home problem. Reason not to opt for a pick-up point may be the distance from a consumers home to the pick-up location, and its limited opening hours. The SDPL improves over the traditional pick-up point by being able to decrease the distance from the consumers' home to the SDPL because of its ability to move around, while also offering 24/7 opening hours for the consumer to pick up their parcel. From an LSP perspective, this innovation has a large potential to reduce delivery cost, without causing too much inconvenience to the consumer. There are a few scenarios in which the logistics of this concept may work. Firstly, the SDPL may be supplied with parcels by a traditional delivery van. This can be done any number of times a day. The SDPL can reposition itself based on the geographical centre of the customers' location of residence. Another scenario is that the vehicle can drive itself from an urban consolidation centre to the relevant location. In this case, the SDPL would preferably drive at night time, to not disturb the normal traffic flows. A challenge for this type of delivery system would be to determine the best location(s) to idle. These locations may be fixed points in an area, or it may park at any available parking space. This innovation is designed exclusively for parcel delivery, and its functional characteristics do not make it a suited means to delivery meals. Overall, this concept has the potential to reduce operational cost for the LSP, while still tending to the needs of the consumer.

A.3.2. Small Curbside Delivery Vehicle

Concept description This concept is a small curbside bound vehicle (SCDV) built for urban last mile goods delivery. It was developed by Starship Technologies. This vehicle can delivery products to your doorstep. In terms of operational speed, this delivery robot travels at the pace of an average pedestrian. It is only suitable for deliveries for which the last mile is very short. Urban deliveries are therefore most suited for this vehicle. Its compartment can contain one parcel at the time due to space constraint. This vehicle will most likely operate on a point to point basis. It can be controlled from a distance and should be able to operate autonomously in the future.

Logistics The small delivery robot developed by starship is - as its name implies - restricted to a certain type of infrastructure. In this case it is the curbside. The vehicle is designed to share infrastructure with pedestrians. From a operational point of view, the SCDV is only suitable for relatively short distances, due to range (most relevant for parcel delivery) and speed (most relevant for meal delivery) constraints. For the transportation of parcels, this vehicle goes against a fundamental principal in logistics: a high consolidation of freight flow (preferably) until the very last mile, for maximum efficiency. This is why the traditional vans are loaded as full as possible within the planning time frame. The SCDV has very limited capacity. In order to not violate the logistics principle of consolidation, this type of vehicle would be best utilized when paired with decentralized urban consolidation centres. Another option is to deploy the SCDV from a hive or mother ship of some sort, to keep the degree of parcel flow consolidation as high as possible, as long as possible. When being used for meal delivery, the SCDV seems to be very suited for delivering food in the (small) adjacent area of the restaurant. The small capacity and therewith point-to-point nature of the vehicle does not differ too much from the current delivery methods. A delivery bike or scooter does not carry more than a few deliveries at once. This means that the shift from traditional meal deliveries to delivery with SCDV is smaller in practical terms that its application in the parcel delivery field. An important aspect, and barrier, of this technology is the licensing and permits that need to be granted in order to be allowed to operate in a real-world environment in the Netherlands. This remains one of the most challenging aspects.

A.3.3. Drone delivery

Concept description This concept features a drone that is able to deliver directly to the consumers home. This can be done super quick and efficiently (in terms of routing). Moreover, this concept is perfectly suited for same hour delivery or last minute purchases. A noticeable downside of this concept may be radius and capacity, as the size of the drone used influences these characteristics. A variation on this concept is the drone that flies to a pick up point. This would require less infrastructure - ie.g. not a landing platform at each home, but one for a residential area - while still being able to quickly deliver goods.

Logistics Where the three aforementioned concepts are ground-bound, the drone delivery (DR) is air bound. This brings about a whole range of opportunities and challenges. In theory, drone can manoeuvre freely in the air and is not restricted to infrastructure, as is the case with the earth-bound roads and highways. This opens up the opportunity for much quicker point-to-point travel, as a drone can draw a straight route from the point of departure to the point of destination. On the other hand, a drone is severely limited in its capacity to carry weight. Therefore, a drone is not easily able to consolidate parcels - which, again, is a fundamental principle in freight logistics. Drones come in many forms and shapes, and therefore the application and operational characteristics can differ broadly. For the sake of adhering to the consolidation principle, drone deliveries would logically be performed short distance, requiring some sort of drone supporting urban distribution centre. This would allow for consolidation up until the last-mile. In reality, there are a lot of aspects still unknown, undefined or uncertain about the application of drones for goods delivery. In the Netherlands, especially in the vicinity of airports, no drones are allowed in the airspace. Moreover, the landing aspect of a drone needs to be designed and looked into. Maybe landing is not necessary, maybe it is. Maybe drones are allowed to fly over rooftops, which enable the earlier mentioned shorter routes for drones. However, it is also realistic to expect the drones to be restricted in their route choice due to safety and privacy reasons. Consumer value and consumer acceptance is also an still unknown aspect. In conclusion, there is still a lot to explore on the topic of drone deliveries. There is a lot of potential, and the technique does already exist. Simultaneously, there are still a lot of barriers to overcome. One of which is the focus of this research: consumer acceptance and value.

A.3.4. Small Scale Courier

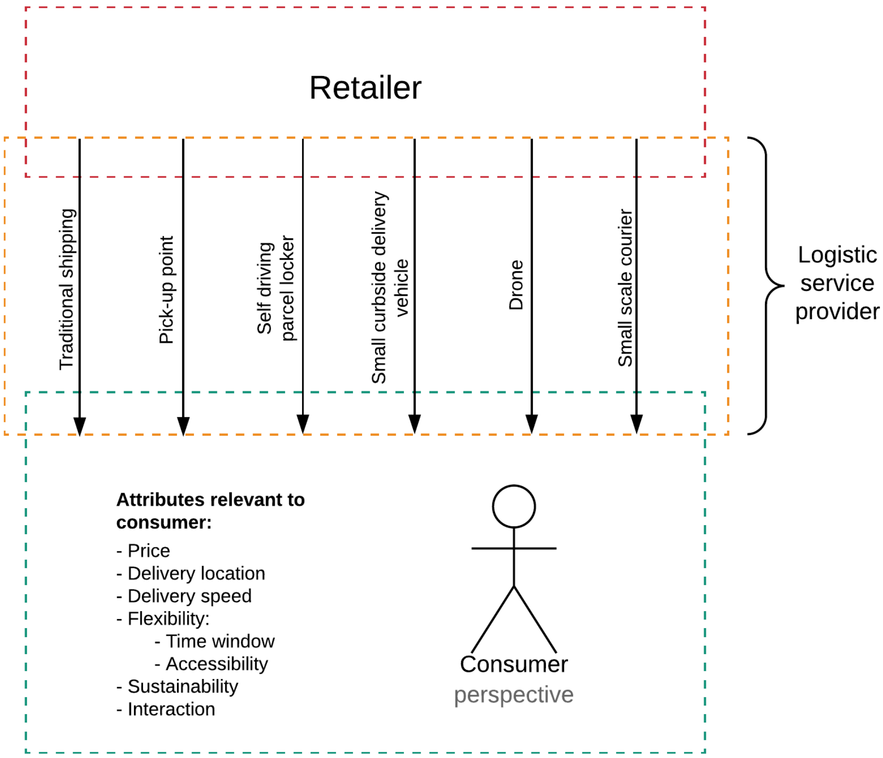
Concept description this concept is non-automated and involves humans. It is innovative and can be tailored to the needs of the consumers. This concepts involves on-demand (pedestrian or bicycle) couriers that can instantaneously pick up and deliver goods within a limited geographical area that is expected to be the size of one city. It may not be automated, but it does offer speedy, on demand and sustainable delivery.

Logistics The small scale courier (SSC) is a very different type of innovation. It is an on demand courier service which can move parcels or groceries or meals. The network of couriers is able to pick-up any product a consumer wishes to receive (within reason) and is able to delivery it within the hour. The service is relatively high cost, but it does offer very high speed. The potential of this delivery innovation in the parcel delivery market lies in its speed and flexibility. Small scale couriers can be used as a local and speedy way to delivery products. If a webshop has a physical store somewhere close by the consumer, it is able to offer its customer high speed deliveries of products to their homes. Another potential of the SSC is to reduce the seasonal peaks for large LSP's by pairing up with them to be able to manage the large demands. For meal delivery, it is interesting to see if there is a market for the SSC's, as they are able to pick-up meals also from restaurants that do not offer the delivery service themselves yet. From a logistical point of view, the SSC's form a network of couriers which operate point to point. Being able to delivery product directly from the store to the consumer prevents a parcel - containing the same very product - having to be transported from a distribution centre to a LSP collection and sorting hub, and from that hub to the consumer, making deliveries more efficient in the bigger picture.

A.4. Factors driving consumer delivery choices

In a market analysis performed by Barclays, the top-five priorities of consumers in the UK are: **cost, speed, flexibility, reputation and service** [22]. These findings - although not conclusive - indicate which factors may be of highest importance for the consumer when choosing a delivery service. Moreover, **home delivery**, keeps coming up as the preferred delivery location. McKinsey[20] reported in 2016 that consumers prefer home delivery to parcel lockers. In a survey with over 4700 participants, they found that only a price difference of €3.- would sway 50% of the shoppers to choose parcel lockers over home delivery. This indicates that the consumer prefers home delivery, but can be swayed towards parcel lockers if the monetary incentive is strong enough. Moreover, a thesis conducted at the university of Brussels[23] also states a strong preference for home delivery. In his thesis report a percentage of 76% prefers home delivery. According to a report by the European Commission[24], 83% of consumers prefer home delivery. Another important factor is a **flexible time window**. Consumers prefer flexible time windows, meaning that they can choose a smaller time frame for delivery[30], which requires them to be at home for a shorter period of time. In recent years the **environmental friendliness** of the purchase is of increasing importance for consumers. As the delivery part of a purchase can be viewed as an extension of the purchase, consumers may value this quality in parcel delivery equally. Although the majority of on-line consumers in the Netherlands in as 2012 survey[29] does not take this factor into account (48% does, 52% does not), there was a significant growth in the importance of environmental impact for consumers (8% growth between 2009 and 2012). In light of the developments in the Netherlands regarding awareness of the environmental impact of our daily life actions, it is worth it to also consider the ecological aspect of deliveries. **Transparency** is another important factor for consumers. Consumers expect more transparency regarding delays, damages or losses within the delivery process[16]. **Advanced information** is s way to offer this transparency. Consumers want more information on the delivery process e.g. new technological information sharing via smart phone or tablet[16]. Last but not least, consumers want **more delivery options.** [16]. This increases the probability that their preferred choice is available.

Figure A.4: Consumer perspective



B

APPENDIX: DESIGN OF THE STATED PREFERENCE SURVEYS

B.1. Stated Preference surveys& Discrete Choice Modelling

B.1.1. Stated Preference surveys

The basics In this paragraph, a few basic terms and definitions will be discussed in order to prevent any confusion. In a **survey**, respondents will be presented choice sets. A **choice set** is a set that contains choice options which are also known as alternatives. An **alternative** (choice option) has distinct values of independent variables (a.k.a. attributes). E.g., cost is €1.-, delivery speed is next day, flexibility is two hours. **Attributes** are independent variables such as cost, time and flexibility that describe the alternative. These attributes have a number different **attribute levels**. E.g. cost has two levels: €1.- and €2.-. Furthermore, it is important to maintain **attribute level balance**, which means that there should be a same number of observations for each attribute level.

Orthogonality In a stated choice experiment, the choice sets are presented to respondents in a survey. The goal is to know which choices are made by respondents, and which trade-off's are at play. Ideally, the influence of each individual attribute (variable: price, delivery time) on the utility of the alternative needs to be determined through a technique called **multivariate analysis**. However, when the **correlation** -strength and direction of a linear relationship between two variables- is too high, it is not possible to determine the effect (parameter) of each attribute reliably. This phenomenon is called **multicollinearity**. **Orthogonality** -as it is the opposite- is the solution to multicollinearity and is used to ensure zero correlation between choice alternatives. In other words: if the choice experiment is constructed orthogonally, the correlation between the attributes of the constructed alternatives is zero. These stated choice experiments may include attribute levels, attributes and **alternatives that not exist yet**.

Labelled vs Unlabelled When confronting a respondent with a choice set, the alternatives can be either labelled or unlabelled. With **labelled alternatives**, the labels represent attributes that are not varied but are associated with the alternative. E.g. if in a choice set, one alternative is an electric car, and the rest is gasoline, then the electric car label sets that alternative apart with its distinct feature. On the other hand, when using **unlabelled alternatives**, all alternatives have the same attributes and the only difference between alternatives is the attribute level.

Main and interaction effects The effect of the variation of one variable on the utility of an alternative is called the **main effect**. However, it might be that one attribute influences another attribute. This means that the variable is not fully independent. These phenomena are called **interaction effects** If interaction between variables occurs, the model will systematically over or underestimate (depending on the direction of the interaction) the model. Interaction effects can be taken into account in the UF of the model by adding a new parameter for the interaction effect. A UF that only captures main effects -cost and speed are independent- is shown in the following equation:

$$U_i = \beta_0 + \beta_1 * cost + \beta_2 * speed$$

The next equation will account for interaction effects by introducing parameter β_3 (price and speed are dependent):

$$U_i = \beta_0 + \beta_1 * cost + \beta_2 * speed + \beta_3 * cost * speed$$

Full factorial design If all possible combinations of attributes and attribute levels are taken into account in the stated choice experiment, this is called **full factorial**. L equals the number of levels and N the number of attributes with corresponding number of levels. The number of different alternatives equals:

$$Alternatives = L^N$$

For an choice experiment with 3 attributes with 2 levels plus 3 attributes with 4 levels, this equals 512 alternatives ($2^3 * 2^4$).

Fractional factorial design Due to the fact that the number of alternatives can become too large very easily with full factorial design, **fractional factorial design** is a suitable way in which the number of alternatives can be reduced drastically. This obvious advantage does however not come without a downside, as interaction effects cannot be estimated. There are two types of fractional factorial design to be distinguished: **orthogonal** -by splitting the choice experiment while maintaining attribute balance- and **efficient**, these methods will be discussed in a further paragraph.

Experimental design When constructing alternatives for the stated choice experiment, experimental designs are used to ensure there is no correlation between attributes which would prevent the ability to determine the main effects of each attribute. Basic plans are tables that can arrange a number of attributes which have a certain number of attribute levels. Each **row** represents an alternative, and a **column** represents and attribute. The values of the basic plan table dictate the level of the attribute that should be chosen in order to prevent correlation. In general, the **more attributes** (columns) taken into account, the **larger** the **basic plan** needs to be. In turn, a larger basic plan implicated **more alternatives** (rows), which leads to **more choice sets**. Illustrated in figure B.1, is the construction of 4 alternatives with 3 attributes that have 2 levels each.

Figure B.1: Constructing alternatives by means of experimental design

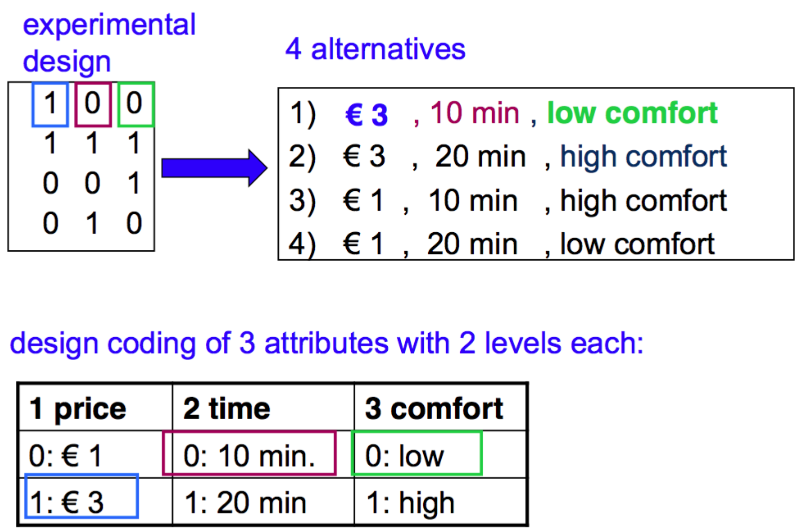


Figure B.2: Basic plans

BASIC PLAN 1: 4; 3; 2^7; 8 trials

*	*	1	2	3	4	5	6	7
0	0	0	0	0	0	0	0	0
0	0	0	0	0	1	1	1	1
1	1	0	1	1	0	0	1	1
1	1	0	1	1	1	1	0	0
2	2	1	0	1	0	1	0	1
2	2	1	0	1	1	0	1	0
3	0	1	1	0	0	1	1	0
3	0	1	1	0	1	0	0	1

BASIC PLAN 2: 3^4; 2^4; 9 trials

1	2	3	4	1	2	3	4
0	0	0	0	0	0	0	0
0	1	1	2	0	1	1	0
0	2	2	1	0	0	0	1
1	0	1	1	1	0	1	1
1	1	2	0	1	1	0	0
1	2	0	2	1	0	0	0
2	0	2	2	0	0	0	0
2	1	0	1	0	1	0	1
2	2	1	0	0	0	1	0

BASIC PLAN 3: 4^5; 3^5; 2^{15}; 16 trials

1	2	3	4	5	1	2	3	4	5	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1
*	*	*	*	*	*	*	*	*	*	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	1	2	3	0	1	1	2	1	0	0	0	0	1	1	0	1	1	1	0	1	1	1	0
0	2	2	3	1	0	2	2	1	1	0	0	0	1	0	1	1	0	1	1	1	0	0	1	1
0	3	3	1	2	0	1	1	1	2	0	0	0	1	1	0	1	1	0	0	1	1	1	0	1
1	0	1	1	1	1	0	1	1	1	0	1	1	0	0	0	0	1	1	0	1	1	0	1	1
1	1	0	3	2	1	1	0	1	2	0	1	1	0	1	1	0	0	0	1	1	0	1	0	1
1	2	3	2	0	1	2	1	2	0	0	1	1	1	0	1	1	1	0	1	0	1	0	0	0
1	3	2	0	3	1	1	2	0	1	0	1	1	1	1	0	1	0	1	0	0	0	1	1	0
2	0	2	2	2	2	0	2	2	2	1	0	1	0	0	0	1	0	1	1	0	1	1	0	1
2	1	3	0	1	2	1	1	0	1	1	0	1	0	1	1	1	1	0	0	0	0	0	1	1
2	2	0	1	3	2	2	0	1	1	1	0	1	1	0	1	0	0	0	0	1	1	1	1	0
2	3	1	3	0	2	1	1	1	0	1	0	1	1	1	0	0	1	1	1	1	0	0	0	0
3	0	3	3	3	1	0	1	1	1	1	1	0	0	0	0	1	1	0	1	1	0	1	1	0
3	1	2	1	0	1	1	2	1	0	1	1	0	0	1	1	1	0	1	0	1	1	0	0	0
3	2	1	0	2	1	2	1	0	2	1	1	0	1	0	1	0	1	1	0	0	0	1	0	1
3	3	0	2	1	1	1	0	2	1	1	1	0	1	1	0	0	0	0	1	0	1	0	1	1

1- 0 0 0 2- 0 0 0 3- 0 0 0 4- 1 1 1 5- 1 1 1
*- 1 2 3 *- 4 5 6 *- 7 8 9 *- 0 1 2 *- 3 4 5

Choice set construction: sequential vs simultaneous Constructing choice sets is all about how to place the constructed alternatives in a choice set. This can be done in two fashions: sequential and simultaneous. With **sequential** choice set construction, the alternatives are placed in two 'bins', and by drawing randomly, the choice sets are constructed. When drawing identical alternatives, both picks need to be placed back into the 'bins'. This process continues until both bins are empty. Sequential construction thus first constructs the alternatives, and draws random choice sets. A downside of this method is that correlation between alternatives is not taken into account. On the other hand, **simultaneous** construction constructs alternatives and choice sets at the very same time. The choice sets are accommodated in the basic plan. This guarantees zero correlation between alternatives. However, this method required at least double the number of columns (with a choice set containing two alternatives), and thus yields many more alternatives and therewith more choice sets.

Efficient designs The essence of efficient designs is to balance the utility of the option (alternatives) in the choice set. When two options in a choice set have an obvious difference in utility, the choice is easy to predict. E.g. If a respondent had to choose between service A which delivers their purchase the same day for €1,- and service B which delivers their purchase in 3 days for €5.-, the choice will be obviously service A. This phenomenon in which one alternative is obviously superior to the other is called **dominance**. When the utilities of the alternatives are estimated roughly, many choice sets can be eliminated because of their obvious outcomes. In order to estimate the utilities of the alternatives, so called **priors** are needed. Priors can be obtained by a small scale pilot survey or by means of literature study. In the end, efficient designs enable a more reliable estimation of parameters with a smaller number of choice sets.

Challenges for constructing stated choice experiments Because the quality of the outcomes of this data collection method and the outcomes of the DCM are highly dependent on the quality of the stated choice experiment, there are a few key challenges to consider. A stated choice experiment should be constructed which has sufficient variation in choice situations in order that the intended utility function can be estimated, in such a way that the estimated parameter are reliable. At the same time, the choice tasks should not exhaust the respondents, and the choice situations should resemble real world situations as much as possible.

Figure B.3: Stated choice experiment: variables

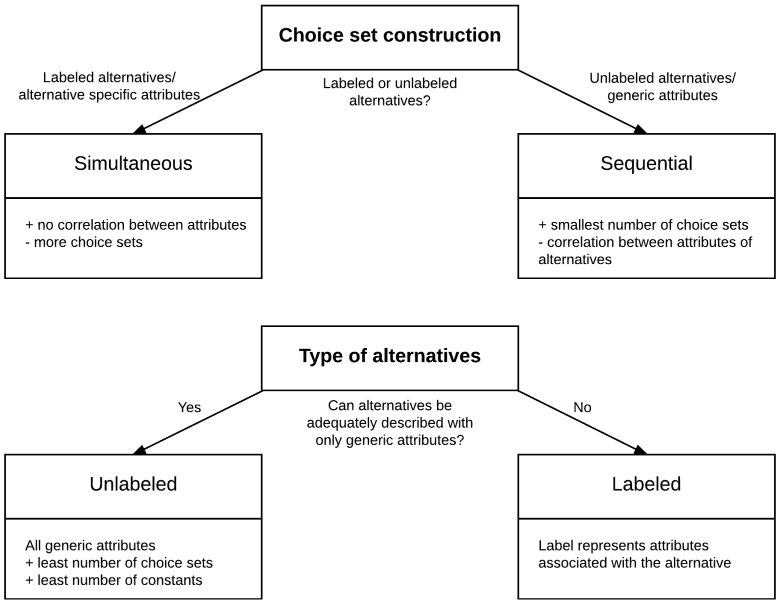
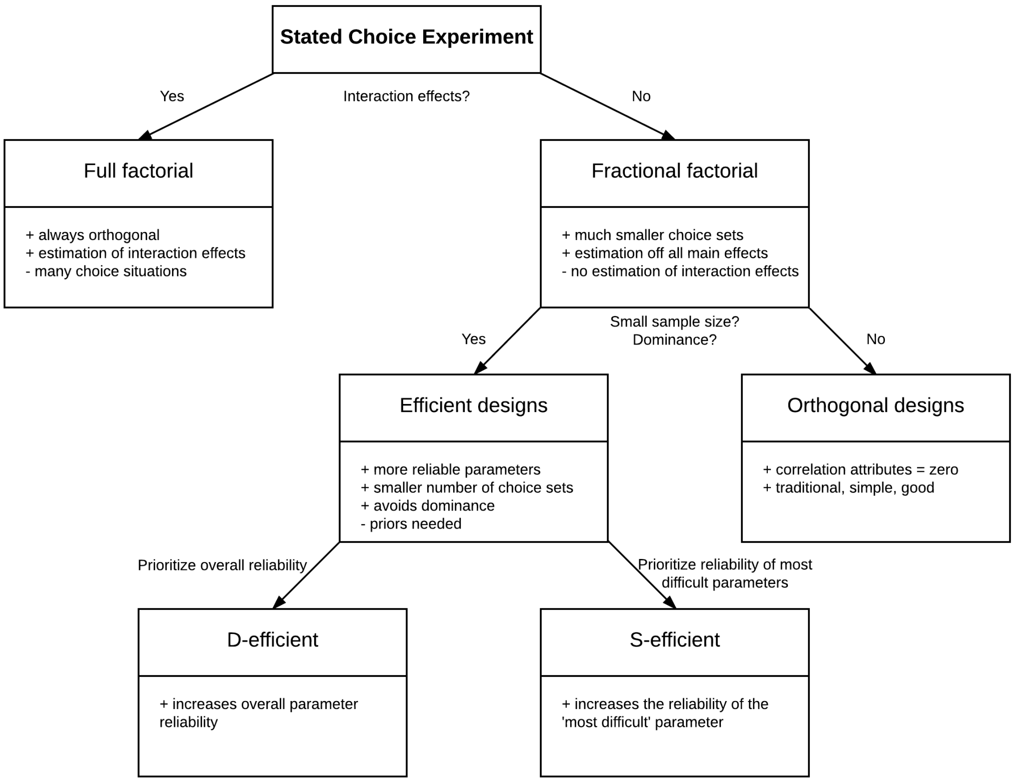


Figure B.4: Stated choice experiment types



B.1.2. Discrete choice modelling

Mixed Logit Model While the RUM and MNL models are relatively simple and can be a suitable and elegant choice in certain situations, there are models available to predict consumer choice that can capture more information. This paragraph discusses the Mixed Logit model (ML). The ML model takes into account preferences, whereas the MNL model does not. The inclusion of preferences is done by introducing a **new variable** (v_n) that takes the correlation between error components into account. The **utility function for the ML model** is mathematically formulated as follows:

$$U_i = v_i + v_{n,...} + \varepsilon_{i,...} = \sum_m (\beta_m * x_{im}) + v_{n,...} + \varepsilon_{i,...}$$

The new variable v_n follows normal distribution $N(0, \sigma_v)$. The upper bound of the normal distribution, σ_n, is the covariance between the error terms of two alternatives *(i,j)*.

$$\sigma_v = cov(U_{n,i}, U_{n,j})$$

The covariance between the error terms of two alternatives reflects the level if **variation in unobserved utility**. When the value of σ_v is high, then many people love it, and many people hate it. When σ_v equals zero, there is no covariance, and the model becomes a MNL model.

$$P(i) = \int_{v_{n,j}}^{\infty} \left(\left(\frac{e^{v_i}}{e^{v_i} + e^{v_j + v_n} + e^{v_j + v_n}} \right) * f(v_n) \right) dv_n$$

When implementing v_n in the utility function, one lets the attitude towards alternatives vary. In other words, the model lets **preference vary**. Another way in which the ML model can deal with covariance is by letting the attitudes towards attributes vary i.e. let the **tastes vary**. This is done by letting $\beta_{n,m}$ follow a normal distribution $N(\beta_m, \sigma_\beta)$. Again, if the mean of both the preference and taste equals zero, the ML model becomes a MNL model.

Random Regret Minimization Random regret minimization(RRM) is a relatively modern approach to choice modelling. This theory assumes that people do not make choices based on absolute utility, but rather on the difference in utility. e.g. A consumer does not care about absolute levels (travel time) but rather about relative levels (difference in travel time). When a attribute of alternative A performs better than that of alternative B, that constitutes rejoice. If it is the other way around, that constitutes regret. A further assumption is that regret weighs heavier than rejoice. In the end, the consumer strives to minimize its regret. The regret of an alternative i is captured in the **RRM model**:

$$R_i = \sum_{i \neq j} \sum_m ln(1 + \exp(\beta_m * (x_{jm} - x_{im})))$$

The **random regret** can be expressed as the regret (R_i) plus a random error term v_i.

$$RR_i = R_i + v_i = \sum_{i \neq j} \sum_m ln(1 + \exp(\beta_m * (x_{jm} - x_{im}))) + v_i$$

If the random error term is i.d.d., then v_i equals zero. The **choice probabilities** based on the regret function can be found by applying it in the MNL model. This gives the following equation:

$$P(i) = \frac{\exp(-R_i)}{\sum_{j=1...j} \exp(-R_j)}$$

B.1.3. Parcel delivery survey design

B.2. Parcel delivery survey design

B.2.1. Consolidation of alternatives parcel delivery

Table B.1 shows the similarities between the SDPL and pick-up point. This enables the joining of the two alternatives into one. All attributes stay the same and will be represented in the attribute ranges. The only new attribute is the interaction. This variable will now vary between human and machine.

Alternative 1: Parcel Pick-up

Table B.1: The SDPL and pick-up point are consolidated into one alternative: parcel pick-up

	Self driving parcel locker	**Pick-up point**	Attr. in UF?
Price	x	x	yes
Location	x	x	yes
Speed	x	x	yes
Window	n.a.	n.a.	no
Reliability	x	x	yes
Sustainability	x	x	yes
Accessibility	x	x	yes
Return option	x	x	yes
Interaction	Fixed (robot)	Fixed (human)	yes

Table B.2 illustrates that the SCDV, SSC and traditional home delivery service share the same attributes. Only interaction is fixed for all three. This attribute will vary between human and machine in the SCE. The three alternatives are consolidated into one: Home Delivery.
Alternative 2: Home Delivery

Table B.2: The SCDV, SSC and Traditional home delivery are consolidated into one alternative: home delivery

	Small curbside delivery vehicle	**Small scale courier**	**Traditional home delivery**	Attr. in UF?
Price	x	x	x	yes
Location	Fixed (home)	Fixed (home)	Fixed (home)	no
Speed	x	x	x	yes
Window	x	x	x	yes
Reliability	x	x	x	yes
Sustainability	x	x	x	yes
Accessibility	n.a.	n.a.	n.a.	no
Return option	x	x	x	yes
Interaction	Fixed (robot)	Fixed (human)	Fixed (human)	yes

The drone delivery alternative is left. This means that the total of alternatives is now three as opposed to 6 in the beginning. Three is a suitable number of alternatives in a choice set.
Alternative 3: Drone

Table B.3: The remaining alternative - drone - has very distinct features and stays a separate alternative

	Drone	Attr. in UF?
Price	x	yes
Location	x	yes
Speed	x	yes
Window	x	yes
Reliability	x	yes
Sustainability	x	yes
Accessibility	n.a.	no
Return option	x	yes
Interaction	Fixed (robot)	no

Table B.4: Alternatives food delivery

	Drone	**SCDV**	**SSC**	**Trad. delivery**	Attr. in UF?	Generic?
			Old attributes			
Price	x	x	x	x	yes	yes
Location	fixed (home)	fixed (home)	fixed (home)	fixed (home)	no	no
Speed	x	x	x	x	yes	yes
Window	n.a.	n.a.	n.a.	n.a.	no	no
Sustainability	x	x	x	x	yes	yes
Accessibility	n.a.	n.a.	n.a.	n.a.	no	no
Interaction	fixed (robot)	fixed (robot)	fixed (human)	fixed (human)	no	no
			New attributes			
Guarantee	x	x	x	x	yes	yes
Type	drone	SCDV	person	person	yes (if unlabelled)	yes

B.2.2. Attribute characteristics

In order to define the utility function for each of the alternatives, the characteristics of the attributes must be known. First, the attributes that apply for each alternative must be identified. Second, it must be known whether an attribute is alternative specific (does not apply to all alternatives) and if the expected ranges of the attributes are the same for all alternatives. If the latter is not the case, one attribute is split into multiple with their own coefficients. E.g. realistically, the price range for home delivery and drone delivery may differ. If so, the price attribute can be split into two - price(hd) and price(dr) - each with their own respective price ranges. Making this distinction is important as it introduces another coefficient (β).

Table B.5: Detailing the attributes (1)

<table>
<tr><th></th><th>Parcel pick-up</th><th>Home delivery</th><th>Drone</th><th>d.f.</th></tr>
<tr><td rowspan="2">Price</td><td>Alt. specific</td><td>Alt. specific</td><td>Alt. specific</td><td rowspan="2">3</td></tr>
<tr><td>Price(pl)</td><td>Price(hd)</td><td>Price(dr)</td></tr>
<tr><td rowspan="2">Location</td><td>Alt. specific</td><td rowspan="2">x</td><td>Alt. specific</td><td rowspan="2">2</td></tr>
<tr><td>Location(pl)</td><td>Location(dr)</td></tr>
<tr><td rowspan="2">Speed</td><td>Alt. specific</td><td>Alt. specific</td><td>Alt. specific</td><td rowspan="2">3</td></tr>
<tr><td>Speed(pl)</td><td>Speed(hd)</td><td>Speed(dr)</td></tr>
<tr><td rowspan="2">Window</td><td rowspan="2">x</td><td>Alt. specific</td><td>Alt. specific</td><td rowspan="2">2</td></tr>
<tr><td>Window(hd)</td><td>Window(dr)</td></tr>
<tr><td rowspan="2">Sustainability</td><td>Generic</td><td>Generic</td><td>Generic</td><td rowspan="2">1</td></tr>
<tr><td colspan="3">Sustainability</td></tr>
<tr><td rowspan="2">Accessibility</td><td>Alt. specific</td><td rowspan="2">x</td><td rowspan="2">x</td><td rowspan="2">1</td></tr>
<tr><td>Accessibility</td></tr>
<tr><td rowspan="2">Interaction</td><td>Alt. specific</td><td>Alt. specific</td><td rowspan="2">x</td><td rowspan="2">1</td></tr>
<tr><td colspan="2">Interaction</td></tr>
<tr><td>No. of attributes</td><td>6</td><td>5</td><td>5</td><td>13</td></tr>
</table>

Table B.5 shows the relation between attribute and alternative. An attribute can either be alternative specific or generic (indicated in the upper cell). In the lower cell, the name of the attribute as it will be used in the UF is presented. If the range of attribute value differs per alternative, the name will have a subscript - e.g. $price_{pp}$ that indicates that its range is unique.

B.2.3. Utility functions

The utility functions of all alternatives are provided below. These equations are used as direct input for the generation of experimental designs in Ngene in the next step.

Alternative 1: Parcel Locker

$$U_{pp} = ASC_{pp} + \beta_1 * price_{pp} + \beta_2 * location_{pp} + \beta_3 * speed_{pp} + \beta_5 * sustainability + \beta_6 * accessibility_{pp} + \varepsilon_{pp} \quad \text{(B.2.1)}$$

Alternative 2: Home Delivery

$$U_{hd} = \beta_9 * price_{hd} + \beta_{10} * speed_{hd} + \beta_{11} * window_{hd} + \beta_5 * sustainability + \beta_8 * interaction + \varepsilon_{hd} \quad \text{(B.2.2)}$$

Alternative 3: Drone

$$U_{dr} = \beta_{12} * price_{dr} + \beta_{13} * location_{dr} + \beta_{14} * speed_{dr} + \beta_{15} * window_{dr} + \beta_5 * sustainability + \varepsilon_{dr} \quad \text{(B.2.3)}$$

B.3. Meal delivery survey design

B.3.1. Attribute characteristics

Table B.4 shows the relationship between the alternatives and the attributes. As can be seen in table B.4, all attributes that are put into the UF are generic. This means that all alternatives can be represented in the SCE by the same set of attributes. Therefore, this stated preference survey will be generic and unlabelled to make it technically less complex.

B.3.2. Utility functions

The utility functions of all alternatives are provided below. These equations are used as direct input for the generation of experimental designs in Ngene in the next step.

Utility function 1

$$U_1 = \beta_1 * price + \beta_2 * speed + \beta_3 * guarantee + \beta_4 * sustainability + \beta_5 * type + \varepsilon_1 \quad \text{(B.3.1)}$$

Utility function 2

$$U_2 = \beta_1 * price + \beta_2 * speed + \beta_3 * guarantee + \beta_4 * sustainability + \beta_5 * type + \varepsilon_2 \quad \text{(B.3.2)}$$

B.4. Constructing the surveys

B.4.1. Pilot survey 1

Feedback A lot of helpful feedback was provided, which can be seen in the list below. In some cases, the survey was discussed verbally afterwards. The feedback collected from the pilot was split into three categories: general remarks that apply to both stated preference surveys, remarks that apply to the non-edible consumable or durable good delivery survey, and remarks that apply only to the take-away food delivery survey.

General feedback

- Provide a small intro text to explain the survey to respondents
- Change spelling for on-line to online and for web shop to webshop
- Look into the sustainability attribute as it is not clear to some respondents

Parcel delivery survey feedback

- Provide a purchase price, as this influences the willingness to pay
- Change name from non-consumable to non-edible consumable or durable

- Refer to further part that clarifies the attributes in the context description
- Correct time window to hours (now minutes)
- How do you imagine a non-home drone delivery with a time window of 1 hour? Do you need to wait outside?
- If speed is same hour, time window cannot be more than 1 hour
- The 'human-machine' notation is confusing. Rather use just 'human' or 'machine'
- Change accessibility into opening hours instead of the mere number of hours (10:00-18:00 instead of 8 hours)
- Adjust price range of drone alternative, the €15.- price is too high

Meal delivery survey feedback

- Change the phrasing choice situation to choice option
- Change price clarification part (copy pasted from survey 1)

General improvements Based on the feedback, some spelling was corrected to a more modern one. Second, an intro text in the context description will be provided in the final survey. Last, the sustainability attribute was changed from '0g or 500g CO2 emission' to 'green choice or non-green choice'. This new sustainability label is vague, and without definition apart from the fact the one is more sustainable than the other. However, from a marketing perspective this does make sense, because in a lot of cases labels are used to indicate sustainability, where many people do not know what it encompasses. AH also does this for their 'green' deliveries. They do not mention what the exact difference is, but they just state that it's greener.

Improvements parcel delivery survey This part shows all the improvements that were made to the survey design based on the feedback provided in the pilot study.

First, the name of the product type was changed to a more precise definition. The former 'non-consumable goods' are now called 'non-edible consumable or durable goods'. This definition, although more complex, does capture more accurately which category is meant.

Second, the context of the final survey includes a purchasing price of €60.-. According to internetkassa.nl [19], the average expenditure per online purchase is €63.- in the Netherlands in 2016.

Third, the price range of the delivery drone was altered from '0, 5, 10, 15' Euro to '0, 4, 8, 12' Euro to make it more realistic. The drone delivery should have a higher maximum price than the other alternatives, but €15.- was too high according to the respondents. Also, the accessibility attribute was made more realistic by changing its values from '24/7 or 12/7' to actual store opening times. The final attribute values are: 12:00-17:00, 09:00-18:00, 09:00-21:00, and 00:00-00:00.

Fourth, the Ngene code was adapter and made conditional to ensure that the unrealistic combination of 'same hour delivery' and a time window of more than one hour' cannot be in the choice sets any more.

Improvements meal delivery survey This part shows the improvements that were made to the survey design based on the feedback provided in the pilot study. Apart from the sustainability label change, not much else had to be adjusted for the take-away food delivery survey. Therefore, this paragraph is very short. The full final survey can be found in the appendix. As well as the correlations for this design.

B.4.2. Pilot survey 2

Feedback

During the execution of the pilot survey, some respondents provided feedback. The main takeaways are listed in this section:

- If the drone delivery speed is one hour, the delivery window cannot exceed one hour. At this moment, the combination of a one hour delivery and a time window larger than one hour occurs.

- Let the respondent rank the importance of the attributes beforehand. This will engage the respondent more, and reduces the change they might not pay attention to the instructions.

- Respondents are less prone to errors when the choice options are right underneath the corresponding column.

- People might interpret delivery time different than intended. When ordering at 18:00 - as instructed -, they might prefer a 60 minute delivery time if that particular respondent is used to eating at 19:00.

- When asking for the online purchase frequency, make bins, instead of letting the respondent fill in a number. This will make data analysis easier.

- It may be beneficial to explain shortly what an "early adopter" is. Some people might not be familiar with the term.

- Consider placing "sustainability" higher in the choice columns if you want to increase the chance of being able to estimate reliable parameters, as respondents tend to pay more attention to the first few attributes, or subconsciously assume that these are more important.

Improvements and changes over pilot surveys
This section provides an overview of the changes made to the final survey.

- An if-statement was incorporated in the coding of the PD survey in order to prevent the combination of delivery speed of one hour, and time window larger than one hour to occur;
- The instructions were changed in order to be more immersive for respondents. This may lead to a higher share of respondents reading the instructions;
- Screening questions were added in order to target a specific group of respondents;
- The instructions for the MD survey now state that one should assume that higher deliver speed is better;
- When asking for buying frequencies, bins are now used instead of integer values;
- Sustainability was moved up two rows in the PD survey to increase the chances of the attribute to be taken into account;
- All respondents were asked to rank the attributes in order of importance.

Prior values
Running the scripts, the parameter estimates for the PD and MD pilot surveys were obtained. The most important information was filtered and is presented in figures B.5 and B.6. The PD pilot has 9 significant parameters out of 29. Moreover, the PD pilot survey parameters are mostly of the expected sign (positive or negative)- meaning they turned out to be as expected. This also holds for the MD parameter estimates, which has 3 significant parameters out of 6.

Errors: parcel delivery pilot survey Unfortunately, the parameter estimates and their properties are not flawless. Both the PD and MD pilot surveys have values that need to be compensated due to errors in the design or data analysis.
The PD estimates give abnormally high standard errors for some parameters. This issue concerns the delivery location and the delivery speed for the Drone Delivery alternative. [DRL1, DRL2, DRL3], [DRS1, DRS2, DRS3]. The standard errors have values up to 1.8 to the power 308. This value signals correlations between these attributes, ultimately rendering the parameters values worthless. This phenomenon might have occurred due to designing the PD survey without effect-coding in Ngene - as this is not supported out of the box. Fortunately, the final survey will not face the same problem, as effect-coding is possible when programming an efficient design. Ultimately, the drone delivery speed parameters were corrected to [0,0,0] because there is no reference to estimate these values. The other speed attributes for the other alternatives have vastly different delivery speeds, thus cannot serve as reference. The drone delivery location parameter was corrected to [0.17,-0.17,-0.17]. This is based on the parameter estimate for the parcel pick-up location (PPL). The "pick-up point" attribute level has a utility of 0.17. Moreover, for the PP location attribute, "street" and "neighbourhood" are valued relatively similarly. Together with the assumption that delivery directly to the home would be preferred over "street" and "neighbourhood" led to the aforementioned values. The mathematical representation of the same reasoning can be seen in equation B.4.1 through B.4.6.

$$Home = DRL1 \tag{B.4.1}$$

$$Street = DRL2 \tag{B.4.2}$$

$$Neighbourhood = DRL3 \tag{B.4.3}$$

$$\begin{aligned} PickupPoint &= -DRL1 - DRL2 - DRL3 \\ &= 0.17 \end{aligned} \tag{B.4.4}$$

$$\begin{aligned} DRL1 &= 0.17, DRL2 \\ &= DRL3 \\ &= -0.17 \lor DRL1 \\ &= -0.17, DRL2 \\ &= DRL3 \\ &= 0 \end{aligned} \tag{B.4.5}$$

$$DRL1 = 0.17 \tag{B.4.6}$$

Figure B.6: Parameter estimates for the MD pilot survey

Parameter name	Parameter	Parameter estimate	Robust Std err	Robust t-test	p-value	Expected sign?
Delivery cost	β_DC	-0.892	0.111	-8.06	0.00*	Yes
Delivery Guarantee	β_DG	0.759	0.131	5.80	0.00*	Yes
Delivery Speed	β_DS	-0.0792	0.00823	-9.63	0.00*	Yes
Delivery sustainability	β_DSS	2.46e-17	9.14e+05	0.00	1.00	No
Delivery type I	β_DT1	0.0273	0.110	0.25	0.80	Unknown
Delivert type II	β_DT2	-0.187	0.109	-1.71	0.09	Unknown

Errors: meal delivery pilot survey During the data analysis, the sustainability parameter $\beta_D SS$ estimate for the MD survey returned a value very close to zero and a standard error value to the power 5. When tracing back the design steps, an error was indeed found. The sustainability parameter in the design was incorrectly translated into the choice tables. Resulting in equal attribute levels for sustainability in all of the choice sets, rending the model unable to determine trade-off's (i.e. either both are sustainable, or both are non-sustainable). The value for βDSS was corrected based on βSS from the PD survey. In order to do so, the βSS parameter from the PD survey needed to be scaled. Table B.6 illustrates how the corrected sustainability parameter for the MD survey was determined.

Table B.6: Scaling of sustainability parameter

Attribute range price PD	6
Attribute range price MD	3
$\beta price$ **PD**	-0.259
$\beta price$ **MD**	-0.892
Utility range PD	1.554
Utility range MD	2.676
Scaling factor	1.722
βSS **PD**	0.396
βSS **MD**	0.682

The sustainability parameter was scaled to the price parameters. The PD survey has attribute range [-2,0,2,4] with $\beta price$ equal to -0.259. The MD survey has attribute range [0,1,2,3] with $\beta price$ equal to -0.892. The utility range of the MD survey parameter was divided by that of the PD survey to obtain the scaling factor, which in turn is used to determine an appropriate value for the βSS parameter for the MD survey. The scaling factor is the ratio between utility ranges. The value for βSS is 0.682. Please note that the price parameter for the *parcel pick-up* alternative in the PD survey was used due to the fact that its price attribute range is most similar to that of the MD survey.

B.4.3. Construction steps

Final survey design When using a D-efficient design, the number of required choice sets can be calculated based on the number of degrees of freedom necessary to estimate all parameters. Equation B.4.7 shows how to acquire the minimum number of choice sets (S) based on the number of degrees of freedom (k) required and the number of alternatives in a choice set (j).

$$S = k/(j-1) \tag{B.4.7}$$

For the parcel delivery survey (PD), k is equal to 35 degrees of freedom (d.o.f.) and j equals 3, as there are three alternatives. This gives an S-value of 17.5. Preserving attribute level balance - ensuring that each attribute level is represented an equal amount of times in the survey - increases the number of choice sets for the PD survey to 20. (20 can be divided by 4, which is the largest number of attribute levels in the PD design). For the meal delivery survey (MD), S equals 10, as the required d.o.f. is 10, and there are two choices in each choice set. Accounting for attribute balance increases S to 12. Using a D-efficient design reduces the number of choice sets from 32 (PD) and 24 (MD) to 20 and 12.

The downside of using an efficient design is the requirement of prior values. These values act as a rough estimation of the parameters, and - simply put - allow for optimization. Priors can be obtained in a number of ways. One of which is prior research and literature. Unfortunately, due to the exploratory nature of this research, there is no known reference literature. This means that the prior values need to be estimated through a pilot survey. This was done in the previous section. After the pilot survey, the final survey was designed. The prior values that were obtained with the pilot survey were used to construct a d-efficient survey. Incremental changes to the survey took place based on the feedback from the pilot. Moreover, because the main data collection was performed by a professional company which specializes in panels, certain adaptations had to be made. This section will only discuss the changes made in the final design, and the differences with the pilot surveys in order not to repeat too much.

NGene

Table B.7: Choice set 1 of the PD survey

	Parcel pick-up	**Home delivery**	**Drone delivery**
Price	€2,-	€9,-	€8,-
Location	Street	Home	Home
Speed	Same evening	Same day	Within 4 hours
Time window	-	2 hours	1/4 hours
Accessibility	00:00-00:00	-	-
Sustainability	Non-green choice	Green choice	Non-green choice
Interaction	Machine	Machine	Machine

Survey format The PD and MD surveys consist or 32 and 24 choice sets. The surveys were split into two parts each, resulting in four surveys: PD1, PD2, MD1, MD2. By means of branching, it was possible to build just two surveys in the online platform. For every respondent, a branching step assigned either part 1 or part 2 of the survey. The split used was 50-50, which results in a coin toss each time the survey was filled out. This way, it is easier and more convenient to execute the survey, as one only have to manage the data collection of two surveys, as opposed to four.

Regarding form-giving, the tables were improved visually to make the content more easily readable. Some colour was introduced as well to make it visually more appealing. This lead to the format as shown in figure B.9.
The pilot surveys had the following characteristics:

- Available in English & Dutch;
- Compatible with desktop, mobile and tablet web browsers;
- Incorporate a split, allowing for an - nearly - equal number of respondents for part 1 and part 2 of each survey;
- Timed the respondents progress tight after completing the instructions, and right after completing the total survey.

Screening and profiling Besides the questions regarding age, area of residence, experience with delivery services, and purchasing frequency, respondents were asked to rank the attributes in order of importance. This was done to engage the respondent in thinking about the attribute meaning before starting the choice set questions. The outcomes of this question may also provide some insights into the type of respondent.

B.4.4. Ngene output final survey

Table B.8: D-efficient design ND survey

	Parcel pick-up						Home delivery					Drone delivery					
Choice set	**Price**	**Location**	**Speed**	**Sust**	**Access**	**Int**	**Price**	**Speed**	**Window**	**Sust**	**Int**	**Price**	**Locaction**	**Speed**	**Window**	**Sust**	**Block**
1	-2	3	3	1	0	0	9	3	3	0	1	8	0	2	1	0	1
2	4	0	3	0	3	0	0	3	2	1	1	8	0	3	3	0	1
3	2	1	1	1	3	1	6	2	0	0	0	4	0	0	2	1	2
4	0	2	1	1	0	1	6	3	1	0	0	4	1	0	3	1	2
5	0	3	2	0	2	1	0	3	0	1	1	12	0	0	2	1	1
6	0	0	1	0	1	0	0	2	3	1	1	4	0	1	0	0	2
7	2	3	3	0	1	1	3	2	1	1	0	8	2	0	0	0	1
8	4	3	1	0	3	0	0	1	1	1	1	0	3	2	3	1	1
9	-2	2	0	0	1	0	6	1	0	1	1	0	3	3	0	1	2
10	4	0	2	1	0	0	9	1	2	0	0	12	3	0	1	0	1
11	-2	1	0	1	0	0	3	2	1	0	1	0	1	2	0	1	1
12	4	2	0	0	0	1	6	2	3	1	0	4	2	1	2	1	2
13	2	1	1	0	2	0	9	0	0	0	1	0	2	3	1	1	2
14	-2	0	2	0	3	1	3	0	0	1	0	12	1	3	1	1	1
15	-2	1	3	0	2	1	0	1	2	1	0	4	3	1	3	0	2
16	4	1	2	1	1	1	6	3	3	1	0	12	1	3	2	0	2
17	2	2	3	1	2	0	9	3	1	0	1	12	3	2	2	0	2
18	0	0	0	1	2	1	9	1	3	0	0	0	2	2	3	1	1
19	2	3	0	1	1	1	3	3	2	0	0	8	1	1	1	0	1
20	0	2	2	1	3	0	3	2	2	0	1	8	2	1	0	0	2

Table B.9: The design for the final FD survey as provided by Ngene

	Alternative 1					Alternative 2				
Set	Price	Speed	Sust	Guar	Type	Price	Speed	Sust	Guar	Type
1	1	60	0	0	2	2	15	1	1	0
2	2	15	1	1	2	1	60	0	0	1
3	2	60	0	0	0	0	30	1	1	1
4	3	30	0	1	0	1	45	1	0	1
5	3	15	0	0	2	0	45	0	1	0
6	1	15	1	1	2	2	30	0	0	0
7	1	45	1	0	1	2	30	0	1	2
8	0	45	1	0	0	3	15	0	1	1
9	0	45	1	1	0	3	45	1	0	2
10	2	30	0	1	1	1	60	1	0	2
11	3	30	1	0	1	0	60	0	1	2
12	0	60	0	1	1	3	15	1	0	0

Figure B.5: Parameter estimates for the PD pilot survey

Alternative	Parameter name	Parameter	Parameter estimate	Robust Std err	Robust t-test	p-value	Expected sign?
Parcel pick-up	Delivery accessibility I	β_PPA1	-0.329	0.160	-2.05	0.04*	Yes
	Delivery accessibility II	β_PPA2	-0.265	0.152	-1.75	0.08	Yes
	Delivery accessibility III	β_PPA3	0.104	0.151	0.69	0.49	Yes
	Delivery cost	β_PPC	-0.259	0.0412	-6.27	0.00*	Yes
	Delivery location I	β_PPL1	0.0306	0.149	0.21	0.84	Yes
	Delivery location II	β_PPL2	0.0798	0.157	0.51	0.61	Yes
	Delivery location III	β_PPL3	-0.280	0.152	-1.84	0.07	Yes
	Delivery speed I	β_PPS1	0.280	0.156	1.80	0.07	Yes
	Delivery speed II	β_PPS2	0.346	0.163	2.12	0.03*	Yes
	Delivery speed III	β_PPS3	0.0881	0.160	0.55	0.58	Yes
Home delivery	Delivery cost	β_HDC	-0.223	0.0244	-9.13	0.00*	Yes
	Delivery speed I	β_HDS1	0.226	0.170	1.32	0.19	Yes
	Delivery speed II	β_HDS2	0.335	0.175	1.92	0.06	Yes
	Delivery speed III	β_HDS3	-0.289	0.166	-1.74	0.08	Yes
	Delivery window I	β_HDW1	1.17	0.161	7.23	0.00*	Yes
	Delivery window II	β_HDW2	-0.515	0.209	-2.46	0.01*	No
	Delivery window III	β_HDW3	-0.816	0.225	-3.63	0.00*	No
Drone delivery	Delivery cost	β_DRC	-0.261	0.0262	-9.98	0.00*	Yes
	Delivery location I	β_DRL1	-0.340	1.80e+308	0.00	1.00	Unknown
	Delivery location II	β_DRL2	0.180	1.83e+03	0.00	1.00	Unknown
	Delivery location III	β_DRL3	0.240	1.53e+03	0.00	1.00	Unknown
	Delivery speed I	β_DRS1	1.23	1.50e+03	0.00	1.00	Unknown
	Delivery speed II	β_DRS2	-0.711	1.80e+308	0.00	1.00	Unknown
	Delivery speed III	β_DRS3	-0.567	903.	-0.00	1.00	Unknown
	Delivery window I	β_DRW1	-0.0219	0.192	-0.11	0.91	No
	Delivery window II	β_DRW2	0.103	0.179	0.57	0.57	Yes
	Delivery window III	β_DRW3	0.177	0.188	0.94	0.35	No
Generic	Interaction	β_I	-0.0339	0.0651	-0.52	0.60	No
	Sustainabiility	β_SS	0.396	0.0610	6.49	0.00*	Yes

Figure B.7: Ngene: script for the d-efficient design PD suvey

```
Design
;alts = ParcelPickUp, HomeDelivery, Drone
;rows = 20
;eff = (mnl,d)
;block = 2
;model:

U(ParcelPickUp) =
b1.[-0.259] * pricepp[-2,0,2,4] +
b2.effects[0.0306|0.0798|-0.28] * locationpp[0,1,2,3] +
b3.effects[0.28|0.346|0.0881] * speedpp[0,1,2,3] +
b4.effects[0.396] * sustainability[0,1] +
b5.effects[-0.329|-0.265|0.104] * accessibility[0,1,2,3] +
b6.effects[-0.0339] * interaction[0,1] /

U(HomeDelivery) =
b7.[-0.223] * pricehd[0,3,6,9] +
b8.effects[0.226|0.335|-0.289] * speedhd[0,1,2,3] +
b9.effects[1.17|-0.515|-0.816] * windowhd[0,1,2,3] +
b4 * sustainability +
b6 * interaction /

U(Drone) =
b10.[-0.261] * pricedr[0,4,8,12] +
b11.effects[0.17|-0.17|-0.17] * locationdr[0,1,2,3] +
b12.effects[0|0|0] * speeddr[0,1,2,3] +
b13.effects[-0.0219|0.103|0.177] * windowdr[0,1,2,3] +
b4 * sustainability

;cond:

if(HomeDelivery.speedhd = 0, HomeDelivery.windowhd = 0)

 $
```

Figure B.8: Ngene: script for the d-efficient design MD suvey

```
Design
;alts = alt1, alt2
;rows = 12
;eff = (mnl,d)
;model:

U(alt1) =
b1[-0.892] * price[0,1,2,3] +
b2[-0.0792] * speed[15,30,45,60] +
b3.effects[0.682] * sustainability[0,1] +
b4.effects[0.759] * guarantee[0,1] +
b5.effects[0.0273|-0.187] * type[0,1,2] /


U(alt2) =
b1 * price +
b2 * speed +
b3 * sustainability +
b4 * guarantee +
b5 * type $
```

Figure B.9: The visually improved tables

	Parcel pick-up	Home delivery	Drone delivery
Price	€2,-	€9,-	€8,-
Location	Street	Home	Home
Speed	Same evening	Same day	Within 4 hours
Time window	-	2 hours	1/4 hours
Accessibility	00:00-00:00	-	-
Sustainability	Non-green choice	Green choice	Non-green choice
Interaction	Machine	Machine	Machine

Figure B.10: Screening question example

1. Met welke zaken heeft u ervaring gehad? *

- ☐ Het laten bezorgen van online aankopen
- ☐ Op vakantie gaan in Zuid-Amerika
- ☐ Het laten bezorgen van maaltijden/eten
- ☐ Eten in een fastfoodrestaurant
- ☐ Een auto huren
- ☐ Op vakantie gaan binnen Europa
- ☐ Eten in een restaurant
- ☐ Een fiets huren
- ☐ Geen van bovenstaande

C

APPENDIX: DATA ANALYSIS

C.1. Sampling method

C.1.1. Sample size requirements

The data sample needs to be of certain size in order to determine the parameter values with statistical significance. To determine the required sample size for both surveys, equations C.1.1 through C.1.3 are used to determine the required number of respondents in order to reach significance for each individual parameter.

$$s.e. = \sqrt{variance} \tag{C.1.1}$$

$$t_{(N=1)} = prior/s.e. \tag{C.1.2}$$

$$N_{(t>1.96)} = 1.96/t_{(N=1)} \tag{C.1.3}$$

The outcomes of this calculation are listed in table C.1. These values are used to determine how to distribute the respondents over the surveys. The total number of available respondents is around 450. For the MD survey, the minimum number of respondents is 30 - as 1394 respondents cannot be realized within this research. For the PD survey, the values for N_{min} differ greatly. Upon closer inspection - and taking budget into account - the sweet spot lies between 30 to 60 respondents. Due to the fact that the PD survey is blocked, this number must be doubled, and therefore lies between 60 and 120. It must be noted that many values of N_{min} are very high. This is due to a small parameter value combined with a high standard error - as can be seen in equation C.1.2.

C.1.2. Data segmentation

In order to identify differences in trade-off's and choices between consumer groups, a few consumer bins were defined. Firstly, a distinction is made between students/young professionals (age 20-34), middle age (35-49) and higher age (50-64). Moreover, a green-minded group is defined based on a statement in the survey on the willingness to contribute to a more sustainable delivery service.

Taking into account the three age groups, the N_{min} minimum sample size increases threefold. This means that the MD survey requires 90 respondents, and the PD requires between 180 and 360 respondents. The total budget is 450 respondents, and thus allows for 90 respondent for the MD survey, and 360 respondents for the PD survey. The desired distribution of respondents can be seen in table C.2

The green-minded group is determined based on a statement in the survey. There is no quota on this group, so it will only be possible to segment data if the number of respondents that fall into this category is high enough - meaning 30 for the MD survey and 120 for the PD survey.

Table C.1: Sample size requirements PD (left) & MD (right) survey

Parameter	**Fixed prior value**	N_{min}
βPPC	-0,259	5
$\beta PPL1$	0,0306	3.623
$\beta PPL2$	0,0798	482
$\beta PPL3$	-0,28	43
$\beta PPS1$	0,28	45
$\beta PPS2$	0,346	28
$\beta PPS3$	0,0881	427
βSS	0,396	3
$\beta PPA1$	-0,329	32
$\beta PPA2$	-0,265	51
$\beta PPA3$	0,104	4
βI	-0,0339	318
βHDC	-0,223	2
$\beta HDS1$	0,226	168
$\beta HDS2$	0,335	42
$\beta HDS3$	-0,289	50
$\beta HDW1$	1,17	5
$\beta HDW2$	-0,515	17
$\beta HDW3$	-0,816	8
βDRC	-0,261	1
$\beta DRL1$	0,17	190
$\beta DRL2$	-0,17	180
$\beta DRL3$	-0,17	16
$\beta DRS1$	0	n.a.
$\beta DRS2$	0	n.a.
$\beta DRS3$	0	n.a.
$\beta DRW1$	-0,0219	10.291
$\beta DRW2$	0,103	477
$\beta DRW3$	0,177	165

Parameter	**Fixed prior value**	N_{min}
βDC	-0.892	3
βDS	-0.0792	2
βDSS	0.682	3
βDG	0.759	3
$\beta DT1$	0.0273	1.394
$\beta DT2$	-0.187	30

C.2. Descriptive statistics

C.2.1. Outliers

As mentioned in the sampling method section, some respondents may be prone to rushing through the survey in order to earn money with minimal effort. These respondents' answers are of no value in this research, as they disrupt the data. There are multiple ways in which a dataset can be affected negatively. The problem however, is that it is in general very difficult to filter out "bad" respondents while guaranteeing that no "good" data is lost. Filtering can therefore lead to problems, especially because one cannot just filter based on a gut feeling. A clearly identifiable filter is the lower bound of completion time. One can assume that when a respondent takes only little time to complete the survey, they will not have paid any attention to the questions.

In order to define this lower bound, it is important to estimate the value based on reference material. For example, the mean completion time for the PD pilot was 11.7 minutes (containing 16 choice sets) and 7.3 minutes for the MD pilot (12 choice sets). The mean completion time for the final survey was 9.4 minutes, with a mode of 5.8 minutes. this implies that outliers with abnormally high completion times have increased the mean. A realistic completion time for the final survey is therefore assumed to be around 6 minutes. When conducting the survey myself, trying to complete the survey as quickly as possible, the average completion time was 90 seconds. When completing the survey with very minimal attention the average time was around 240 seconds. All these observations combined, all outliers which have $t < 180$ were filtered out.

As can be seen in table C.3 and figures C.1 and C.2, there are relatively many "speeders". 74 out of 548 were removed from the data set. It should be noted that PanelClix has already compensated for the high number

Table C.2: Desired frequency distribution of respondents

	PD 1	PD 2	MD	Total
20-34	60	60	30	150
35-49	60	60	30	150
50-64	60	60	30	150
Totaal	180	180	90	450

of speeders - there was agreed upon 450 respondents. Therefore, the final total number of respondents is 474.

Table C.3: Outlier frequencies

	t<180s	t>180s	Total
PD 1	31	179	210
PD 2	33	189	222
MD	10	106	116
Total	74	474	548

Figure C.1: Completion time distribution

Time (w.o. filter)			
		(s)	(min)
N	Valid	548	
	Missing	0	
Mean		565	9,4
Std. Error of Mean		79	1,3
Median		323	5,4
Mode		348	5,8
Minimum		76	1,3
Maximum		34103	568,4

Figure C.2: Completion time distribution (t>180s)

Time (filter: t<180s)			
		(s)	(min)
N	Valid	474	
	Missing	0	
Mean		632	10,5
Std. Error of Mean		91	1,5
Median		349	5,8
Mode		348	5,8
Minimum		180	3,0
Maximum		34103	568,4

C.2.2. Frequency distribution

In order to successfully segregate data, it is of importance that the distribution of respondents is even over the different bins. The quota for the ag bins can be see in table C.2 in chapter 5.1.3. The minimal data set size for the PD survey is 120 respondents (60 + 60), and 30 for the MD survey. The branching mechanism in the survey does not guarantee the desired distribution as it "flips a coin" each time. This section checks if the desired distributions were indeed obtained.

C.2.3. Demographics

This section discusses the key demographic features of the respondents in the data set. Figure C.3 and C.4 show that the largest share of respondents orders food and shops online on a monthly bases. Moreover, over 20% states to do so every week.

An overwhelming majority of the respondents - 75% - lives in inner cities. As provided in figure C.5. With only 25% living in non-inner city urban areas. Note that the respondents which live rurally were filtered out at the start of the survey. Altogether, the 75% inner city representation within the sample is positive, for most of the problems associated with current delivery services are concentrated in inner cities.
Moreover, most of the respondents have jobs, thus are working. On average 72% of the respondents work, with 50% full time, and 22% part time. Only 9% of the respondents is a student. This is a large departure from the pilot sample demographics, of which the majority was a student. Lastly, 20% does not have a job. This bin includes both people who are willingly without a job, as well as unwillingly. It is also noteworthy that the distribution is almost equal for both surveys. Please consult figure C.6 for all data.

Almost all respondents have experience with experience with meal delivery and online shopping - 87% and

Table C.4: Frequency distribution early adopters

		"I am an early adopter."					
		Strongly agree	*Agree*	*Neutral*	*Disagree*	*Stronly disagree*	*Total*
Distribution over surveys	*PD 1*	9	47	72	41	10	179
	PD 2	**8**	**47**	89	28	17	189
	MD	**5**	**26**	41	24	10	106
	Total	22	120	202	93	37	474

Figure C.3: Online shopping frequency respondents

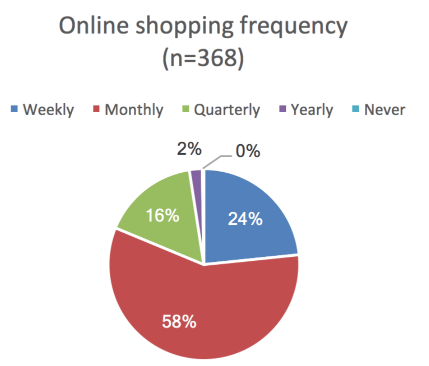
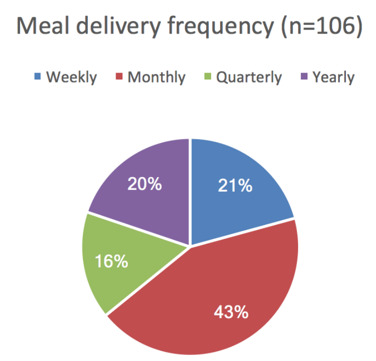


Figure C.4: Meal delivery frequency respondents



96% respectively (figure C.7). All respondents have at least experience with one of the subjects, otherwise they would have been filtered out in the screening part of the survey. This is also a positive finding. As a personal note, it might be interesting to mention that the high meal delivery experience share was not entirely expected.

Figure C.6: Occupation of respondents

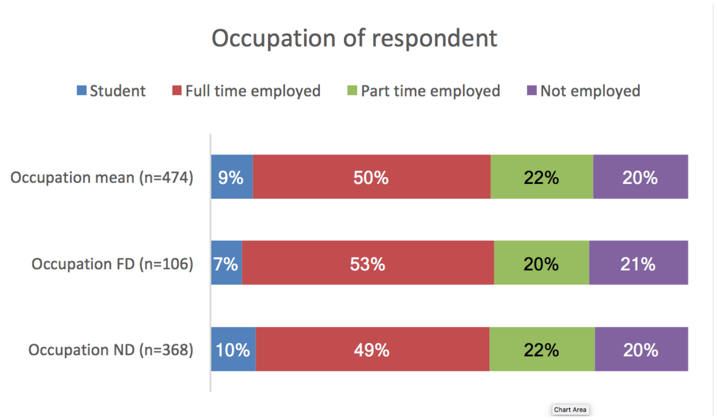


Figure C.5: Location of residence

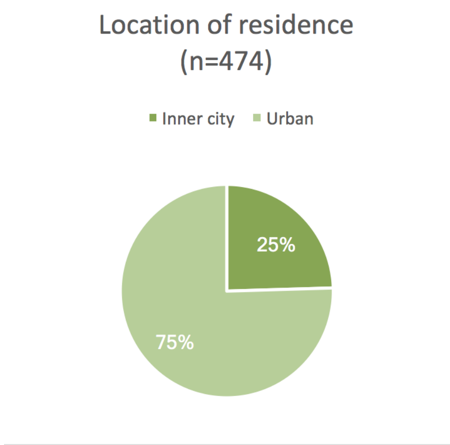
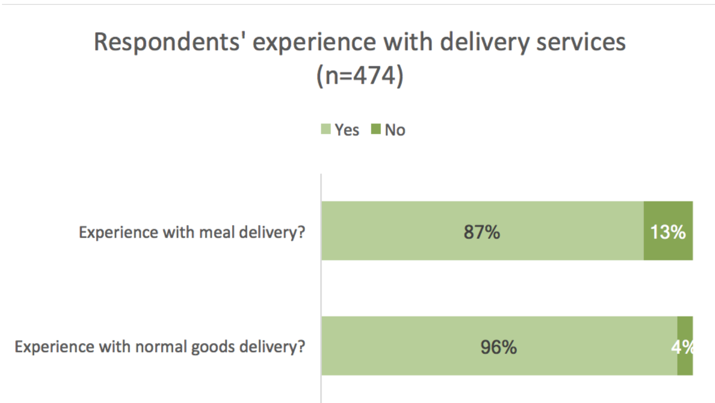


Figure C.7: Experience with delivery services



C.2.4. Attitudes

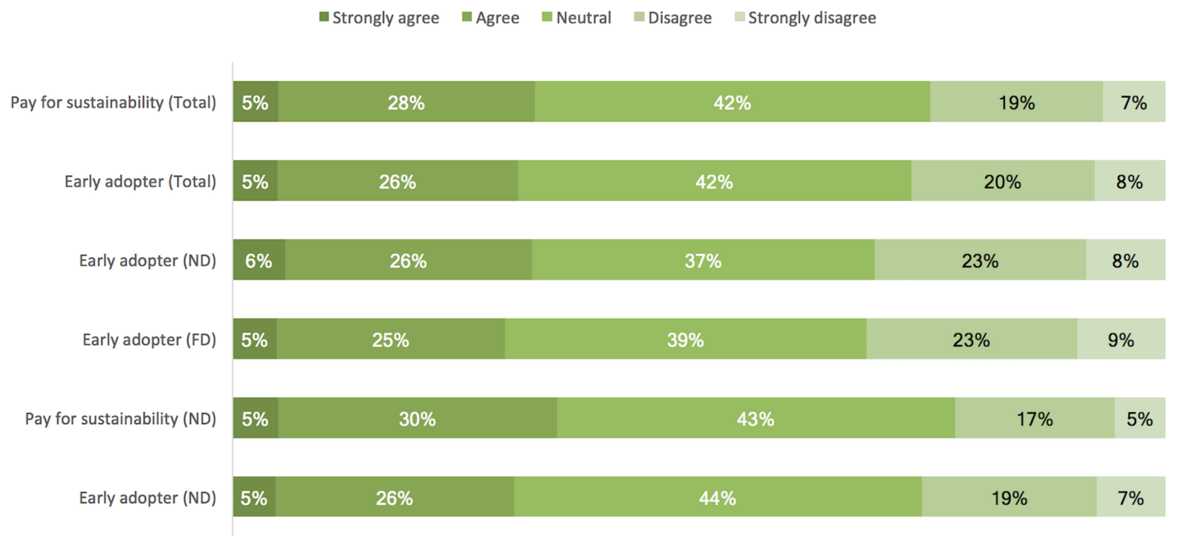
This section explores the respondents' prioritization of the different attributes. Also, the distribution of the responses on the statements is looked into. These statistics give insight into the priorities of the respondents in this sample, and can be taken into account when drawing conclusions in a later stage.

Figure C.8 displays the distribution of answers given to the statements. The answers had a range from "strongly disagree" till "strongly agree". Looking at the "green" statement, one can observe an average percentage of 33% of respondents answering positively - meaning that they (strongly) agree. Interestingly, 35% of the PD survey respondents has a positive attitude towards contributing to a cleaner environment, as opposed to just 31% of the MD survey respondents. This might imply that the respondents in this sample are more aware of the environmental impact of parcel delivery as opposed to food delivery. 42% of the total sample was neutral on this statement, and 26% (strongly) disagreed. This means that the number of respondents with positive attitudes are larger than the ones with a negative attitudes towards the sustainability statement.

When taking a look at the early adopter statement, a total of 31% agrees, 42% is neutral, and 28% disagrees. Overall, the distribution of early adopters seems to be quite symmetric. It may be noteworthy to add that within the "agree" and "disagree" bins, the share of respondents which wholeheartedly disagree is larger than the share which wholeheartedly agrees - 8% versus 5% respectively. The difference between the distribution between the PD survey respondents and the MD respondents is negligible.

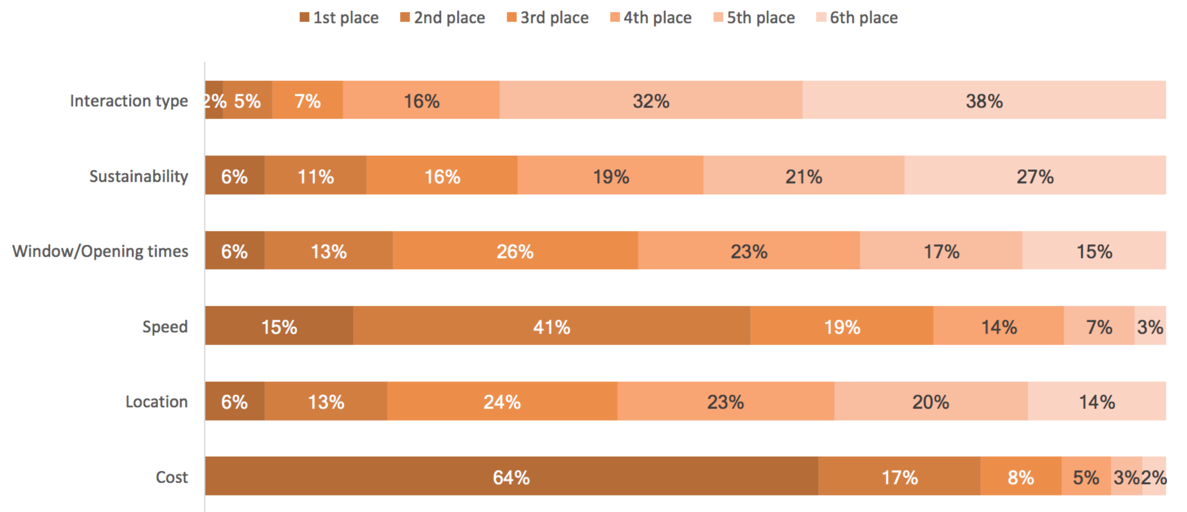
At the start of the survey, before the choice set questions, respondents were asked to rank the attributes in order of importance. Figure C.9 display the outcomes of this question for the PD survey respondents. An

Figure C.8: Distribution of answers of statements



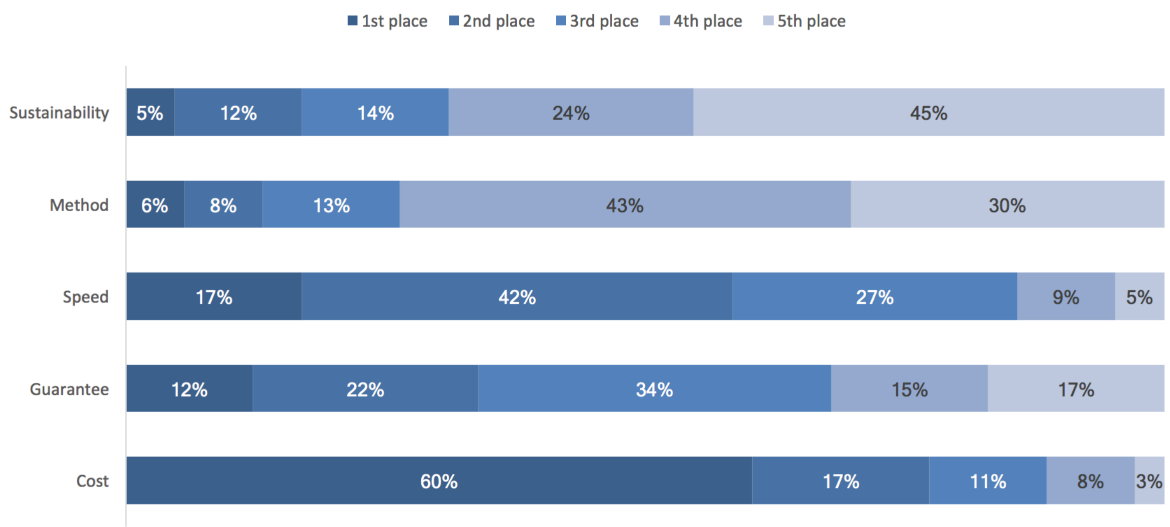
overwhelming 64% of the respondents chose *price* as the most important attribute. *Speed* appears to be the second most important attribute, as 41% ranked this as their second most important attribute. Time window and opening times are closely tied for third and fourth place, and have roughly the same distribution. Sustainability is ranked fifth most important, and the interaction attribute is a clear last. Only 33% of the PD respondents had sustainability in their top three.

Figure C.9: Ranking of attributes PD



The attributes of the MD survey were also ranked. Figure C.10 displays the distribution of answers. Just like with the PD survey, cost is dominating first place with 60%. Speed is second most important, guarantee third, sustainability fourth, and finally the delivery method was ranked last. The low ranking of the delivery method may be because respondents are not familiar with the advanced delivery methods proposed in the survey. Either this, or they do not care, and merely want their food to be delivery as soon as possible at lowest cost.

Figure C.10: Ranking of attributes MD



At the end of the survey, the respondents were asked to indicate which attributes they took into account when choosing the delivery service. If the answer is "yes", then the respondents indicated that this attribute was of importance. If the answer is "no", then the attribute had no or limited influence on the delivery choice according to the respondent. Figure C.11 shows the outcomes for the PD survey, and figure C.12 for the MD survey. The distributions match the expectations based on the attribute ranking outcomes quite well. There were a few differences, such as that the delivery method in the MD survey was apparently more frequently important for respondent than sustainability.

Figure C.11: Most important attributes PD

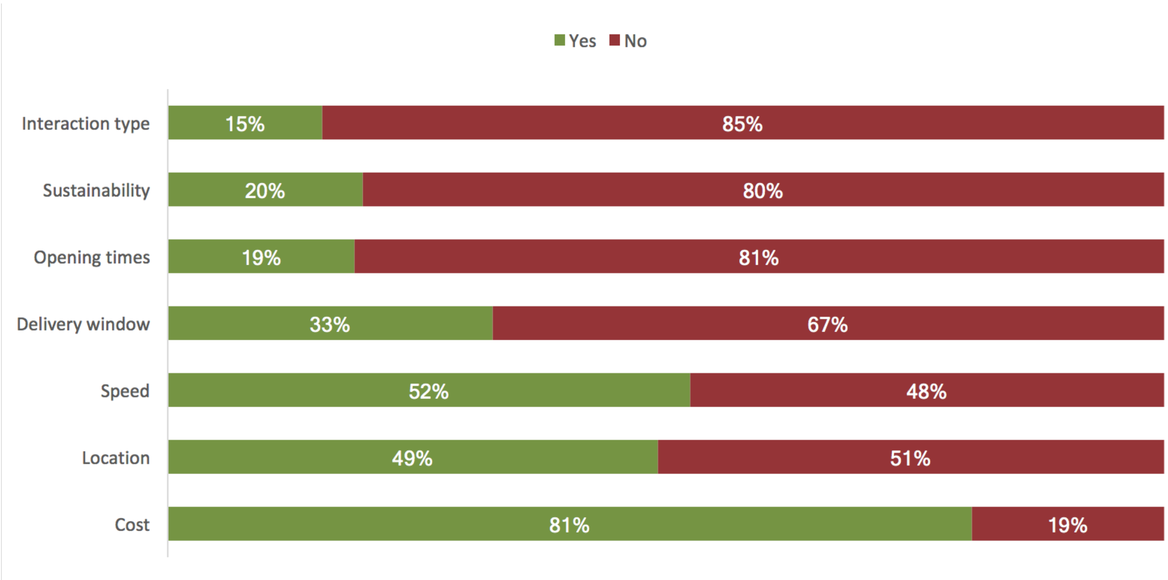
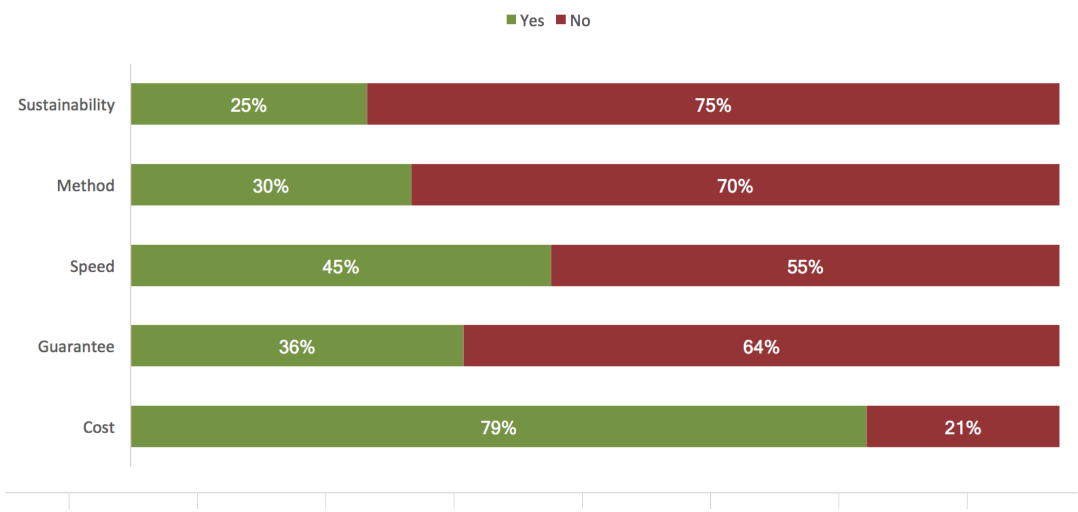


Figure C.12: Most important attributes MD

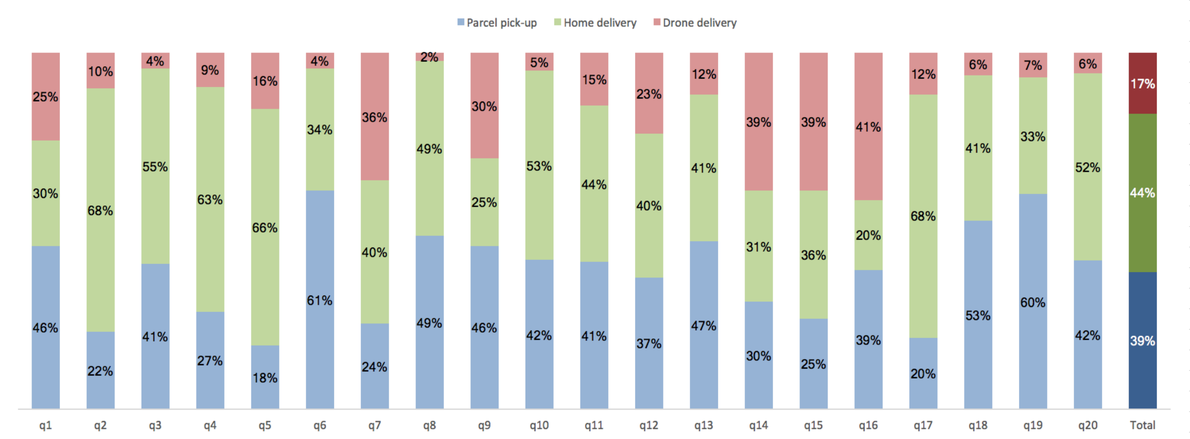


C.2.5. Choice frequencies

This section discusses the choice frequencies for the choice sets.

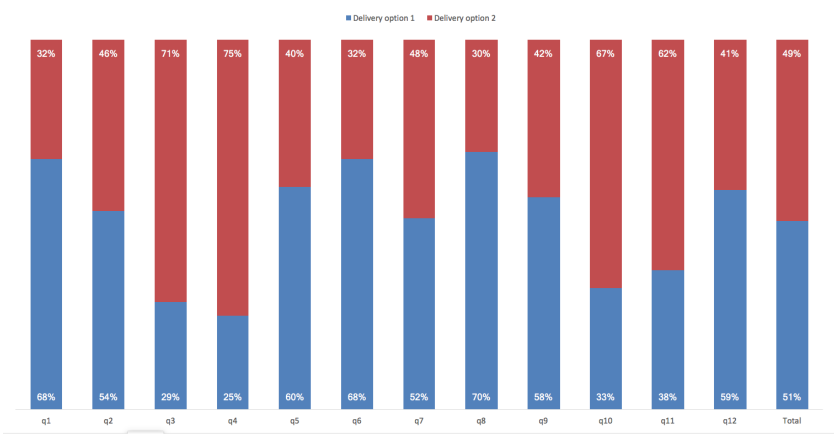
PD survey The PD survey choice distribution - as displayed in figure C.13 - varies vastly per question. However, in general, the drone delivery service was chosen significantly less than the other two. This pattern is substantiated by the mean of the choice set distributions, in which drone delivery has a share of only 17%. The home delivery and parcel pick-up distributions are much closer, with an advantage of 6% in favour or the home delivery. There is no apparent dominance at play - i.e. choice shares which exceed 80% - which is positive.

Figure C.13: Frequency distribution choices PD survey



MD survey The MD survey choice distribution - as displayed in figure C.14 - also differ quite a lot per choice set. The average share of delivery option 1 is 49%, and 51% for delivery option 2. In this unlabelled experiment, the choice distribution say less about the alternatives, as they are generic. It is however important to check if there was no apparent case of dominance - which there was not.

Figure C.14: Frequency distribution choices MD survey



C.3. Model interpretation

C.3.1. Parameter expectations Parcel Delivery

There are three choice options in this experiment: parcel pick-up (PP), home delivery (HD) and drone delivery (DR). These delivery services each have specific attributes and attribute levels. This section discusses these attribute levels and what is expected of the parameter estimates. The attributes that are part of the PD experiment are: price, location, speed, delivery window, accessibility, sustainability and interaction. Factors taken into account are: relative importance, expected sign (either positive or negative) and significance.

Alternative specific constants The ASC represents the utility for an alternative when all attribute levels equal zero. In other words, this constant captures the utility which cannot be assigned to the attributes. The ASC value for PP is fixed and equals 0. The ASC values for HD and DR are variable and are expected not te be equal to 0, as they are the utility difference relative to PP (which equals 0).

Price (PP, HD, DR): The price attribute parameters are estimated using a linear and quadratic component. This is because the relation between delivery price and utility is expected to be quadratic. The price attribute is expected to be the dominant – i.e. the most important - attribute in the choice experiment, or at least among the most important attributes. Moreover, the price parameters are expected to be negative, meaning that an increase in price has a negative utility. Due to the fact that price is generally an important factor for consumers, this parameter is expected to be significant. Lastly, the utility ranges will differ between the alternatives because each alternative has a different attribute (price) range.

Speed (PP, HD, DR): This attribute applies to all choice options. It does however differ between the alternatives. Speed is expected to be an important factor. This attribute is expressed in terms of time – i.e. same hour, same day, etcetera. The speed attributes is modelled as a ordinal variable. Therefore, a negative pseudo-linear relation is expected between speed and utility. PP has "same day", "same evening", "next day" and "2 days". It is expected that a longer waiting time equals lower utility. For the HD option, values "same hour", "same day", "next day" and "2 days" were incorporated. DR has "same hour", "within 2 hours", "within 4 hours" and "same day". For HD and DR, the same expectation as for PP holds. However, because DR offers speedier delivery than PP and HD, the utility contribution will be different.

Location (PP, DR): This attribute only applies to the parcel pick-up and drone delivery option. The delivery location of the home delivery option does not vary. When a parcel is not delivered at home, this requires the consumer to go outside of their home in order to pick it up. It is expected that this will be viewed a negative for a consumer. Thus, having to go outside is expected to have a negative utility contribution. Moreover, due to the fact that home delivery is the preferred delivery choice for a large share of consumers, this attribute is expected to be among the most important. The location attribute levels differ between PP and DR. PP has "street", "neighbourhood", "station" and "pick-up point". Street and neighbourhood are most likely to be closest to home. The convenience of the station and pick-up point location is dependent on the relative distance from the consumers home, work and daily routes. Of these two, the pick-up point has an advantage due to – generally – there being more in the same area than train stations – implying that the distance from consumers' homes is smaller. Therefore, it is expected that pick-up point is preferred to station. DR has "home", "street", "neighbourhood" and "pick-up point". Due to the ordinal nature of these locations, it is expected that home has the largest utility contribution whereas pick-up point has the lowest.

Accessibility (PP): The PP option is the only alternative in which accessibility is incorporated. The accessibility attribute can be compared to "office hours", as it represents the time intervals between which one can pick-up their parcel at the designated place. Same as with the delivery window, the relative importance of this factor is unknown. Therefore, it is expected that longer office hours equal higher utility.

Delivery window (HD, DR): Consumers are expected to perceive a larger time window as negative, for this is a time period in which they are forced to one location. In other words, a larger time window is expected have a lower utility than smaller ones. It is not very well known to which extend this attribute is important to the consumer – apart from that it is somewhat important. This attribute applies to HD and DR. The values for HD varied between 30 minutes and 5 hours, with 90 minutes increments. The DR time window varied between 15 minutes and 1 hour, with 15 minute increments. The expected outcome is "lower is better".

Sustainability (PP, HD, DR): The sustainability attribute applies to all alternatives. It represents a greener means of transportation for the parcel. The sustainability factor is either "green choice" or "non-green choice". The relative importance of this attribute is unknown, but it is expected to be one of the less important attributes, as price, speed and location are expected to be dominant. The utility is expected to be positive for the "green choice" and negative for the "non green choice". The significance of this attribute is also unknown.

Interaction (PP, HD): This attribute represents the interaction between the consumer and the delivery service. It can either be "human" or "machine". Human simply being a person as we know delivery services today. Machine implies that there is a digital step involved with retrieving the parcel. It is expected that consumers are either indifferent towards the different interaction types, or that they prefer human interaction as this is currently most common, and machines involve extra steps which can be seen as a hassle.

C.3.2. Parameter interpretation Parcel Delivery

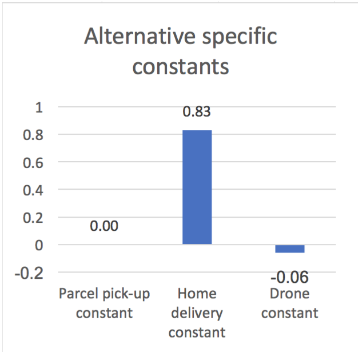
Alternative specific constants

Significance: only the HD parameter is significant, and can be generalized to the population which fits the profile of the respondents in the survey. The drone ASC parameter is not significant. The parcel pick up ASC was fixed at a value of 0, and does not have properties like significance and p-value.
Parameter value: The parameter ASC outcomes for the PP, HD and DR alternatives are 0, 0.83 and -0.06 respectively. This means that DR has the lowest alternative specific utility - as its value equals -0.06 -, that PP has the second highest ASC, and that HD has the highest ASC.
Interpretation: There was no specific expectation regarding the DR ASC (-0.06) compared to the PP ASC (0). As it turns out, the difference is a mere 0.06 utils. However, because of a lack of statistical significance, this difference only applies to this sample. For the population the difference equals zero, which means that the intrinsic utility of DR does not differ from that of the PP alternative. The HD ASC is has a value of 0.83, which means that it has 0.83 utils more intrinsic utility than PP and DR. HD being the highest of the three can be explained by the fact that this is currently the most familiar and most used delivery service. People in general are prone to choosing something with which they are familiar.

Table C.5: Alternative specific constants parcel delivery

Name	Value	Robust Std err	Robust t-test	p-value	Significant?	Expected sign?
Parcel pick-up constant	0.00	-	-	-	-	-
Home delivery constant	0.83	0.13	6.36	0.00	Yes	Yes
Drone constant	-0.06	0.12	-0.47	0.64	No	Unknown

Figure C.15: ASC parameter estimates parcel delivery



Price

Significance: price was represented by two parameters, one for the linear component and one for the quadratic. For the price parameter estimates, only one (parameter 2)is significant at the 5% level. At the 10% level, the first parameter is also significant. Both are of the expected sign (negative).
Parameter values: The first (only significant at 10% interval) parameter has value -0.05, and the second (significant) has value -0.02.
Curve characteristics: The curves, as can be seen in figure C.16, show a negative quadratic curve. This is due to the fact that the quadratic component was significant, proving the curve to be quadratic to the population. The price ranges do differ between the alternatives, which explains the differences between the three curves.
Utility range: the utility ranges differ between alternatives due to different attribute ranges. PP has a price ranging between -2 and 4 Euro. This leads to a utility range of 0.53 utils. HD has a range between 0 and 9 Euro, and a utility range of 1.89. For the DR delivery, the price ranges between 0 and 12 Euro. The utility ranges is 3.14 utils. The ranges increase quadratically due to the quadratic component. However, it is more comprehensive to compare the utility ratios for the price attribute due to the different price ranges. The price utility ratio for PP is 23%, for HD it is 50%, and for DR it is 66%.
Interpretation: only the parameter for the quadratic component is significant at the 5% interval, which means that the price parameter is purely quadratic to the population. However, the parameter for the linear component is significant at the 10% interval, which means that it is very likely that both play a role. Due to the quadratic nature the more difference in utility between prices with the same increments higher up the range. In other words: in terms of utility, the difference between 1 and 2 Euro is smaller than the difference between 10 and 11 Euro. This effect leads to vastly different utility ranges, as the DR utility range is around six times as large than the PP utility range, while the price range differs only a factor two. In order to compare the influence of the price factor, one should look at the utility ratios, which are 23% (PP), 50% (HD) and 66% (DR). As expected, a combination of higher prices and broader ranges increases the relative importance of the price factor. In conclusion, a low price is much preferred to a high price as a price increase penalised quadratically. In other words, a high price is much more likely to become the dominant factor when choosing a delivery service.

Table C.6: Price parameter estimates parcel delivery

Name	Value	Robust Std err	Robust t-test	p-value	Significant?	Expected sign?
Price parameter 1 (linear)	-0.05	0.03	-1.80	0.07	No	Yes
Price parameter 2 (quadratic)	-0.02	0.00	-6.69	0.00	Yes	Yes

Figure C.16: Price parameter estimates parcel delivery

Speed

Significance: for each alternative there are three indicator variables to determine the utility contribution of each delivery speed level. Of these nine parameters, not every value is statistically significant at the 5% interval. For PP, only parameter 3 is significant. For HD, only parameter 2 is significant. And for DR, parameters 1 and 2 are significant.

Parameter values: for **PP**, parameter 1 and 2 are not significant, and thus the values cannot be generalized to the population. Regarding parameter 1 and 2, the null-hypothesis is accepted, which means that the utility contribution for "same day" and "same evening" is equal to 0, which with effects-coding means that they have average utility compared to the other attribute levels. The "next day" delivery speed has a utility contribution of 0.30, and "2 days" has a utility of -0.50. For **HD**, "same hour" and "next day" has average utility at a value of 0 (as their parameters are not significant). Delivery speeds "same day" and "2 days" have a utility contribution of 0.30 and -0.28. For **DR**, "same hour" has a utility of -0.26, "2 hours" has a utility of -0.20, "4 hours" is not significant, and "same day" has 0.40.

Curve characteristics: The three graphs in figure **??** show for each alternative how the utility contribution is distributed for the different delivery speeds. Delivery speed was modelled as an ordinal variable. Therefore, a negative relation between delivery speed and utility was expected. Ergo, longer delivery times equal lower utility. One can observe that for **PP**, there is a negative relation between "next day" and "2 day" delivery. The values for "same day" and "same evening are not significant, and thus have average utility at a value of 0. Considering that variables 1 and 3 were not significant for **HD**, a negative relation can be seen between "same day" and "next day" delivery. With **DR**, things are different. There appears to be a positive relation between delivery speed and utility. The "4 hours" delivery speed is not significant - and can be set to 0 - and the other three attribute levels go from -0.26 to -0.20 to 0.40, which is a positive curve.

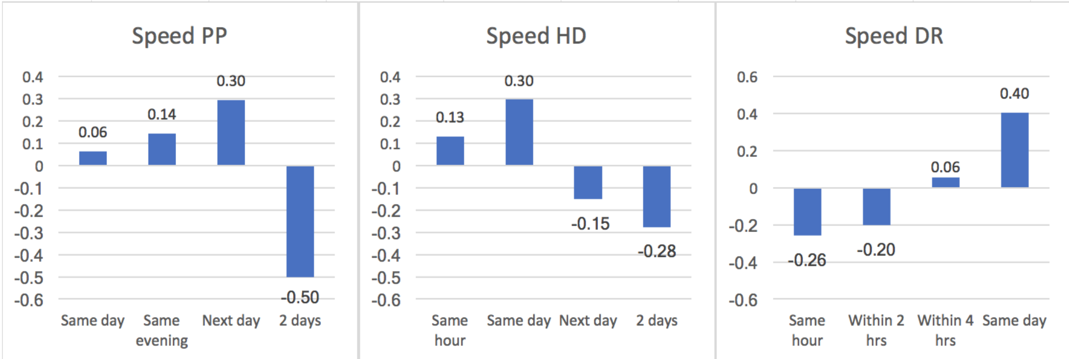
Utility range & ratio: The utility ranges for the speed attribute for PP, HD and DR are 0.80, 0.57 and 0.66 respectively. This translates into a ratio of 34% for PP, 20% for HD and 14% for DR.

Interpretation: The shortest delivery times do not result in highest utility for all alternatives. This is peculiar, as it was expected that faster delivery equals more convenience for the consumer. For HD and DR, same day is best. For PP, next day is. It might be that a longer delivery times suffices for the consumer, or that the respondents did not take the extremely fast delivery options seriously, as these are now not readily available. This is especially the case for DR, for which the slowest delivery (same day) has the highest appreciation. The reason for this behaviour could be that same hour is too fast for the consumer. It might be incompatible with their daily planning, as they are not used to this speed right now. One could argue, due to the second speed parameter for PP being significant at the 10% interval, that same evening is preferred over same day. This might be because this is the soonest an average consumers can pick up their parcel anyway. Lastly, within the speed ranges of the alternatives, consumers are less sensitive for changes in speed for the HD and DR service than they are for PP. Apparently, the change in delivery speed for PP is perceived as worse and more inconvenient than for HD and DR.

Table C.7: Speed parameter estimated parcel delivery

Name	Value	Std err	t-test	p-value	Significant?	Expected sign?
Parcel pick-up: Speed 1	0.06	0.08	0.77	0.44	No	Yes
Parcel pick-up: Speed 2	0.14	0.08	1.72	0.08	No	Yes
Parcel pick-up: Speed 3	0.30	0.07	4.20	0.00	Yes	Unknown
Home delivery: Speed 1	0.13	0.15	0.87	0.38	No	Yes
Home delivery: Speed 2	0.30	0.09	3.20	0.00	Yes	Yes
Home delivery: Speed 3	-0.15	0.09	-1.61	0.11	No	Yes
Drone delivery: Speed 1	-0.26	0.12	-2.25	0.02	Yes	No
Drone delivery: Speed 2	-0.20	0.10	-2.03	0.04	Yes	No
Drone delivery: Speed 3	0.06	0.09	0.62	0.53	No	No

Figure C.17: Speed parameter estimates parcel delivery



Location

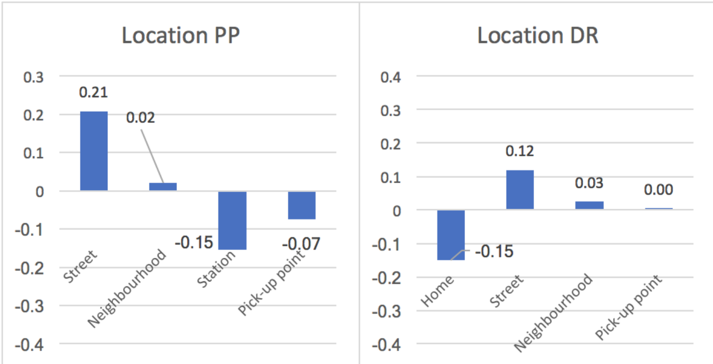
Significance: there are a total of six parameter estimates for delivery location. Three to represent PP and another three for DR. Only the first of the three PP location parameters is significant at the 5% level. None of the DR delivery location parameters are significant. This means that delivery location does matter for PP, but does not matter for DR. At the 10% level, the third parameter for PP also becomes significant.
Parameter values: As none of the DR location parameters are significant, it is not relevant to discuss the parameter values. These values would only apply to the sample, not the population. However, due to the fact that delivery location preference is something that might differ a lot among respondents, the non-significance can also be because these opposite preferences cancel each other out in the aggregate parameter estimates. Unfortunately, it is not possible to check if this is the case with the MNL model. The PP location parameter values in figure C.18 show a positive value of 0.21 for "street", a (non-significant) value of 0.02 for "neighbourhood", a negative value of -0.15 for "station", and a value of -0.07 for pick-up point. This clearly shows that a delivery in the street of residence is valued most by consumers. At the 10% interval the "station" location is significant. While less certain, it does indicate that the station location has a clear negative value (-0.15).
Curve characteristics: The PP curve behaves as expected. Station is least appealing to the respondents. Street is values highest, neighbourhood is second best, and pick-up point third. There was no clear expectation regarding the appreciation of a delivery in your neighbourhood or at a pick-up point. It turns out that the difference was slightly in favour of the delivery in you neighbourhood.
Utility range & ratio: the utility range of PP is 0.36, and accounts for 15% of the total variation in utility for this alternative. DR is not significant, has a range of 0.27 utils, and a ratio of 6%.
Interpretation: The station delivery location is clearly not very convenient for consumers. This is probably because the distance to a station differs largely between individuals. It could mean that this option is only attractive for a certain sub group of consumers, most likely ones living near to a station or ones commuting by train on daily basis. An important finding is that a delivery in a consumers' street is more convenient than a traditional pick-up point. This indicates there is value in consumers for pick-up points in their direct vicinity. Regarding DR, non of the parameter estimates can be generalized to the population. However, as mentioned earlier, this does not necessarily mean that DR location plays no role in delivery service choice making. It

can also be accounted for by taking into consideration that delivery location preference can differ between consumers. This implies that the non-significance is in fact a result of opposite preferences cancelling each other out. In order to get a more definitive answer to this question, a more advanced model must be used, as MNL models cannot distinguish variance in preference between respondents.

Table C.8: Location parameter estimates parcel delivery

Name	Value	Std err	t-test	p-value	Significant?	Expected sign?
Parcel pick-up: Location 1	0.21	0.08	2.65	0.01	Yes	Yes
Parcel pick-up: Location 2	0.02	0.08	0.27	0.79	No	Unknown
Parcel pick-up: Location 3	-0.15	0.08	-1.83	0.07	No	Yes
Drone delivery: Location 1	-0.15	0.11	-1.37	0.17	No	No
Drone delivery: Location 2	0.12	0.10	1.17	0.24	No	Unknown
Drone delivery: Location 3	0.03	0.09	0.28	0.78	No	Unknown

Figure C.18: Location parameter estimates parcel delivery



Accessibility

Significance: the PP accessibility attribute is represented by three parameters (1, 2, 3). The first two are significant, and the third is not.

Parameter values: the lowest utility for the shortest opening hours of "12u-17u" was expected. What was not expected was the highest utility being assigned to "09u-18u". The utility contribution for the four attribute levels are: -0.29, 0.18, 0.04 (not significant) and 0.07.

Curve characteristics: the curve does not behave as expected. Accessibility was assumed to be an ordinal variable, as longer opening times equals more flexibility for consumers. However, this relation can only be seen between "12u-17u" and "09u-18u", as the utility goes up from -0.29 to 0.18. The last two accessibility levels (09u-21u, 00u-00u) were appreciated with a value of around zero utils. This means that these opening hours are values as average, as opposed to what was expected.

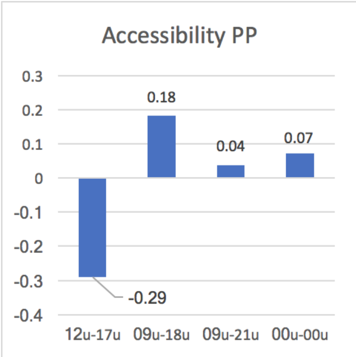
Utility range & ratio: the total variation of utility contribution by the accessibility attribute is 0.47 utils. When looking at the ratio between this variation and the total utility variation for the PP alternative, this amounts to a value of 20%. This makes accessibility the thirds most influential factor on choice for PP.

Interpretation: the accessibility factor plays a substantial role when choosing a delivery service. The factor is unique to the PP delivery service, and accounts for 20% of the total utility variability. This makes accessibility the third most important factor for PP (out of six). The curve does not behave as expected. There seems to be a preference for the "09u-18u" accessibility level. It was expected that the longer opening hours such as "09u-21u" and "00u-00u" would have an edge over the others. The reason behind this is unknown at this moment. Unfamiliarity with larger opening hours may play a role. But realistically, this should not be an issue with the "09u-21u" accessibility level, as this is already the case for some pick-up points within supermarkets.

Table C.9: Accessibility parameter estimates parcel delivery

Name	Value	Std err	t-test	p-value	Significant?	Expected sign?
Parcel pick-up: Accessibility 1	-0.29	0.08	-3.80	0.00	Yes	Yes
Parcel pick-up: Accessibility 2	0.18	0.08	2.42	0.02	Yes	No
Parcel pick-up: Accessibility 3	0.04	0.08	0.47	0.64	No	Yes

Figure C.19: Accessibility parameter estimates parcel delivery



Delivery window

Significance: only one of the six parameters values is significant. This is parameter DR window 3. This means that the values for PP window found in this research only apply to the sample, and not to the whole population.

Parameter values: the only significant parameter has a value of 0.30 utils. The rest of the values are assumed to be equal to zero for the population.

Curve characteristics: the DR window curve seems to be quite erratic, and does not show the expected ordinal behaviour. However, when we take into consideration that only the utility contribution for "3/4 hrs" and "1 hrs" apply to the population due to significance, there is a negative ordinal relation between the two attribute levels as the "1hrs" time window is values lower than "3/4 hrs".

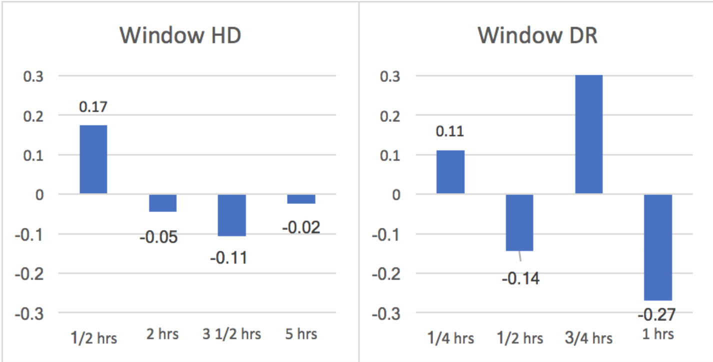
Utility range & ratio: the utility contribution variation of the DR window ranges 0.57 utils. This translates to a ratio of 12%. This puts delivery window at third most influential for DR delivery.

Interpretation: the delivery window does not play a role in the delivery process basis on the results of this research. The values found are only applicable to this sample. This is unexpected, as this factor was assumed to behave as an ordinal variable. For DR delivery, the time window does play a role. There is a negative relation between delivery window size and utility, and the utility ratio is 12%. It does remain peculiar that this effect was not found for HD window, as the time windows for HD are much larger than for DR.

Table C.10: Delivery window parameter estimates parcel delivery

Name	Value	Std err	t-test	p-value	Significant?	Expected sign?
Home delivery: Window 1	0.17	0.12	1.41	0.16	No	Yes
Home delivery: Window 2	-0.05	0.09	-0.53	0.60	No	No
Home delivery: Window 3	-0.11	0.12	-0.86	0.39	No	No
Drone delivery: Window 1	0.11	0.09	1.26	0.21	No	Yes
Drone delivery: Window 2	-0.14	0.11	-1.33	0.18	No	No
Drone delivery: Window 3	0.30	0.11	2.73	0.01	Yes	No

Figure C.20: Window parameter estimates parcel delivery



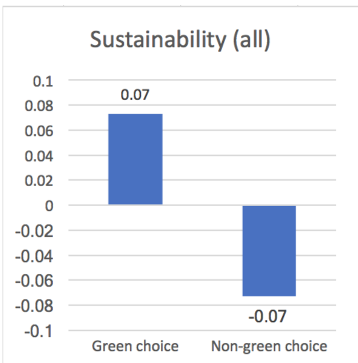
Sustainability

Significance: the parameter is not significant. Its p-value is 0.20. One could argue that - assuming that a more sustainable service has a positive relation to utility - a one tailed p-value would equal 0.10, and sustainability would thus be significant at the 10% interval. However, this is quite far fetched. Moreover, it would be less of a stretch to assume that there might be a large difference between respondents regarding the value of sustainability. As a certain share of consumers value sustainability, and others do not. The sustainability parameter remains insignificant in this research.
Parameter value: the sustainability parameter is not significant. However, because this is a very interesting factor the parameter value will shortly be discussed. Its value is 0.07. This is firstly a positive relation between sustainability, as expected. Moreover, the value is quite low.
Curve characteristics: there is a positive relation between sustainability and utility, albeit not significant at the 5% level.
Utility range & ratio: the utility range equals 0.14 utils. To this into perspective, sustainability has a 6% influence on the total utility variation of PP, 5% of that of HD, and 3% of DR.
Interpretation: there are good reasons to believe that there is an effect of delivery sustainability on the delivery choice. However this was not proven in this research within this sample. The reason behind this may be a large difference in attitudes between consumers. One may value sustainability greatly, and other may not value it at all. Furthermore, the value is quite small, which makes it increasingly difficult for the parameter to become significant. Even if there is an effect in the true population, it is on average quite small. The relative utility contribution for this attribute ranges between 3% and 6%.

Table C.11: Sustainability parameter estimates parcel delivery

Name	Value	Std err	t-test	p-value	Significant?	Expected sign?
Sustainability	0.07	0.06	1.29	0.20	No	Yes

Figure C.21: Sustainability parameter estimates parcel delivery



Interaction
Significance: the interaction factor is not significant. Neither at the 5% nor 10% interval.
textbfinterpretation: the interaction variable has a very small value of 0.02 utils. This makes it very difficult to become significant. This means, that even if there is an effect, its influence is very marginal. This can be seen when looking at the utility ratios which are between 1% and 2%. A non-significant parameter is necessarily a bad thing. In this case it just means that consumers are indifferent to the interaction type, which is a positive finding for automated parcel delivery services.

Table C.12: Interaction parameter estimate parcel delivery

Name	Value	Std err	t-test	p-value	Significant?	Expected sign?
Interaction	0.02	0.02	0.88	0.38	No	Yes

Figure C.22: Interaction parameter estimates parcel delivery

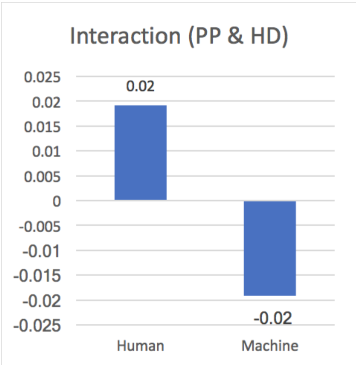


Table C.13: Utility ratios parcel delivery attributes

Utility-ratios	Parcel pick-up	Home delivery	Drone delivery
Price	23%	65%	65%
Speed	34%	20%	14%
Location	15%	-	6%
Accessibility	20%	-	-
Window	-	10%	12%
Sustainability	6%	5%	3%
Interaction	2%	1%	-
Sum	100%	100%	100%

C.3.3. Parameter expectations meal Delivery

There are two generic choice options in this experiment: option 1 and option 2. These choice options share the same attributes, of which the attribute values are varied. This section discusses these attribute values and the expected implications for the parameter estimates. The attributes that are part of the meal delivery experiment are: price, speed, guarantee, sustainability and delivery type.

Price The price attribute is expected to be dominant. This parameter may have the largest range, and thus impact. Its value is expected to be negative, as in general higher price equals lower utility from a consumer perspective. Moreover, this parameter is expected to be significant.

Speed With meal delivery, the urgency to eat is an important factor to take into account. Having the food earlier would, in that case, be better. Therefore, it is expected that delivery speed is also of great importance. The speed parameter is expressed in terms of the time it takes to deliver the meal in minutes. Thus, this parameter is expected to have a negative coefficient, as longer waiting time traditionally equals less utility. It may be close to the price parameter in terms of importance. This parameter is also expected to be significant.

Guarantee The delivery guarantee represents a promise for a delivery to be completed within the aforementioned delivery time (represented by the speed parameter). This is essentially assurance for the consumer that their meal will be delivered within the promised time. The parameter is expected to be positive, as assurance is generally positive. The importance of this attribute is not yet known, thus there are no specific expectations in that regard.

Sustainability For meal delivery, the sustainability factor may be of difference importance than with parcel delivery. A positive relation between sustainability and utility is expected. There are no specific expectations regarding the magnitude of this parameter.

Delivery method The delivery method indicated which means of delivery was used. This can be either drone, small curbside delivery vehicle, or a person. This parameter was effect-coded in order to determine the utility for the nominal variable. The traditional delivery by means of a person is expected to have the highest utility, because it is the most familiar option, and involves a human factor. Second highest is expected to be the drone delivery, due to a certain coolness and novelty factor. The importance of this attribute is not yet known, and therefore there are no specific expectations regarding its extend.

C.3.4. Parameter interpretation meal delivery

The parameter estimation for the meal delivery survey is done in a similar fashion as for the parcel delivery survey. The parameter estimations are assessed on the following aspects: **significance**, **value**, **curve characteristics**, **utility range & ratio** and **interpretation**. For more context, please refer to section **??**. The meal delivery survey has unlabelled alternatives, and therefore, the parameters apply to both choice options in the survey.

Price **Significance:** the price parameter is significant, as expected. And can therefore be generalized for the population within the profile of the respondents in this research. **Value:** the parameter value is -0.377. The negative sign was expected. **Curve characteristics:** the curve is linear and negative. There is not much more to report on the curve, as it is behaves as expected. **Utility range & ratio:** the prices for meal delivery ranges from zero to three Euro. The span of the utility for the price parameter therefore is 1.131. The relative utility contribution is 39% of the total variability. **Interpretation:** this parameter is the most important factor for meal delivery, at a relative importance of 40%. The parameter has a larger utility contribution than its counterparts in the parcel delivery survey up until around a delivery price of 16 Euro. This is where the two curves would intersect. This implies that consumers are less willing to pay for meal delivery compared to parcel delivery. The utility range is relatively modest, this is due to a small price range. Overall, the price parameter behaves as expected. Comparing its properties to the other attributes will most likely yield the most interesting results.

Table C.14: Parameter estimate price, MD

Name	Value	Robust Std err	Robust t-test	p-value	Significant?	Expected sign?
Price	-0.377	0.0695	-5.42	0	Yes	Yes

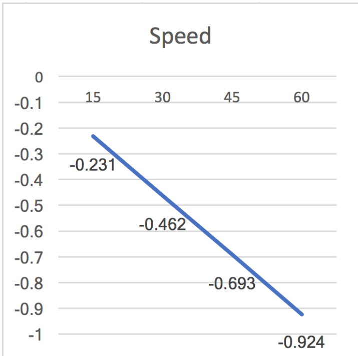
Figure C.23: Graph price parameter estimate MD

Speed **Significance:** the delivery speed parameter is significant. **Value:** the speed parameter has a value of -0.0154 utils. This value may seem small, however keep in mind that the speed attribute is expressed in terms of minutes. Therefore, the utility range will be larger than the value itself might imply. **Curve characteristics:** the curve is negative and linear. Exactly as expected. **Utility range & ratio:** the difference between the highest and lowest utility equals 0.693 utils. And the relative utility contribution is 24%. **Interpretation:** overall, this parameter behaves as expected. Its span is not as large as that of the delivery price. Delivery price turns out to be 15% more important than delivery speed within both attribute ranges.

Table C.15: Parameter estimates speed, MD

Name	Value	Robust Std err	Robust t-test	p-value	Significant?	Expected sign?
Speed	-0.0154	0.00557	-2.76	0.01	Yes	Yes

Figure C.24: Graph speed parameter estimate MD



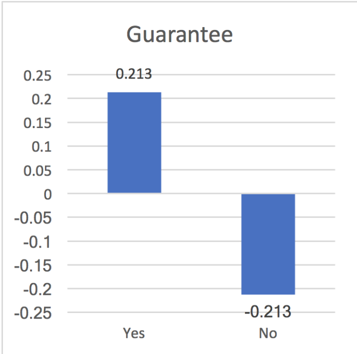
Guarantee **Significance:** the guarantee parameter value is significant, which means that it can be generalized for the population. **Value:** its value is 0.213. Due to this variable being effect-coded because it is a nominal variable, the utility of a guaranteed delivery within time equals 0.213 utils, and no guarantee equals -0.213 utils. **Curve characteristics:** the curve is as expected. A guaranteed delivery yields a positive utility, and a non guaranteed delivery yields negative utility. **Utility range & ratio:** the difference between highest and lowest utility equals 0.426 utils. This yields a 15% share of the total utility variability. **Interpretation:** the fact that this parameter is significant, means that consumers within this sample consider this factor to be important. Initially, there were no specific expectation regarding the influence of this attribute on delivery choice. Its utility ranges 0.426 and this places this attribute relatively close to delivery speed (0.693) in terms of importance. In practical terms this means that consumers are willing to pay for the assurance that their food will be delivered on time.

Table C.16: Parameter estimates guarantee, MD

Name	Value	Robust Std err	Robust t-test	p-value	Significant?	Expected sign?
Guarantee	0.213	0.0604	3.52	0	Yes	Yes

Sustainability **Significance:** the sustainability parameter estimate is not significant. Therefore, the parameter interpretation only applies to the sample. **Value:** the value of the parameter is 0.0304, which is low. **Curve characteristics:** the positive coefficient means that the green delivery has positive utility, and non-green delivery has negative utility. This is as expected. **Utility range & ratio:** the utility range equals twice the parameter value and amounts to 0.06. **Interpretation:** at roughly one tenth the importance of delivery speed, the sustainability factor has very low utility in comparison to the other attributes. A difference between the weight of sustainability for parcel delivery or meal delivery was expected. As it turns out, the estimate for parcel delivery (0.14) is substantially higher than for meal delivery. After correcting for scaling differences between the two surveys, the sustainability is still easily twice as important for parcel delivery than for food delivery. Moreover, compared to the other attributes within the meal delivery experiment, sustainability has

Figure C.25: Graph guarantee parameter estimate MD



low importance. This may be explained by the fact that when consumers order food, there is a certain urgency inferred by hunger. This may lead to sustainability becoming less important, and price and speed becoming more important. Or maybe consumers are still less aware of the impact of meal deliveries than for parcel deliveries.

Table C.17: Parameter estimate sustainability, MD

Name	Value	Robust Std err	Robust t-test	p-value	Significant?	Expected sign?
Sustainability	0.0304	0.0595	0.51	0.61	No	Yes

Figure C.26: Graph sustainability parameter estimate MD

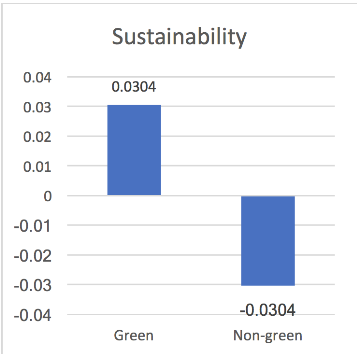


Table C.18: Coding scheme delivery method

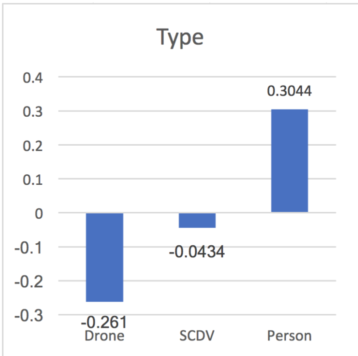
Delivery method	Parameter 1	Parameter 2	Utility
Drone	1	0	-0,261
SCDV	0	1	-0,0434
Person	-1	-1	0,3044

Delivery method **Significance:** there are two delivery method parameters. This is due to the fact that this is a nominal variable with three levels (drone, small curbside delivery vehicle, person), and thus requires two indicator variables. The first parameter is significant, however, the second one is not. **Value:** the parameter values are -0.261 and -0.0434. This translates into a utility of -0.26 for a delivery by drone, -0.04 for a delivery by SCDV and 0.30 for delivery by a person. The coding scheme can be seen in table C.18. **Curve characteristics:** the curve was expected to be v-shaped (start positive, then go down, and go up again). The utility for delivery by person was expected to be highest, followed by the utility for delivery by drone. As it turns out, the drone delivery has lowest utility, changing the shape of the curve. **Utility range:** the difference between highest and lowest utility is 0.5654. This translates into a ratio of 20%, and makes this factor third most important. **Interpretation:** unexpectedly, meal delivery by drone is valued lowest by the consumer with a value of -0.261 utils. Delivery by means of a small curbside delivery vehicle is scaled to 0 utils due to the fact it is not significant. With delivery by a person valued at 0.3044, the relation is almost positively linear. Practically, this means that the respondents assigned quite some value to the traditional delivery by person. This implies that the newer delivery methods - especially drones - are associated with hassle or some sort of inconvenience. Delivery by drone more than delivery by SCDV. The utility range is 0.5654, which puts it near the same range as delivery speed and delivery guarantee. This means that the importance of the delivery method factor should not be underestimated. The high importance was not expected, but is nonetheless very interesting.

Table C.19: Parameter estimates delivery method, MD

Name	**Value**	**Robust Std err**	**Robust t-test**	**p-value**	**Significant?**	**Expected sign?**
Delivery method 1	-0.261	0.0486	-5.37	0	Yes	No
Delivery method 2	-0.0434	0.0496	-0.88	0.38	No	No

Figure C.27: Graph delivery method parameter estimate MD



D

APPENDIX: RESULTS & INTERPRETATION

D.1. Consumer groups

This section highlights differences in delivery service choice making between different consumer groups. From a market perspective it is of importance to know if the parameter estimates obtained for the whole dataset, are the same across certain subgroups. This section looks into which groups have different parameter estimates, and if these deviations are substantial (read: significantly different). The consumer groups which are taken into consideration in this section are: age group 20-34 (millennials), age group 35-49 (generation x), age group 50-64 (boomers) and a subset with only the respondents who indicated to be "green minded". This section provides an answer to the sub question *"How do delivery preferences differ between consumer groups?"*.

For each subset, the parameter estimates were calculated by means of python-biogeme in the same fashion as discussed earlier in this chapter. The parameter outcomes where then filtered: only the significant parameter estimate values were kept. Comparing insignificant parameters to each other is of no use. In order to determine if the consumer sub groups' preferences and trade-off's are statistically different from that of the total sample, the 95% confidence intervals (CI) were used as a criterion. This lower and upper bound of this interval indicate if other parameter values are statistically different. The CI's are determined with equation D.1.1. If the (significant) parameter values of a subset lies outside of these bounds, it can be assumed to be statistically different.

$$CI(95\%) = \beta \pm 1.96 * s.e. \tag{D.1.1}$$

D.1.1. Data segmentation parcel delivery

Figure D.1: Cross subset parameter estimate comparison parcel delivery

	Total				Green	20-34	35-49	50-64
Parameter name	**Sig.?**	**CI-low**	**Value**	**CI-high**	**Value**	**Value**	**Value**	**Value**
Parcel pick-up constant	-	-	-	-	-	-	-	-
Drone constant	*	-0,30	**-0,06**	0,18	*	0,48	-0,58	*
Home delivery constant	**Yes**	0,57	**0,83**	1,09	*	1,33	*	1,51
Price parameter 1 (linear)	*	-0,11	**-0,05**	0,00	*	*	*	*
Price parameter 2 (quadratic)	**Yes**	-0,02	**-0,02**	-0,01	-0,02	-0,02	*	-0,03
Drone delivery: Location 1	*	-0,36	**-0,15**	0,06	*	*	*	*
Drone delivery: Location 2	*	-0,08	**0,12**	0,32	*	*	*	*
Drone delivery: Location 3	*	-0,15	**0,03**	0,20	*	*	*	*
Drone delivery: Speed 1	**Yes**	-0,48	**-0,26**	-0,03	*	*	-0,46	*
Drone delivery: Speed 2	**Yes**	-0,40	**-0,20**	-0,01	-0,40	*	*	*
Drone delivery: Speed 3	*	-0,12	**0,06**	0,23	*	*	0,37	*
Drone delivery: Window 1	*	-0,06	**0,11**	0,28	*	*	*	*
Drone delivery: Window 2	*	-0,36	**-0,15**	0,07	*	*	*	*
Drone delivery: Window 3	**Yes**	0,09	**0,30**	0,52	0,58	0,42	*	0,50
Home delivery: Speed 1	*	-0,16	**0,13**	0,42	*	*	*	*
Home delivery: Speed 2	**Yes**	0,12	**0,30**	0,48	*	0,32	*	0,66
Home delivery: Speed 3	*	-0,33	**-0,15**	0,03	*	*	*	-0,52
Home delivery: Window 1	*	-0,07	**0,17**	0,42	*	*	*	*
Home delivery: Window 2	*	-0,21	**-0,05**	0,12	*	*	*	*
Home delivery: Window 3	*	-0,35	**-0,11**	0,14	*	*	*	-0,56
Interaction	*	-0,02	**0,02**	0,06	*	*	*	*
Parcel pick-up: Accessibility 1	**Yes**	-0,44	**-0,29**	-0,14	-0,40	-0,37	*	-0,38
Parcel pick-up: Accessibility 2	**Yes**	0,03	**0,18**	0,33	*	*	0,27	*
Parcel pick-up: Accessibility 3	*	-0,12	**0,04**	0,19	*	*	*	*
Parcel pick-up: Location 1	**Yes**	0,05	**0,21**	0,36	*	*	0,29	0,55
Parcel pick-up: Location 2	*	-0,13	**0,02**	0,17	0,28	*	*	*
Parcel pick-up: Location 3	*	-0,32	**-0,15**	0,01	*	*	*	-0,63
Parcel pick-up: Speed 1	*	-0,10	**0,06**	0,23	*	*	*	0,40
Parcel pick-up: Speed 2	*	-0,02	**0,14**	0,31	*	*	*	*
Parcel pick-up: Speed 3	**Yes**	0,16	**0,30**	0,43	*	0,29	0,34	0,36
Sustainability	*	-0,04	**0,07**	0,18	0,15	0,25	*	0,30

Sig. & higher value
Sig. (total = non-sig.)
Sig. & lower value

The differences in parameter values found by the data segmentation are discussed in this part by naming the differences per consumer group relative to the total dataset. Figure D.1 shows the parameter values of the total sample as well as the corresponding CI's. The parameter estimates of the sub sets are shown only if they are significant. If not, the cell is filled by an asterisk. Moreover, some cells have colour coding. The green colour highlights the parameter estimates which have a statistically higher value than the main sample. The orange colour highlights the parameter estimates which have a statistically lower value than the main sample. The blue colour highlights the parameter estimates which are significant, whereas the estimates in the main sample were not. In the next segment, the noteworthy differences and patterns are discussed.

Green group

There are two parameter estimate values which are noteworthy for the green consumer group. Firstly, the drone delivery window of 3/4 hours is appreciated more highly than for the total dataset. This means that the green group tilts even more towards a preference for a 3/4 hour delivery window. Secondly, the second PP location parameter is significant whereas this is not the case for the total dataset. This means that the pick-up location neighbourhood is preferred to street. Overall, many parameters are not significant within this group. This may be due to the relatively low sample size. As expected, the sustainability parameter was significant. The value was twice as high than that of the total sample, at a value of 0.15. In conclusion: there are a few differences between the green group and the total sample. However, too little parameters are significant to be able to signify the differences. Expectedly, the sustainability factor is significant for this group, where these respondents explicitly indicated to be willing to spend more money on a sustainable delivery method.

Age group 20-34
This sub group assigns a positive value to drone delivery. Moreover, home delivery is also appreciated more highly than for the total sample. This means that the pick-up point is valued less, as these are all relative values. Furthermore, sustainability is significant for this sub group. It is also more than three times higher (0.25) than for the total sample (0.07). This is remarkable, and very relevant for marketing purposes, as sustainability was assumed to play an insignificant role with parcel delivery choice making.

Age group 35-49
This sub group also assigns significant value to the drone delivery. However, this time around it is a negative value of (-0.58). HD and PP are both equal to zero. This means that PP and HD are valued equally, and that DR is valued lower. Next, the drone delivery speed of "within 4 hours" is valued highest as opposed to the "same day" delivery for the whole data set. This implies that the age group 35-49 has a different drone delivery speed sweet spot.

Age group 50-64
The oldest group in the dataset - age 50-64 - values home delivery much more highly than PP and DR at a value of 1.51 (HD) versus 0.0 (DR, PP). Moreover, this generation is more sensitive to price, as the quadratic price parameter is higher (-0.3) than that of the total sample (-0.2). Moreover, the difference in appreciation between "same day" and "next day" is higher. This means that this group has a higher willingness to pay for a same day delivery than for a next day delivery. Next, the convenience of a PP delivery in the same street is more important for this group. PP at the station is more inconvenient for this group than for the total sample. Also, the PP delivery speed of "same day" is more important for this group as well. Lastly, the sustainability factor is significantly important for this group. Its value (0.30) being almost four times as high as for the total group (0.07).

From an attribute perspective
The **DR constant** value and sign differs greatly between consumer groups. Age group 20-34 assigns positive value to DR, whereas 35-49 assigns negative value to DR. **Home delivery** seems to be especially valued by groups 20-34 and 50-64. **Price sensitivity** is higher for the highest age group. **Interaction** is not of significant influence for any of the groups nor the whole data set. **Sustainability** is only important for the 20-34 and 50-64 age groups.

D.1.2. Data segmentation meal delivery

For meal delivery, the same steps were taken to segregate the data. The differences in parameter values found by the data segmentation are discussed in this part by naming the differences per consumer group relative to the total dataset. Figure D.2 shows the parameter values of the total sample as well as the corresponding CI's. The parameter estimates of the sub sets are shown only if they are significant. If not, the cell is filled by an asterisk. Moreover, some cells have colour coding. The green colour highlights the parameter estimates which have a statistically higher value than the main sample. The orange colour highlights the parameter estimates which have a statistically lower value than the main sample. The blue colour highlights the parameter estimates which are significant, whereas the estimates in the main sample were not. In the next segment, the noteworthy differences and patterns are discussed.

Figure D.2: Cross subset parameter estimate comparison meal delivery

	Total				Green	20-34	35-49	50-64
	Sig.?	CI-low	Value	CI-high	Value	Value	Value	Value
Delivery price	Yes	-0,51	**-0,38**	-0,24	-0,39	-0,40	-0,50	-0,27
Guarantee	Yes	0,09	**0,21**	0,33	0,37	0,30	*	0,21
Speed	Yes	-0,03	**-0,02**	0,00	-0,02	-0,03	*	*
Sustainability	*	-0,09	**0,03**	0,15	0,30	*	*	*
Delivery method 1	Yes	-0,36	**-0,26**	-0,17	*	-0,22	-0,29	-0,29
Delivery method 2	*	-0,14	**-0,04**	0,05	-0,19	*	*	*

Sig. & higher value
Sig. (total = non-sig.)
Sig. & lower value

Green group
The green group differs from the whole data set in a couple of ways. Firstly, the green group values delivery guarantee (0.37) more than the total sample (0.21) does. This in turn means a higher willingness to pay for this feature. Most importantly, the sustainability factor is indeed important for this group. Its value is 0.30, which equals a WTP of €1.54. Lastly, drone delivery is valued average, the delivery robot below average, and the delivery by person as highest. This differs from the total sample which valued drone and delivery robot the other way around.

Age groups [20-34, 35-49, 50-64]
The age groups do not differ significantly from the main sample. The only remarkable differences are that the 35-49 group does not value delivery guarantee. Moreover, groups 35-49 and 50-64 are not sensitive to delivery speed. This means that the values within this scope (15 till 60 minutes) are all acceptable for these groups.

Just as with the data segregation for the parcel delivery dataset, the results can be seen in tables D.1 and D.2 for a visual overview.

D.2. Willingness to pay

Theoretical framework The willingness to pay (WTP) for each attribute (level) represents the monetary value of a certain aspect of the delivery services assessed in this research. In choice modelling, the value of a delivery service is the sum of the value of the different factors of which the service is comprised. This value is expressed in terms of utility. The willingness to pay is another means of expressing value: in monetary terms. It can be determined by two factors: the coefficient of price (in terms of utility) and the coefficient of an attribute.

Willingness to pay parcel delivery First, the willingness to pay for the parcel delivery experiment is discussed. As price is quadratic, there are two price coefficients. One for the linear component, and one for the quadratic component. Therefore, the tangent of the price factor is dependent on price. The WTP is determined by means of equation D.2.1 through D.2.3, in which the coefficient for an attribute is divided by the first derivative of the price function.

$$U(price) = \beta_{C1} * price + \beta_{C2} * price^2 \tag{D.2.1}$$

$$U'(price) = \beta_{C1} + 2\beta_{C2} * price \tag{D.2.2}$$

$$WTP = \frac{\beta_{attribute}}{\beta_{C1} + 2\beta_{C2} * price} \tag{D.2.3}$$

The results for parcel pick-up (nesting pick-up point, and self driving parcel locker), home deliveries (nesting home delivery, small curbside delivery vehicle, and small scale courier) and drone delivery can be seen in tables D.1, D.2 and D.3. Please note that the willingness to pay was determined for each price point represented in the choice modelling design. The willingness to pay for the parcel delivery experiment is a continuous function in principle due to the quadratic nature of the price function. As can be seen in the tables D.1

through D.3, the willingness to pay for each attribute (level) decreases when the delivery price increases. This is because of the negative quadratic price function.

Please also take into consideration that for the effect-coded variables, the monetary values in the tables represent the absolute value of an attribute level. The willingness to pay in this case is relative. Let us look at an example for the PP alternative (table D.1): at a price of €2.-, the WTP for a delivery in the consumers' street (€1.68) in stead of at a pick-up point (-€0.61) is the difference between the two and thus equals €2.29. This also holds for comparing WTP for the same attribute level across delivery prices.

Table D.1: Willingness-to-pay for PP factors parcel delivery

Parcel pick-up				
Delivery price	-€2.00	€-	€2.00	€4.00
	WTP speed			
Same day	-€4.30	€1.18	€0.52	€0.33
Same evening	-€9.60	€2.63	€1.16	€0.74
Next day	-€19.80	€5.43	€2.39	€1.53
2 days	€33.70	-€9.25	-€4.07	-€2.61
	WTP location			
Street	-€13.96	€3.83	€1.68	€1.08
Neighbourhood	-€1.40	€0.38	€0.17	€0.11
Station	€10.34	-€2.84	-€1.25	-€0.80
Pick-up point	€5.02	-€1.38	-€0.61	-€0.39
	WTP accessibility			
12u-17u	€19.53	-€5.36	-€2.36	-€1.51
09u-18u	-€12.21	€3.35	€1.47	€0.94
09u-21u	-€2.52	€0.69	€0.30	€0.20
00u-00u	-€4.79	€1.31	€0.58	€0.37
	WTP sustainability			
Green	-€10.07	€2.76	€1.21	€0.78
	WTP interaction			
Machine	€2.68	-€0.74	-€0.32	-€0.21

Table D.2: Willingness-to-pay for HD factors parcel delivery

Home delivery				
Delivery price	€-	€3.00	€6.00	€9.00
	WTP speed			
Same hour	€2.39	€0.82	€0.50	€0.36
Same day	€5.45	€1.87	€1.13	€0.81
Next day	-€2.76	-€0.95	-€0.57	-€0.41
2 days	-€5.08	-€1.75	-€1.05	-€0.75
	WTP window			
1/2 hrs	€3.20	€1.10	€0.66	€0.48
2 hrs	-€0.83	-€0.29	-€0.17	-€0.12
3 1/2 hrs	-€1.95	-€0.67	-€0.40	-€0.29
5 hrs	-€0.42	-€0.14	-€0.09	-€0.06
	WTP sustainability			
Green	€2.76	€0.95	€0.57	€0.41
	WTP interaction			
Machine	-€0.74	-€0.25	-€0.15	-€0.11

Table D.3: Willingness-to-pay for DR factors parcel delivery

Drone delivery				
Delivery price	€-	€4.00	€8.00	€12.00
	WTP speed			
Same hour	-€4.77	-€1.34	-€0.78	-€0.55
Within 2 hrs	-€3.72	-€1.05	-€0.61	-€0.43
Within 4 hrs	€1.04	€0.29	€0.17	€0.12
Same day	€7.45	€2.10	€1.22	€0.86
	WTP location			
Home	-€2.74	-€0.77	-€0.45	-€0.32
Street	€2.19	€0.62	€0.36	€0.25
Neighbourhood	€0.46	€0.13	€0.08	€0.05
Pick-up point	€0.09	€0.02	€0.01	€0.01
	WTP window			
1/4 hrs	€2.04	€0.58	€0.34	€0.24
1/2 hrs	-€2.65	-€0.75	-€0.43	-€0.31
3/4 hrs	€5.54	€1.56	€0.91	€0.64
1 hrs	-€4.94	-€1.39	-€0.81	-€0.57
	WTP sustainability			
Green vs non	€2.76	€0.78	€0.45	€0.32
	WTP interaction			
Human vs machine	-€0.74	-€0.21	-€0.12	-€0.09

Willingness to pay meal delivery Secondly, the willingness to pay for the meal delivery experiment is discussed. The meal delivery model is much simpler than the parcel delivery model. Price is represented by a linear component only, which makes that the tangent of the price-utility function is equal for all prices. The WTP was derived by using equations D.2.4, D.2.5 and D.2.6.

$$U(price) = \beta_{price} * price \tag{D.2.4}$$

$$U'(price) = \beta_{price} \tag{D.2.5}$$

$$WTP = \frac{\beta_{attribute}}{\beta_{price}} \tag{D.2.6}$$

The results can be seen in table D.4. Because the meal delivery experiment is unlabelled, the WTP is not alternative dependent. For the meal delivery experiment, the WTP is expressed differently than for the parcel delivery experiment. This is because the variables (except for delivery method) were modelled linearly. This difference is demonstrated through a couple of examples:

Example 1: What is the WTP for a delivery service which is 15 minutes faster?
The WTP for delivery speed is €0.04 per minute of speed. This means that 15 minutes of time are worth $15 * £0.04$. *The total value of the WTP therefore is €0.60.*

Example 2: What is the WTP for a delivery by a person compared to delivery by drone?
The value for 'person' is €0.81. In this case, the difference between values matter. In comparison, the value for 'drone' is €-0.26. Therefore, the WTP for a delivery by person instead of delivery by drone is €1.07.

Table D.4: Willingness-to-pay for the meal delivery factors

	Utility	Willingness-to-pay	Unit
Price [utils/€]	-0.38	-	-
Guarantee [utils/guarantee]	0.43	€1.13	€/guarantee
Speed [utils/minute]	-0.02	€0.04	€/minute
Sustainability [utils/sustainability]	0.06	€0.16	€/sustainability
Drone [utils/drone]	-0.26	-€0.69	€/drone
SCDV [utils/SCDV]	-0.04	-€0.12	€/SCDV
Person [utils/person]	0.30	€0.81	€/person

D.3. Choice prediction

D.3.1. Delivery service scenario's parcel delivery

1. Parcel point

The parcel point delivery service is the representation of the current 'PostNL-punt' and 'Kiala-punt' pick-up point delivery services. The delivery location is a designated pick-up point which can be chosen by the consumer, and the delivery speed is generally two days. When the parcel has arrived at the pick-up location, the consumer can pick it up within the opening hours. Table D.5 shows the specifications of the parcel point delivery service.

Table D.5: Delivery specifications parcel point

	1. Parcel point			
Price	-€2,00	**€-**	€2,00	€4,00
Speed	Same day	Same evening	Next day	**2 days**
Location	Street	Neighbourhood	Station	**Pick-up point**
Accessibility	12u-17u	09u-18u	**09u-21u**	00u-00u
Window	-	-	-	-
Sustainability	Green choice	**Non-green choice**	-	-
Interaction	**Human**	Machine	-	-

2. Self driving parcel locker

The self driving parcel locker is a non-stationary parcel wall. The idea is that this delivery solution functions like a regular parcel wall as already used on some train stations. However, this delivery innovation is also able to move from point to point. This potentially decreases the distance between the pick-up point and the consumers' home for increased convenience. The interaction with the consumer is electronic, for there is no personnel needed to operate the self driving parcel locker. Table D.6 shows the specifications of the self driving parcel locker.

Table D.6: Delivery specifications self driving parcel locker

	2. Self driving parcel locker			
Price	**-€2,00**	€-	€2,00	€4,00
Speed	Same day	Same evening	Next day	**2 days**
Location	Street	**Neighbourhood**	Station	Pick-up point
Accessibility	12u-17u	09u-18u	09u-21u	**00u-00u**
Window	-	-	-	-
Sustainability	**Green choice**	Non-green choice	-	-
Interaction	Human	**Machine**	-	-

3. Traditional home delivery

This delivery service represents a home delivery service as we know it today. This means that the parcels are transported with a delivery van and are delivered at the consumers' doorstep by a delivery person. Generally, this delivery service takes 2 days, and with most purchases it is free of charge. Table D.7 shows the specifications of the traditional home delivery service.

Table D.7: Delivery specification traditional home delivery

	3. Traditional home delivery			
Price	**€-**	€3,00	€6,00	€9,00
Speed	Same hour	Same day	Next day	**2 days**
Location	**Home**	-	-	-
Accessibility	-	-	-	-
Window	1/2 hrs	2 hrs	**3 1/2 hrs**	5 hrs
Sustainability	Green choice	**Non-green choice**	-	-
Interaction	**Human**	Machine	-	-

4. Small scale courier

The small scale courier is a local, small scale courier service which is able to assign couriers to local deliveries. It can be seen as a form of express service. The couriers use a green model of transport, and are able to deliver within the hour. The delivery cost does increase due to the specialized and fast nature of the service. Table D.8 shows the specifications of the small scale courier.

Table D.8: Delivery specifications small scale courier

	4. Small scale courier			
Price	€-	€3,00	€6,00	**€9,00**
Speed	**Same hour**	Same day	Next day	2 days
Location	**Home**	-	-	-
Accessibility	-	-	-	-
Window	**1/2 hrs**	2 hrs	3 1/2 hrs	5 hrs
Sustainability	**Green choice**	Non-green choice	-	-
Interaction	**Human**	Machine	-	-

5. Small curbside delivery vehicle
The small curbside delivery vehicle is a compact delivery robot which can replace the traditional home delivery person. The SCDV therefore has comparable delivery service specifications as the traditional home delivery. Of course, the main difference is that the SCDV is automated, and thus requires the transaction of the parcel from the delivery company to the consumer to be digital. Table D.9 shows the specifications of the small curbside delivery vehicle.

Table D.9: Delivery specifications small curbside delivery vehicle

	5. Small curbside delivery vehicle			
Price	**€-**	€3,00	€6,00	€9,00
Speed	Same hour	Same day	Next day	**2 days**
Location	**Home**	-	-	-
Accessibility	-	-	-	-
Window	1/2 hrs	**2 hrs**	3 1/2 hrs	5 hrs
Sustainability	**Green choice**	Non-green choice	-	-
Interaction	Human	**Machine**	-	-

6. Drone delivery
The drone delivery proposition can be done in many ways. In this section, the drone delivery is specified as a fast delivery service. This means that the delivery time is low, but price is high. It was assumed that the drone will land somewhere in the consumers' street, and is able to perform very quick deliveries.

Table D.10: Delivery specifications drone delivery

	6. Drone delivery			
Price	€-	€4,00	**€8,00**	€12,00
Speed	Same hour	Within 2 hrs	**Within 4 hrs**	Same day
Location	Home	**Street**	Neighbourhood	Pick-up point
Accessibility	-	-	-	-
Window	1/4 hrs	**1/2 hrs**	3/4 hrs	1 hrs
Sustainability	**Green choice**	Non-green choice	-	-
Interaction	**Machine**	-	-	-

D.3.2. Parcel delivery scenario's & choice distributions

In this section, six delivery choice scenario's are presented. For each of these scenario's the choice shares are also given to give an impression of the capabilities of the MNL model. First, the scenario is shortly explained, secondly the results are discussed. Each result table presents the choice shares and the choice options available, with their respective features. Please keep in mind that these choice predictions apply to urban areas, as this was the scope of the sample.

Scenario 0: traditional
This scenario includes only the traditional delivery services. This means that the traditional home delivery is compared to the parcel point. Table D.11 shows the delivery specifications and choice shares. Home delivery has a predicted share of 73%, and parcel point a predicted share of 27%.

Table D.11: Choice shares scenario 0: traditional delivery services

	Scenario 0: traditional delivery services		
	PP	HD	DR
Scenario 0	**Parcel point**	**Traditional home delivery**	**-**
Price	0,00	0,00	n.a.
Speed	2 days	2 days	n.a.
Location	Pick-up point	n.a.	n.a.
Accessibility	09u-21u	n.a.	n.a.
Window	n.a.	3 1/2 hrs	n.a.
Sustainability	Non-green choice	Non-green choice	n.a.
Interaction	Human	human	n.a.
Choice share	**27%**	**73%**	**-**

Scenario 1: drone as express service

This scenario looks at the impact of a drone service alongside the current delivery services. The new drone delivery would be an express service, and the choice share predictions indicate the shift from current services to the drone delivery. Table D.12 shows the delivery specifications, and the projected shares. In this case, the drone delivery service would take a market share of 10%, and would leave parcel point at 24% and traditional home delivery ar 66%. The shift of 10% might not seem like a large shift. However, when taking into account the fact that the context of the survey was a purchase of a product with no particular hurry, it is quite logical for the drone share to be relatively low.

Table D.12: Choice shares scenario 1: drone as express service

	Scenario 1: drone as express service		
	PP	HD	DR
Scenario 1	**Parcel point**	**Traditional home delivery**	**Drone delivery**
Price	0,00	0,00	8,00
Speed	2 days	2 days	Within 4 hrs
Location	Pick-up point	n.a.	Street
Accessibility	09u-21u	n.a.	n.a.
Window	n.a.	3 1/2 hrs	1/2 hrs
Sustainability	Non-green choice	Non-green choice	Green choice
Interaction	Human	human	Machine
Choice share	**24%**	**66%**	**10%**

Scenario 2: Self driving parcel locker

This scenario serves to compare the impact of implementing the SDPL into the delivery market. Measure the impact, two scenario's are compared: one with the parcel point (2.1) and one with the SDPL (2.2). Both scenario's include the traditional home delivery and drone service as well. The results in table D.13 show that the choice share of the SDPL is 30%, which is an 6% increase compared to the parcel point delivery service (24%).

Table D.13: Choice shares scenario 2: self driving parcel locker

	Scenario 2: self driving parcel locker		
	PP	HD	DR
Scenario 2.1	**Parcel point**	**Traditional home delivery**	**Drone delivery**
Choice share 2.1	**24%**	**66%**	**10%**
	PP	HD	DR
Scenario 2.2	**Self driving parcel locker**	**Traditional home delivery**	**Drone delivery**
Price	-2,00	0,00	8,00
Speed	2 days	2 days	Within 4 hrs
Location	Neighbourhood	n.a.	Street
Accessibility	00u-00u	n.a.	n.a.
Window	n.a.	3 1/2 hrs	1/2 hrs
Sustainability	Green choice	Non-green choice	Green choice
Interaction	Machine	human	Machine
Choice share 2.2	**30%**	**61%**	**9%**

Scenario 3: home delivery innovations

scenario 3 compares the different market shares of the delivery services that were nested in the HD alternative. These delivery services are: traditional home delivery, small scale courier and small curbside delivery vehicle. This was done by running three scenario's and varying the HD delivery option. The small scale courier is a quick delivery option, which is expected to have a relatively low share due to the higher price. The results can be seen in table D.14. Traditional home delivery has a share of 66%, small scale courier a share of 40%, and SCDV a share of 69%. Compared to the base delivery service, SCC has a 26% lower market, and SCDV has a 6% higher market share.

Table D.14: Choice shares scenario 3: home delivery innovations

	Scenario 3: home delivery innovations		
	PP	HD	DR
Scenario 3.1	**Parcel point**	**Traditional home delivery**	**Drone delivery**
Choice share 3.1	**24%**	**66%**	**10%**
	PP	HD	DR
Scenario 3.2	**Parcel point**	**Small scale courier**	**Drone delivery**
Price	0,00	9,00	8,00
Speed	2 days	Same hour	Within 4 hrs
Location	Pick-up point	n.a.	Street
Accessibility	09u-21u	n.a.	n.a.
Window	n.a.	1/2 hrs	1/2 hrs
Sustainability	Non-green choice	Green choice	Green choice
Interaction	Human	human	Machine
Choice share 3.2	**43%**	**40%**	**17%**
	PP	HD	DR
Scenario 3.3	**Parcel point**	**Small curbside delivery vehicle**	**Drone delivery**
Price	0,00	0,00	8,00
Speed	2 days	2 days	Within 4 hrs
Location	Pick-up point	n.a.	Street
Accessibility	09u-21u	n.a.	n.a.
Window	n.a.	2 hrs	1/2 hrs
Sustainability	Non-green choice	Green choice	Green choice
Interaction	Human	Machine	Machine
Choice share 3.3	**22%**	**69%**	**9%**

Scenario 4: battle of the fastest
The battle of the fastest involves the SSC and drone delivery as they can compete directly to each other based on their speed. Table D.15 contains the predicted choice shares. SSC has a higher share at 70%, and drone has a share of 30%.

Table D.15: Choice shares scenario 4: battle of the fastest

	Scenario 4: battle of the fastest		
	PP	HD	DR
Scenario 4	**-**	**Small scale courier**	**Drone delivery**
Price	n.a.	9,00	8,00
Speed	n.a.	Same hour	Within 4 hrs
Location	n.a.	n.a.	Street
Accessibility	n.a.	n.a.	n.a.
Window	n.a.	1/2 hrs	1/2 hrs
Sustainability	n.a.	Green choice	Green choice
Interaction	n.a.	human	Machine
Choice share 4	**-**	**70%**	**30%**

Scenario 5: fully automated
The fully automated scenario compares the market performance of the three automated delivery services: SDPL, SCDV and drone delivery. SDPL and SCDV can compete directly because they both offer a 2 day delivery. Drone is (again) the faster (express) delivery service. Table D.16 shows the choice shares. SDPL has a share of 27%, SCDV has a share of 65%, and drone a mere share of 8%.

Table D.16: Choice shares scenario 5: fully automated

	Scenario 5: fully automated		
	PP	HD	DR
Scenario 5	**Self driving parcel locker**	**Small curbside delivery vehicle**	**Drone delivery**
Price	-2,00	0,00	8,00
Speed	2 days	2 days	Within 4 hrs
Location	Neighbourhood	n.a.	Street
Accessibility	00u-00u	n.a.	n.a.
Window	n.a.	2 hrs	1/2 hrs
Sustainability	Green choice	Green choice	Green choice
Interaction	Machine	Machine	Machine
Choice share 5	**27%**	**65%**	**8%**

Parcel delivery implications In general, the home delivery services have an edge over the other delivery services in terms of market share. This means that the traditional home delivery and the small curbside delivery vehicle do best. However, this is due to the fact that consumers prefer a home delivery. When looking at the performance of the pick-up point type delivery services (parcel point and self driving parcel locker), one can observe that the new SDPL has an edge over the current parcel point. Drone delivery - as in these scenario's - is an express service, and offers a speedier delivery at higher cost. The same hold for the small scale courier. These services both have a relatively low market share (as expected). Between the two, the SSC has an edge over drone.

D.3.3. Meal delivery scenario's & choice distributions

This section demonstrates a few scenario's in which different delivery proposition compare in terms of predicted choice shares. Per scenario, a short explanation and the results are presented.

Scenario 1: only price
In the first scenario, the only factor that is varied is price. Remember that only differences in utility matter of the MNL model. Therefore, when all other delivery specifications are equal, the pure effect of price variation can be demonstrated. Scenario 1 varies the price from €0.- to €2.- with increments of €1.-. Table D.17 shows

that the price shares are 46% (€0.-), 32% (€1.-) and 22%(€2.-). This means a market share decrease of 10% per price increment of €1.-.

Scenario 2: only method
Scenario two only varies the delivery method (person, SCDV and drone). This means that the pure impact of delivery method on market share is demonstrated in this scenario. Table D.17 contains the delivery choice shares. Delivery by person has a share of 44%, SCDV has a share of 31%, and drone has a share of 25%. With delivery by person as a reference point, the SCDV performs 13% worse, and drone performs 19% worse.

Table D.17: MNL choice distributions meal delivery scenario's 1-2

	Scenario 1: only price			**Scenario 2: only method**		
	Alt 1	Alt 2	Alt 3	Alt 1	Alt 2	Alt 3
Price	0	1	2	0	0	0
Speed	45	45	45	45	45	45
Guarantee	no	no	no	no	no	no
Sustainable	no	no	no	no	no	no
Method	person	person	person	person	SCDV	drone
Choice share	46%	32%	22%	44%	31%	25%

Scenario 3: only speed
This scenario involves only a speed increase to demonstrate the impact of delivery speed on choice shares. The speeds used are 30, 45 and 60 minutes. Table D.18 shows that the market shares are 41% (30 minutes), 33% (45 minutes) and 26% (60 minutes). This implies a 7.5% choice share decrease per 15 minute delivery time increase.

Scenario 4: only guarantee
Scenario 4 shows the effect of the delivery guarantee on delivery service choice. Table D.18 shows that the difference between the two is 20% (60% versus 40%), in favour of the delivery with guarantee.

Table D.18: MNL choice distributions meal delivery scenario's 3-4

	Scenario 3: only speed			**Scenario 4: only guarantee**		
	Alt 1	Alt 2	Alt 3	Alt 1	Alt 2	Alt 3
Price	0	0	0	0	0	-
Speed	30	45	60	45	45	-
Guarantee	no	no	no	yes	no	-
Sustainable	no	no	no	no	no	-
Method	person	person	person	person	person	-
Choice share	41%	33%	26%	60%	40%	-

Scenario 5: only sustainability
This scenario shows the effect of the sustainability of the meal delivery service on the delivery choices. The difference in market share is very small at 4%. The delivery specifications and choice shares can be seen in table D.19. It is quite clear that consumers do not care about the sustainability of their meal delivery service at this moment.

Scenario 6: drone
Scenario 6 represents a situation in which the drone delivery competes with other delivery services on speed guarantee and sustainability, while being a bit more expensive. The drone is 15 minutes faster, and costs one to two Euro more than the other options. The drone delivery has a 20% market share compared to the 54% for the free delivery, and 26% for the €1.- delivery.

Table D.19: MNL choice distributions meal delivery scenario's 5-6

	Scenario 5: only sustainability			**Scenario 6: drone**		
	Alt 1	Alt 2	Alt 3	Alt 1	Alt 2	Alt 3
Price	0	0	-	0	1	3
Speed	45	45	-	45	45	30
Guarantee	no	no	-	no	no	yes
Sustainable	yes	no	-	no	no	yes
Method	person	person	-	person	SCDV	drone
Choice share	52%	48%	-	54%	26%	20%

Scenario 7: old versus new
The seventh scenario revolves around a situation in which automated delivery services are introduced in favour of the traditional delivery by a delivery person. The automated delivery services (drone and SCDV) are quicker, guarantee a delivery within time, and are more sustainable. In order to shift the market share towards the new delivery services, the traditional delivery option has a price of €2.-, whereas the automated deliveries are free of charge. This scenario with a clear technology push yields a choice share of 15% for the traditional delivery, 47% for the delivery with a SCDV, and a 38% choice share for delivery by drone. This scenario clearly demonstrates that consumers are massively willing to switch their delivery choices when the right incentives are being used. The details can be viewed in table D.20.

Scenario 0: reference
This scenario serves purely as a reference to illustrate that indeed only the differences between utility matters. This means that when all choice options are equal, the choice becomes a coin toss. Therefore, a even share of 33% is predicted when three equal services compete. Table D.20 reflects this.

Table D.20: MNL choice distributions meal delivery scenario's 7-0

	Scenario 7: old versus new			**Scenario 0: reference**		
	Alt 1	Alt 2	Alt 3	Alt 1	Alt 2	Alt 3
Price	2	0	0	0	0	0
Speed	45	30	30	45	45	45
Guarantee	no	yes	yes	no	no	no
Sustainable	no	yes	yes	no	no	no
Method	person	SCDV	drone	person	person	person
Choice share	15%	47%	38%	33%	33%	33%

Meal delivery implications The meal delivery market reacts strongest to changes in delivery price, speed and guarantee. The drone delivery option has a slight disadvantage, as it is associated with inconvenience compared to the SCDV and delivery by person. Most importantly, the MNL tool is helpful to assess which market proposition result in which market shares. Ultimately, each one of these delivery methods is able to serve the requirements of the consumer, it is important to have a rough estimate of which marketer propositions can compete with each other. The MNL tool provides just that. The results are not meant to be interpreted as the absolute truth, however, the projections do give an indication of the effects of varying delivery aspects such as price, speed and guarantee.

D.4. Implementation advice

This section provides market proposition advise for the different delivery innovations. This advise is based on the outcomes of the parameter estimates (section 4.3.3), their significance (as can be seen in 5.2), and the choice model scenario outcomes in appendix D.3.2 and D.3.3.

Parcel delivery: self driving parcel lockers The self driving parcel locker, hereafter referred to as SDPL, was defined in this research as a parcel pick-up point with the capability to change location in order to decrease the distance from the locker to the consumers' homes, or to be able to drive to an urban consolidation centre to restock on parcels. The SDPL is unmanned, and is accessible 24/7, as it is not limited to store hours as is the case with traditional pick-up points. Due to the high degree of consolidation associated with pick-up point type delivery, and the automation factor, it was assumed that this delivery method can potentially reduce delivery cost drastically for the LSP. This introduces a reason to provide consumers with an incentive to choose this delivery service over others. Therefore, the price was set to -€2.-, which constitutes a discount of the purchase when choosing this delivery option.

When comparing the SDPL market performance to that of the traditional pick-up point, the market share (compared to a traditional home delivery and drone delivery) increases with 6% relative to that of the traditional pick-up point. The absolute values are 24% and 30% market share. This means that the SDPL is able to replace the current pick-up points while increasing the market share.

Regarding the market proposition, it would be acceptable to use a price of €0.- instead of the €2.- discount. The predicted market share decrease is only 1% for this decrease in price. Please take into account that this small decrease only applies to the price interval from -2 to 0. The price curve is quadratic, and the 'penalty' for price increase will thus be progressive instead of linear.

The overall advice regarding the SDPL market proposition is to match the price of the current parcel point service. Moreover, the 2 day delivery speed may stay the same, as this allows for more efficient planning and higher consolidation. The distinctive features of the SDPL – which are a location nearer to consumers' homes, longer opening hours, and a sustainability label – make it more attractive than its predecessor (the parcel point).

Parcel delivery: small scale courier The small scale courier, abbreviated to SSC, was defined in this research as a local, on-demand, courier delivery service. In practice, the SSC is capable to delivery any product from any store at the customers' request. A courier within the network will then be assigned to a pick-up or delivery. This service can potentially be used together with shops and LSP's. Shops can offer local deliveries, where the product can be taken out of the stores instead of the distribution centres. This enables quicker deliveries, and less transport needed for the delivery of products. LSP's could team up with local SSC's to offer quick deliveries, or to handle the seasonal peak pressure without having to over dimension their overall capacity. The SSC were specified in this research as same hour, personal delivery. At a price of €9.-. The service is sustainable – and thus has the green-choice label.

The SSC its forte primarily is its capability to delivery quickly, and personally. Therefore, the SSC was compared to the drone delivery in the MNL scenario's. In a scenario where there are only two quick deliveries available (SSC and DR), SSC would take a market share of 70% versus 30% for the DR. In this scenario, the SSC is quicker than a drone, and one Euro more expensive. It is clear that this delivery type is preferred to drone in a direct face off. When comparing its performance to the traditional home delivery, we see a decrease in market share from 66% for the traditional delivery, versus 40% for SSC delivery. This 26% choice share decrease was expected, because the SSC is much more expensive. Nevertheless, it still holds up nicely.

Market proposition-wise, the SSC is very flexible. The service as it is currently works with its own platform, independently from LSP's. From the MNL model calculations, there is apparently a substantial share of consumers who is willing to pay more for a quick delivery as the SSC offers. Therefore, exploring the possibilities for teaming up with local shops form bigger brands may be interesting. The retail chain can therewith offer a swift delivery of their products which are taken from local stock, which also reduces extra transportation kilometres. Teaming up with local stores which currently do not offer deliveries is also an option, but this is already part of the strategy of the SSC. Collaborations with LSP's is also possible. SSC can serve as a quick and personal delivery service, perhaps for special deliveries. Another option is to use SSC's as buffer capacity for seasonal peaks in delivery demand.

Overall, because of the rather unique and flexible market position of the SSC, there are multiple potentially successful market propositions. At the current (modelled) price of €9.-, the service can attract a substantial choice share. If it is possible to reduce the delivery price due to scaling factors, this share will increase progressively. Moreover, when working together with retailers, there are possibilities to 'market' a lower price. This is already done for all 'free' deliveries for web shops – as the delivery costs are accounted for in the product prices. When delivering products from local stock, the freight kilometres can also be reduced, which is beneficial from a societal point of view.

Parcel delivery: small curbside delivery vehicles The small curbside delivery vehicle, or SCDV, is a compact curb-bound vehicle that is able to be operated remotely and transport small parcels. The SCDV can be used for urban last-mile deliveries. The characteristics of this service may resemble that of the current home delivery service in which the parcel is delivered by a delivery person. In this research, the SCDV was modelled to match the traditional home delivery's price and delivery speed. The difference is only the sustainability and interaction, and the time window (which is smaller for the SCDV).

The performance of the SCDV compared to the current home delivery service was evaluated with the MNL model. The main question is if this vehicle can substitute the current delivery method, which in practical terms means that the market share stays the same. Since the sustainability and interaction factors were insignificant, it can be concluded that the consumer is completely indifferent between the current home delivery method and the SCDV delivery. Still, this research abstracted all delivery services in order to model them all. When running the MNL model, the SCDV had a somewhat higher choice share of 69% versus the 66% share of the current home delivery service. This is an increase of 3%. Please note that in this comparison, the SCDV has a smaller time window than the current home delivery service. In the end, it seems that SCDV can perform equally well as the current home delivery service. When comparing its performance against all automated delivery services (the self driving parcel locker, and the drone delivery), the SCDV had a choice share of 65%.

The market proposition of the SCDV could be similar as the current home delivery service. This means that it will simply replace the delivery persons in the process. According to the model which was estimated in this research, consumers do not assign different utility to either. This is because the sustainability and interaction attributes were insignificant. When taking into account that for several sub groups the sustainability factor did return significant parameters, it can be said that the SCDV will have an edge over current home delivery services for those specific groups.

In the end, the SCDV does not perform worse than a home delivery by a person according to the model estimate in this research. This may not seem like much, but it can actually be very positive, as the consumer acceptance seems to be equal. Therefore, it can be concluded that, based on the model used in this research, the SCDV can potentially be a suitable way to automate current delivery services. The main challenge for the SCDV might therefore not be consumer acceptance, but finding a way to make this delivery method fit into the delivery process from a logistical point of view. The delivery robots have a small capacity, and therewith defy the common practice of freight consolidation. The solution to this may be the creation of a hive or mother-ship kind of station which carries these delivery vehicles until the very last mile to the consumers' doorstep. The hive in this example may be an urban distribution centre, and the mothership may be a self driving vehicle.

Parcel delivery: drone delivery The drone delivery (DR) its main difference with the other delivery innovations it that it is not road-bound. Just like the SCDV it is only capable of carrying a relatively small parcel. Moreover, with drones, the payload its weight also plays a big role. There are many forms of drones imaginable, and for this research a rotor based drone was imagined for the drone delivery service. With the air-bound characteristic of the DR, the deliveries can potentially be carried out much quicker than by road. DR does not get hindered by traffic for example. In the MNL model part of this research, the DR was modelled as a quick delivery service. This included a high speed, but also high price. The location where the drone lands was chosen to be the 'street' where the consumer lives. In the future, it may turn out to be more convenient when a street shares a delivery platform, due to infrastructure cost and delivery noise amongst other reasons. The delivery speed is within 4 hours, and the price tag is €8.- which is comparable to the same day deliveries that are available right now.

When comparing the performance of the drone delivery to the traditional parcel points and home deliveries, the market share is only 10%. Compared to the SDPL and SCDV, its choice share is only 8%. Also, when comparing it to its most similar rival (SSC), it only gets 30% choice share. This has to do with a relatively high price, and a much lower alternative specific constant. This means that consumers appreciate the home delivery type services (amongst which is the SSC) higher than the drone delivery, regardless of the attribute levels. This translates into a negative bias towards drones. The reason of which is not known, and cannot be determined within this research.

The drone delivery market proposition was assumed to be a high cost, high speed delivery. The question then is: what is the acceptable market share in order to tend to the needs of the consumer, and be profitable for the LSP? This research does not answer this question. As mentioned already, there are two factors that lower the choice share of the drone delivery drastically: a lower ASC than for the HD type delivery services, and a high price. From the results and details in this thesis research, the first issue cannot be solved due to a lack of information about where this negative bias stems from. However, the second problem, the high price, may be lowered or marketed as lower. The price attribute behaves quadratic, and thus an increase in penalised progressively. According the MNL choice tool developed in this research, the DR delivery service is able to compete with the self driving parcel locker at a delivery price of between €3.- and €4.-. Is this is profitable for an LSP is, of course, a different topic.

Ultimately, the drone delivery service is a more specialized way of delivery. The high cost, high speed characteristic may only appeals to a relatively small share (8-10%) for the average consumer. It should be noted that the trade-off's found in this research were specifically for the scenario in which the consumer was not in a hurry. It is expected that the choice share increases when delivery time is more important to consumers. If an LSP wants to use drones as a replacements for the current home delivery service, it is key to offer competitive prices for this service. On the practical side, there are still a lot of challenges to overcome before drones can be operated in the real world for this application, as the air space is very tightly regulated.

Meal delivery The meal delivery model represents a few different delivery methods. The current delivery, a delivery by SCDV, a fast delivery (possibility buy SSC) and a drone delivery. These different delivery methods were represented by a set of attributes. The main factor in distinguishing the services is the 'delivery method' factor. This attribute could take three values: 'person', 'SCDV', or 'drone'. The utility ratio of this factor is 20%, which represents percentage of the total variation in utility. In other words, the delivery method has quite some impact on delivery choice and is third most influential after price (39%) and speed (24%). The delivery by 'person' is preferred by consumers at a value of 0.30 utils. SCDV is second (-0.04) and drone is third (-0.26). This means that from the automated delivery services, the SCDV has an edge over the drone.

Of course, every one of these delivery services can be of equal value for consumers if the service characteristics are right. For example, one could argue that the -0.22 utils difference between drone and SCDV can be compensated by other factors such as price and speed. If the drone is 15 minutes faster than the SCDV, the delivery value for consumers is equal. If the drone offers delivery guarantee and SCDV does not, the delivery value for consumers is equal. And if price is reduced by 58 cents, the services are equal.

The sustainability factor was found to be statistically insignificant for the total sample. However, the sub set of 'green minded' respondents did return a significant parameter for the sustainability attribute with a value of 0.30 utils. This means that there is a group of consumers which value, or in other words are willing to pay for, a more environmentally friendly delivery service. The willingness-to-pay is around €1.50.

The main take away from this research is that there are indeed differences in consumer appreciation for the different delivery methods. And therewith, the new delivery types will introduce noticeable changes for consumers and may change the way they choose. However, in practice, the consumer mostly does not get to choose the delivery service. They get (or pay for) the service when they purchase with the meal. Still, with the MNL tool that was developed, there can be determined how different delivery systems compete. This could for example make a difference in how delivery platforms like Deliveroo compete with rivals. Or bigger food chains like Domino's pizza, may introduce different delivery options if they find that it serves their customers better and creates an opportunity for extra revenue.

In the end, the advise is to study the effects of changes in delivery policy with help of the model developed in this research. It may not provide a one-on-one comparison with practice, but is does allow to study how consumers hypothetically make choices, what they prefer, and which trade-off's they make. This enables the optimization of current and future delivery systems.

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