EXPLORING THE MARKET POTENTIAL OF BICYCLE CROWDSHIPPING:

A BI-LEVEL ACCEPTANCE PERSPECTIVE

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Exploring the Market Potential of Bicycle Crowdshipping

A Bi-level Acceptance Perspective

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PREFACE

This thesis comes out of my fascination on how the Dutch people deal with their bicycles. Be it shopping groceries, fetching parcels, picking up children at schools, commuting to work, or visiting friends, the Dutch can do countless activities with their bikes. As a person with an interest in logistics, witnessing these phenomenon myself brought an idea that struck in my mind. I wondered on the potential of engaging these cyclists to help solving city's parcel distribution problem. In Indonesia, I have seen how the power of crowd has demonstrated its ability to enhance people's mobility through motorbikes ridesharing platform (take Go-Jek and Grab, for example). Yet, applying the same concept through an even greener means of transport (bikes) for freight transport activities left me intrigued. Based on these motivations, here comes this research that aims to share you the idea as to how crowdsourced bike couriers can potentially reduce our reliance on conventional delivery vans. This study attempts to support the materialization of a more sustainable city logistics.

First and foremost, I would like to thank God for His mercy in giving me the ability to initiate and complete this thesis.

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SUMMARY

The growth of ecommerce has led to significant increase in direct-to-consumer deliveries and the associated last mile. Customers are becoming more demanding in terms of delivery speed and service. This situation brings pressure to the logistics carrier due to the necessity of smaller and more frequent delivery lots, which is more costly. For the environment, this trend entails higher delivery activities within urban neighbourhoods that lead to adverse effect of congestion, emission, and pollution, depriving the liveability of a city.

Crowdshipping emerged as one of the solution for city freight distribution by utilizing the capacity of existing travellers in the transport network to perform goods transportation. The concept is reliant mainly on two stakeholders; a network of couriers that serve the delivery (supply) and a pool of customers (demand) to feed the couriers. Because of its two-sided stakeholders, in crowdshipping managing the balance between demand and supply poses a higher challenge than conventional courier, in which dedicated courier could be assigned to match the demand. Current research have tried to overcome the challenge by conducting behavioural research to gauge the acceptance of stakeholders towards crowdshipping service. Such research attempted to guide the crowdshipping platform to identify contributing factors/features that essentially help to retain the crowdshipping network. Unfortunately, the research have been conducted so far merely evaluate either the supply or demand side of the system, while in fact sustainable crowdshipping service could only be achieved by understanding both sides of the system. A crowdshipping platform that attracts a lot of customers would not sustain without ensuring sufficient couriers, *vice versa*.

This research therefore attempted to fill the knowledge gap by proposing the following research question:

What is the market potential of bicycle crowdshipping, taking into account bi-level behavioural acceptance.

This research takes bicycle as a particular mode for crowdshipping as it is aligned with the main value proposition of crowdshipping (i.e. eco-friendly) and also due to substantial amount of cycling trips in the Netherlands. Moreover, crowdshipping research involving bicycle as the main delivery mode is hardly evident in the literature.

To answer the research question, the study firstly identified the potential market scope to be penetrated by bicycle crowdshipping service. In terms of spatial context, bicycle crowdshipping can step into local and last mile delivery. The former implies that bicycle crowdshipping serves home delivery by cooperating with local stores that provide click and collect service. The latter requires bicycle crowdshipping to establish partnership with urban delivery hub or parcel pickup points. Regarding shipment characteristics, bicycle crowdshipping could carry up to 25 kilograms of package with volume up to 60 dm^3. Most of the current crowdshipping services provides home delivery for all range of products. These findings implied that bicycle crowdshipping is not the most suitable option for consolidated delivery. Considering potential future applications, it was concluded that last mile delivery from pickup points and local stores would be the selected market scope for this bicycle crowdshipping study.

Having known the potential market scope, literature review and benchmarking were carried out to investigate main value propositions of bicycle crowdshipping and the corresponding

service (demand) and job (supply) attributes. The main differentiation of bicycle crowdshipping lies on its flexibility to define delivery condition and its benefits to the society and the environment. Bicycle crowdshipping creates value by matching between couriers and customers and managing the balance between these two. Moreover, bicycle crowdshipping is responsible to determine pricing scheme that assures a sustainable operation. Also with literature review and benchmarking, various service and job attributes of bicycle crowdshipping were identified. Service attributes were categorized according to four groups; traditional feature, control over delivery condition, quality and security, and other differentiation factors. Job attributes were distinguished into three groups; travel setting, rewarding factors, and penalizing factors. Unique value propositions such as CO2 emission savings need to be emphasized when assessing stakeholder's acceptance towards bicycle crowdshipping.

To measure the supply and demand side of bicycle crowdshipping, an efficient-design stated choice experiment (SCE) was developed. Beforehand, criteria-based shortlisting according to expert opinion were carried out to capture the most relevant service and job attributes. The selected service attributes were delivery cost, delivery speed, delivery time window, performance rating, and CO2 emission savings. The selected job attributes were delivery time of day, additional travel time, profit, package weight, and CO2 emission savings. The selected parameters were assigned to the SCE and afterward the resulting attribute weights are deployed to a multinomial logit model representing the individual probability of making/performing crowdshipping demand and supply. All of the selected service attributes were found to significantly influence customer's probability to choose crowdshipping service. Delivery cost appeared as the most important service attribute, followed by adjustable delivery time window, delivery speed, CO2 savings, and performance rating. As for job attributes, two parameters (delivery time of day and CO2 savings) do not significantly influence cyclist's probability to perform a delivery. Additional travel time appeared to be the most important job attributes, followed by package weight and profit.

Elasticity and sensitivity analysis concluded that demand of bicycle crowdshipping is highly sensitive towards price, especially within the price of 4 euro and above. In contrast, supply of bicycle crowdshipping is rather inelastic towards profit, which is signified by the value of elasticity that never reaches above 1. These contradicting properties showed that stimulating crowdshipping supply would be more challenging than demand. To capture the market share of crowdshipping, a market equilibrium model was proposed. The model suggests that, aside from the probability of supply and demand, crowdshipping market share would be dependent on the amount of demand available within the market scope, the amount of cycle commuting trips available, and the productivity of a courier (drop factor). A step wise implementation framework was proposed to guide the crowdshipping platform to apply the model.

A case study in Delft was conducted to generate a tangible analysis of bicycle crowdshipping market. Market share was solved per each demand OD-pair to align the analysis with discrete choice theorem. To assure demand-supply balance, assumptions on crowdshipping membership rate – representing the percentage of cyclists registered as crowdshipping member – was introduced. Crowdshipping has the potential to acquire 14% to 26% of market share with 0.5% membership rate. Increasing the membership rate would result in improved market share and decreased equilibrium price, which is in line with demand-supply theory. Market share estimation was carried out according to two different perspectives; effect of change in bicycle crowdshipping service attributes to its market share, and effect of change in traditional shipping service attributes to bicycle crowdshipping market share. It was revealed that bicycle crowdshipping would not gain a considerable extent of market share due to the inelastic property of its supply function. Providing adjustable delivery time window gave the highest impact in crowdshipping market share. In contrast, traditional shipping would obtain significant market share by improving its service level due to its flexibility with respect to courier supply. Providing adjustable delivery time window also gave the highest impact to traditional shipping's market share.

The research is built on several assumptions and limitations, meaning that the results should be treated with caution. However, important insights can still be inferred as learning points. For practical point of view, the research suggested that adjustable delivery time window plays important role in enticing customers in shifting their delivery preference. Although the effect is subtle, CO2 emission savings also proved to influence preference on bicycle crowdshipping. As such, crowdshipping platform must emphasize those two factors to allow differentiation with other shipping options. The research also shown that bicycle crowdshipping should be responsive to the market changes, for instance by constantly evaluating its pricing. The model provides an interesting insights on the effect of altering service level to bicycle crowdshipping market share, which would be valuable for bicycle crowdshipping platform to evaluate its decision in leveraging its competitiveness. Due to inelastic supply, crowdshipping needs to creatively stimulate its supply side by other methods rather than changing the courier's fee, for instance by optimizing its routing system or by improving drop factor per courier.

Departing from the study limitation, further research would be necessary to improve the relevance of this research. An equivalent study needs to be conducted within different spatial area to infer the generalizability of the model. This research only focuses on commuting trips to capture potential delivery trips, hence a future research could also explore other travel purposes such as shopping and leisure. The research assumes an arbitrary level of crowdshipping membership rate. To refine the model, a further research could be conducted to identify the probability of an individual cyclist to opt as a member of crowdshipping platform. The research applied a rather analytical approach, thus it neglected delivery routing and scheduling from the model. To improve the realism, these two aspects should be incorporated. The study completely separated item price and shipping price, while in practice diverse pricing schemes are applied. Another study can be conducted by incorporating different pricing structure such as marked up price. Lastly, the research assumes that all online shops would provide bicycle crowdshipping as one of the delivery options. To improve the research relevance, a follow-up study can be conducted to measure online shop's willingness to cooperate with bicycle crowdshipping.

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CHAPTER 1: Introduction

1.1 Background

Technological development which stimulates the growth of e-commerce has lead to a significant increase in direct-to-consumer deliveries and the associated "last mile" (Savelsbergh & Van Woensel, 2016). To get the products that they purchased, customers can simply wait until the package is delivered at home. Internet shopper's preference towards delivery speed entice the retailers to provide express shipments such as same-day-delivery, which entails lower delivery volume with higher frequency - the so-called small-lot delivery (Bouwman, 2017; Francke & Visser, 2015). This situation may lead to the growth of van deliveries within urban areas. From logistics carrier's perspective, this situation brings costly transport operations due to inefficient utilization of capacity, not to mention other risks such as unattended/failed delivery (Visser, Nemoto, & Browne, 2014). From citizen's perspective, the adverse effect of increased freight logistics consisting of safety issue, emission, congestion, and pollution bring disutilities to cities' livability (Quak & Tavasszy, 2011).

The concept of crowdshipping emerged as one of the solutions to overcome city logistics challenges. To this end, the service is defined as a platform that connects the customers to a crowd of travelers/commuters that are willing to pick up and deliver packages along their way (later on it is called 'crowdshipping'). Based on the sharing economy concept, crowdshipping leverage the excess capacity of the travelers in transportation network to also carry goods for the purpose of city distribution. Beside its less negative effects to the environment, crowdshipping offers advantage to other form of deliveries as it provides delivery in a fast and personalized way. Parcel delivery request is dealt with in an individual level, making it possible to reduce the shipment lead time and to arrange specific pickup and delivery conditions (Punel & Stathopoulos, 2017). The cost of service is also potentially cheaper since dedicated delivery fleet is not necessary. Because of its potential, crowdshipping business model in recent years attracted either startup companies or well-known players in logistics industry. In the Netherlands we can find Trunkrs, a startup company that engages car commuters to pick up packages in their filling stations and deliver them to recipients along the way home (van Cooten, 2016). In Sweden DHL launched MyWays, a platform where individual requiring deliveries can connect with commuters that are willing to deliver packages with a small fee (Rougès & Montreuil, 2014). In the US, Deliv provide a service in which customers can place order from home and subsequently a community of (occasional) couriers can bid a price to perform the delivery (zipments.com). On the global scale, more than 50 companies worldwide have been using the concept of crowdshipping (VentureRadar, 2017).

Aside from its benefits, there are some concerns related to crowdshipping. The first concern is that the use of crowdshipping service may cause rebound effect; the traveler may be enticed to generate more vehicle.km in order to satisfy demands (Paloheimo, Lettenmeier, & Waris, 2016). Knowing that many of the crowdshipping service relies on car travelers, this situation would be against the ideal of crowdshipping to create a more sustainable delivery. The second concern is related to the service quality and security. Crowdshipping depends on the participation of occasional couriers which may hinder the acceptance of the users; they have no assurance on the reliability and accountability of the courier and they have to share private information such as emails and house addresses to unknown people serving as couriers (Devari, Nikolaev, & He, 2017). The last concern is related to the sustainability of the business model. On one hand, there should be sufficient demand to retain the service and to attract more couriers. On the other hand the availability of couriers (supply) should also be assured to maintain the service quality, while in practice it might be challenging due to occasional nature of the employment. The failure of crowdshipping initiatives such as Saddl.nl and eBay Now signified the importance of assuring both demand and supply to sustain the service (Rougès & Montreuil, 2014; Saddl, 2015).

Engaging bicycle commuters/travelers to perform crowdshipping task might be a potential avenue to partly address the aforementioned concerns. Particularly in the Netherlands, bicycle is known as one of the important modes for traveling. It is also not uncommon to find travelers carrying goods or shopping items with their bicycle. On average, 2.8 million daily trips in the Netherlands are made by bicycle (CBS, 2016c). This signifies the availability of potential carriers to perform bicycle crowdshipping. Bicycle can carry small volume shipments with high frequency, which corresponds to typical characteristics of ecommerce delivery (Visser et al., 2014). In the scope of european city centers, bicycle freight is potentially capable to carry two-third of the freight transport (Lenz & Riehle, 2013). Bicycle is perceived as promising alternative for replacing motorised modes (such as delivery vans) to transport goods in a short distance (Maes & Vanelslander, 2012; Reiter & Wrighton, 2014). Lastly, bicycle is free of rebound effect surrounding crowdshipping method; additional trip.km made by bicycle to satisfy crowdshipping demands will not be a burden to the environment. Instead, it generates health benefits through increased physical activity among the citizens participating as occasional courier (Heinen, van Wee, & Maat, 2010). Considering its value propositions, further research regarding the potential of bicycle crowdshipping is indeed necessary.

1.2 Research Definition

1.2.1 Problem Statement

Most of the existing research in the field of crowdshipping emphasized the operational aspects; that is, finding an optimum configuration of crowdshipping service (such as matching algorithm, routing and scheduling, courier composition) by means of simulation and mathematical optimization (Punel & Stathopoulos, 2017). For example, study by (Arslan, Agatz, Kroon, & Zuidwijk, 2016) and (Archetti, Savelsbergh, & Speranza, 2016) produced a computational simulation that matches crowdshipping tasks with a mixed of occasional drivers and dedicated drivers. Analogous research has been conducted by (Devari et al., 2017) with the focus on utilising user's social network as a pool to select potential courier. These operational research, although are useful to generate concrete measures on the impact of crowdshipping (such as cost and emission reduction), are profoundly reliant on assumptions about behavioral acceptance of both couriers (supply side) and/or potential customers (demand side) to such service (Punel & Stathopoulos, 2017). Operational research that incorporate behavioural acceptance (in other words, decision making process) into the crowdshipping model is hardly evident. The only example the author could find is research by (Devari et al., 2017) that uses binary logit regression to capture delivery probability based on profile of the travellers. In practice, transportation system is unique compared to other technical systems, in a sense that its performances greatly depend on the users' behavior (Teodorovic & Janic, 2016). The presented facts underline the first research gap:

The necessity of study on behavioral acceptance towards crowdshipping to complement the current operational model.

Unlike traditional delivery, in which dedicated couriers would be assigned to 'supply' the service for any incoming demand from customers, crowdshipping relies on occasional couriers. In this sense, successful crowdshipping operation depends a great deal not only to the inclination of the customers, but also to the intention of travellers to perform delivery. Interestingly, research on (behavioral) acceptability of crowdshipping have thus far been conducted only to measure either the demand side, which can be translated into the acceptance of potential customers to use the service, or the supply side, which can be translated into the willingness of potential couriers to perform delivery. An instance for a 'supply' study is the research by (Miller, Nie, & Stathopoulos, 2017) which discovered that the value of traveler's willingness to work[1] for executing crowdshipping task is higher than the value of willingness to pay for travel time savings. Their finding is intuitive given that people would like to gain more than they spend. It is also found that the additional travel time caused by detour and the monetary incentive play a vital role to attract potential couriers. On the 'demand' side, the research of (Punel & Stathopoulos, 2017) focused on the identification of the acceptability of crowdshipping service within specific distance and shipping attribute context. It is observed that for short distance delivery, potential users would value the availability of driver performance monitoring and delivery speed, and cost remains the most important criteria on selecting shipping options.

Focusing on partial side of the system would have a downside; a complete picture on the market potential could not be acquired, because of the following rationale. Knowing the willingness to pay might be beneficial. However, without considering the willingness to work, we couldn't be sure if imposing a certain price (referring to willingness to pay) could pay-off the compensation expected by the travellers. Oppositely, establishing the compensation scheme merely based on willingness to work of traveller couldn't guarantee that customers are willing to pay for the same or higher rate. Crowdshipping requires the critical mass to sustain the service; it needs lots of carriers to ensure fast service and at the same time sufficient customers to feed the couriers (Rougès & Montreuil, 2014). Hence, understanding one side of the system would not suffice; the knowledge on determinants of supply and demand side and the capability to manage the balance between them is needed to ensure scalability of crowdshipping (Frehe, Mehmann, & Teuteberg, 2017; McKinnon, 2016). Comprehensive information is therefore imperative to gain knowledge on the sustainability of crowdshipping business model. Currently, it is not possible to find prevailing research that embrace simultaneous examination into supply and demand of crowdshipping. The preceding situations lead to the second research gap:

The absence of behavioural research that concurrently evaluate supply and demand side of crowdshipping and its implication to crowdshipping market potential.

To the best of author's knowledge, little attention has been given to research the potential of bicycle crowdshipping. Among them are the computational analysis by (Kafle, Zou, & Lin, 2017) that introduce cyclists and pedestrians to complement first mile and last mile of truck delivery, and research by (Paloheimo et al., 2016) that examine the impact of pilot crowdshipping project to organize books delivery for the public library. The first research found that over half of the existing customers could be served by crowdshipping, yet it paid no attention to behavioural acceptance. The second identified the motivation of users and carriers as part of the research question. However, the latter covered only library material deliveries and application to a broader range of service would require further research (Paloheimo et al., 2016). Until this study is carried out, the prospective market penetration of bicycle crowdshipping remains unclear. Given its limitation in terms of maximum payload

[1] The term 'willingness to work' is adopted from research on crowdshipping supply by (Miller et al., 2017)

and distance range, more insights into the service attributes and value propositions of bicycle crowdshipping would be needed. In the context of the Netherlands, existing crowdshipping research paid no concern to the modes of transport being used to deliver the packages, and thus they do not capture specific attitudes associated with the mode of delivery. It may seem paradoxical, as the Netherlands is among the countries in the world with the highest percentage of cyclists. Bicycle crowdshipping remains a potential research avenue, given that crowdshipping users are identified to have more concern about the environment (Punel, Ermagun, & Stathopoulos, 2018). Hence, the environmentally-friendly feature of bicycle crowdshipping may generate different preference characteristics amongst the potential users. The previous propositions signifies the third research gap:

The absence of behavioural research that examine the market potential of bicycle crowdshipping, especially in The Netherlands.

1.2.2 Objective

This research is carried out to fill the knowledge gap on crowdshipping bi-level acceptance and its implication to the market penetration and the lack of knowledge on the market potential of bicycle crowdshipping. For both of which, behavioural perspective plays an essential role. To answer the research gaps, the study is firstly aimed to produce preliminary study on bicycle crowdshipping. Preliminary study is intended to formulate two elements; market context and service attributes. The first element will define prospective market context to be penetrated by bicycle crowdshipping, covering spatial scale of the delivery and shipment characteristics. The second element will specify value proposition and service attributes of bicycle crowdshipping which corresponds to the prospective market.

The second aim of the study is to measure behavioural acceptance of crowdshipping and its implication to the market potential. This entails three elements. The first element will add insights on the demand side of bicycle crowdshipping by measuring customer's acceptance towards the service. The determinants of the service, characterised by the willingness to pay of potential users by incorporating shipping attributes and service context, will be analysed to estimate the service demand. The second element will provide insights on the supply side of the bicycle crowdshipping, the potential couriers. This is done by measuring the willingness to be paid (or also called 'willingness to work') of bicycle commuters and other factors that drive their motivation to participate in crowdshipping. The third element will produce analysis on the interplay between demand and supply side of the system which generates insight on potential market penetration level. In total, five elements of research will be investigated throughout the study.

1.2.3 Research Questions

The problem statement and the research objective implies the following research question:

What is the market potential of bicycle crowdshipping, taking into account bi-level behavioural acceptance?

The term 'potential' here means the extent to which bicycle crowdshipping can be offered as a viable shipping option for package delivery in the urban context. It can be measured in terms of market share. The term 'bi-level' means both supply and demand side of the system are considered as the key elements that influence market potential of bicycle crowdshipping. This is what differentiates this study from earlier research on crowdshipping acceptance. To answer the main research question, several sub-questions (SQs) are proposed.

The first sub-question concerns determining the relevant market scope for bicycle crowdshipping. Despite the fact that supply and demand in crowdshipping constitute a harder-to-solve 'chicken and egg problem'[2] (Rougès & Montreuil, 2014), scoping the demand beforehand will ease the researcher to understand the problem, since the service attributes that follow will have to suit the demand scope. Moreover, bicycle has limitations in terms of load and range which implies less market flexibility than motorized fleet. Later on, the defined market scope is also important to frame the concept of bicycle crowdshipping to research respondents.

SQ #1: What is the prospective market scope of bicycle crowdshipping, and what attributes characterise this market?

In accordance to the market scope, the second sub-question will enumerate possible service/job attributes and value propositions that can be used to measure the acceptance of relevant stakeholders (potential users and carriers) towards bicycle crowdshipping. Defining the service/job attributes is essential because they affect stakeholder's acceptance towards the service (Punel & Stathopoulos, 2017).

SQ #2: What are the possible value propositions and service/job attributes to be offered in response to the prospective market?

The third and fourth sub-questions will respectively generate the measurements on demand and supply side of the system. These include identifying the attributes that strongly influence the acceptance to bicycle crowdshipping and estimating their relative importance. To limit the size of the study, attributes from SQ #2 might need to be shortlisted before investigating the significant attributes. The list of important attributes and their respective weights will be plugged into demand and supply function to estimate the share of crowdshipping.

SQ #3: Which service attributes contribute to customer's acceptance on crowdshipping, and what is the relative importance of these factors? How do this acceptance translate to the service demand?

SQ #4: Which job attributes influence bicycle commuters' acceptance to participate in crowdshipping, and how do they weight these factors? How do this acceptance translate to the service supply?

The last sub-question will make use of the supply and demand function generated by the former two sub-questions to formulate a market penetration model. The first aim is to find supply-demand intersection which indicates the level of service at which the probability of crowdshipping acceptance are the same (hence, the potential market penetration level). Supply-demand balance is needed in crowdshipping to ensure viability of the service (McKinnon, 2016). The next aim is to identify other factors beyond monetary terms that affect the market penetration level.

SQ #5: Given the bi-level acceptance, how could one determine potential market penetration level of bicycle crowdshipping? Which factors would contribute to improve the market penetration?

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[2] The market scope (hence, the scale of demand) to be served by crowdshipping depends on the number of couriers available. Yet, to attract the mass of couriers, a sufficient number of demand should be exist. This circular relationship creates chicken and egg problem harder for crowdshipping than traditional courier.

1.2.4 Relevance

The relevance of this research can be distinguished according to societal and scientific point of view.

From a scientific perspective, this research helps to address emerging issues regarding crowdshipping behavioural acceptance. The third and fourth research sub-question will serve this purpose by providing underlying factors affecting the acceptance of stakeholders towards crowdshipping. The study will provide a more holistic approach on the market diffusion of crowdshipping service by concurrently evaluating demand and supply, which is currently lacking given that most behavioral research evaluates only either side of the system. This contribution is accommodated by developing a model that examines the relationship between crowdshipping supply and demand and its implication to the market penetration level. Lastly, the research will help to improve current operational model on crowdshipping. Knowledge on the influencing factors could serve as an input for agent-based simulation study that can provide overall effects of crowdshipping, such as potential emission reduction or potential shift on freight transport modes (Frehe et al., 2017).

From a societal point of view, this research can be useful for logistics provider interested in crowdshipping business model. Firstly, this research will guide them to identify potential service attributes of crowdshipping that will be favored by relevant stakeholders, herein are referred to as the couriers and the potential customers. Secondly, this research will aid them to identify the possible incentive and pricing mechanism to sustain the network size. Some researches emphasized that one of the primary crowdshipping business challenges is to maintain the stakeholder acceptance (Frehe et al., 2017; McKinnon, 2016; Rougès & Montreuil, 2014) and hence the research would help to tackle this challenge. Instead of relying purely on the market force to identify the optimum service level, crowdshipping platform could use the model from this study to accelerate its learning curve. By doing so, it is expected that crowdshipping platform would be able to thrive and sustain before it is running out of resource. Thirdly, the research result will be of importance to help to identify the market penetration of crowshipping, which is done by finding the equilibrium point between supply and demand side of the system. Lastly, the research will help to overcome political and legal barriers that hinder crowdshipping business. By providing empirical evidence on crowdshipping potential, the research can help to induce political actors to accommodate crowdshipping business, for instance through imposing tax reduction for crowdshipping providers (Frehe et al., 2017; Le & Ukkusuri, 2018a).

1.3 Methodology & Deliverables

This section describes how each of the research sub-questions (SQs) defined previously could be answered throughout the research. Based upon this information, the framework of the study will be developed.

SQ #1

To answer the first sub-question, firstly the spatial scale of the service will be examined. The operating area of bicycle crowdshipping might be different from other delivery modes given its range limitations. Secondly, the nature of the demand will be explored. The characteristics of the demand such as shipment (commodity) type and cargo characteristics (size and weight) will be examined. To answer the mentioned propositions, a literature study on bicycle courier such as those performed by (Lenz & Riehle, 2013) and (Schliwa, Armitage, Aziz, Evans, & Rhoades, 2015) will be conducted. Literature study on bicycle courier is chosen due to limited crowdshipping literature and its close characteristics to bicycle crowdshipping. Additionally, benchmarking on current practices from bicycle crowdshipping and bike courier companies will be performed. Crowdshipping is a relatively new field of research and literature in this topic is still limited. To supplement the literature, benchmarking is therefore imperative to gain knowledge and lessons learned from the existing practices. This approach could also improve the relevance of the research from a practical end. The information could be gathered from various sources, namely by inspecting company websites and internet articles. Online databases such as Venture Radar would be helpful to find companies offering bicycle crowdshipping or services alike.

SQ #2
To answer this sub-question, the first stage is to conduct a literature overview to acquire attributes that might be of relevance. It covers attributes that measure demand side (customer acceptance) as well as supply side (courier acceptance). For the former, some interesting examples to initiate with are research by (Punel & Stathopoulos, 2017) and (Rougès & Montreuil, 2014). For the latter, some relevant resources are studies by (Miller et al., 2017) and (Paloheimo et al., 2016). Also to cater the lack of literature, some research findings on ridesharing, last mile delivery, and bicycle courier will be adopted alongside current studies on crowdshipping. Departing from the same concern as the first sub-question, benchmarking service and job attributes of existing crowdshipping services in the market, preferably ones that also offer bicycle as part of the delivery means, is indeed necessary. Moreover, referring into the current practice would help the researcher to identify distinct attributes of crowdshipping. An interesting example to be learned is Zipments, a crowdshipping service that promotes delivery by bicycle to emphasize their environmental concern (McKinnon, 2016). Benchmarking with bike courier companies could also be performed. The similarity of modes being used by such service would provide a good starting point to determine bicycle crowdshipping's attributes.

SQ #3 and SQ #4
For answering the third and fourth sub-question, a discrete choice model (DCM) will be used to gauge the acceptance of potential customers and couriers. Selecting delivery option or deciding whether to deliver a package are, in essence, a human decision-making process, and DCM has been widely applied to model such phenomenon. DCM has the ability to incorporate diverse type of attributes to estimate utility of an option, ranging from concrete measures, such as cost, to intangible measure, such as flexibility. Such characteristics makes DCM suitable for this study, given that some crowdshipping users/couriers are also motivated by non-concrete attributes such as concern to the environment (Punel et al., 2018). Stated choice experiment (SCE) will be designed to measure the systematic influence of each service attributes (Louviere, Hensher, & Swait, 2000). SCE appears to be a feasible option given that bicycle crowdshipping, although is presented to respondents as a hypothetical option, is quite imaginable and understandable especially in the Netherlands. The survey will be conducted through online mediums (emails and social media), since the potential users of crowdshipping are people with familiarity with internet and smartphones – an obvious characteristic of online shoppers (Punel & Stathopoulos, 2017). There will be two SCEs to be conducted; the first to gauge the demand side, and the second to measure the supply side. Experiment design software Ngene will be used to generate a suitable design for the stated choice experiment (ChoiceMetrics, 2014). As for the estimation of choice model parameters, BIOGEME software will be utilized (Bierlaire, 2003).

The demand and supply model will take the form of a closed-loop multinomial logit model (MNL), depicted by equation (1), that has been extensively applied in transportation research. In the context of demand side, P_{in} represents the probability at which a potential customer would opt for bicycle crowdshipping as a delivery option among other shipping options (e.g., traditional shipping and self-pickup). In the context of supply side, P_{in} represents the probability at which a potential courier would perform a delivery task. The utility of bicycle crowdshipping option (and other competing options that will be formulated later on) is represented by equation (2). The utility of a delivery option is presented as a linear additive function of the observed attributes *m* and unobserved error term ε_{in}. Linear additive function is preferred at first hand because of its easily interpretable properties compared to nonlinear models (Train, 2009). Note that ε_{in} denotes the difference between the actual utility obtained by the decision makers (U_{in}) and representation of utility that is developed by the researcher using the observed variables (V_{in}) (Train, 2009). To make the closed loop MNL equation applicable, the error term ε_{in} is assumed to be identically- and independently-distributed (IID) with extreme value type 1 (Gumbel) distribution (McFadden, 1973).

$$P_{ni} = \frac{e^{V_{ni}}}{\sum_j e^{V_{nj}}} \tag{1}$$

where

P : probability that a delivery alternative will be chosen
V : observed utility of delivery alternative
$i \,\&\, j$: index for delivery alternative
n : index for individual decision maker

$$U_{ni} = \sum_m \beta_m X_{mni} + \varepsilon_{ni} \tag{2}$$

where

U : utility of a delivery alternative
β : marginal utility of an attribute
X : attributes level
ε : unobserved utility component (error terms)
i : index for delivery alternative
n : index for individual decision maker
m : index for attributes

For the third sub-question, a set of choice tasks is presented to illustrate the service features of bicycle crowdshipping. The result of the second sub-question (attributes list) will serve as an input for the choice task. It is likely that the service attributes will be comparable to existing crowdshipping service, but with the addition of specific attributes that distinguish bicycle crowdshipping with other services. Introductory information will be provided to guide the respondents in understanding the survey context. To ensure the realism of the choice task, other shipping options rather than bicycle crowdshipping such as standard shipping and opt-out option (not to send a package at all) will be included (Punel & Stathopoulos, 2017). The stated choice experiment will be used as input to develop MNL model representing the acceptance (or demand) function of bicycle crowdshipping. At this point, the probability that a customer would like to use bicycle crowdshipping among other shipping options can be estimated. Based on the model parameters, the value of willingness to pay will also be derived. The respondents to be targeted in the first survey is people with online shopping experience.

For the fourth sub-question, a set of choice tasks is presented to illustrate the characteristics of the job for crowdshipping setting. To this end, it should be ensured that the shipping context (e.g., delivery distance) for the first survey is aligned with the shipping context conveyed in the second survey. Consistency is necessary knowing that the relationship between both sides will be analysed in the fifth sub-question. Similar to the previous sub-question, the survey result is used to generate a MNL model representing bicycle commuter's acceptance on crowdshipping. As such, the probability that a traveler would like to perform a delivery can be calculated. The value of willingness to work, representing the amount of time a cyclist would like to give up in exchange to profit, will be derived. The targeted participants of the second survey would be people who cycles to commute (either as the main mode or as an access/egress) or people who have an interest to do so.

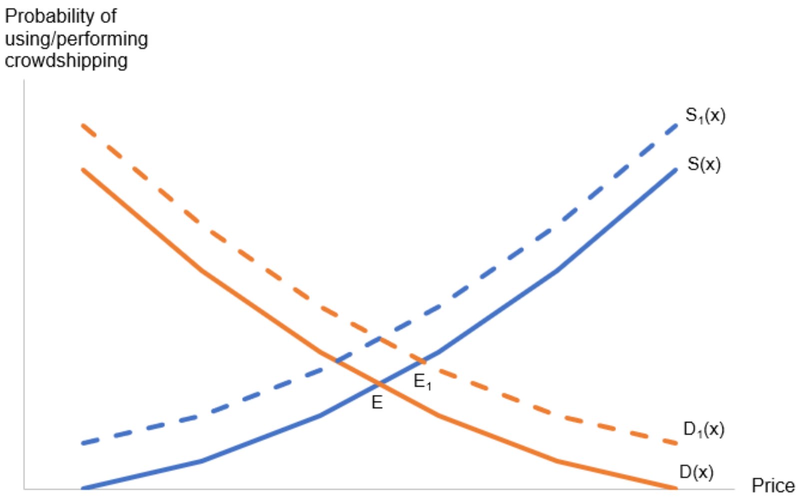

Figure 1 Proposition of crowdshipping demand-supply relationship

SQ #5

Having the influential service and job attributes defined in previous sub-question, in answering this sub-question we use the proposition that crowdshipping supply and demand are both affected by price level. Figure 1 serves a rough illustration on the supply-demand relationship. As can be seen, price is positively correlated with commuter's willingness to work as crowdshipper (indicated by line S(x)), while the opposite relationship applies for customer's acceptance (depicted by line D(x)). The first stage to answer this sub-question is formulating equilibrium state to find point E – the intersection of supply and demand curve (or, the potential market penetration level). The second stage is finding the sensitivity of the demand and supply function to other driving factors beside price level. The objective is to find a possibility to increase the service acceptance within the same price level (i.e., to shift the demand/supply function upwards). For instance, providing information on potential carbon emission savings by using crowdshipping platform might shift customer's acceptance function to $D_1(x)$, hence resulting a higher market share (E_1). These insights are important to determine which service attributes and features would be helpful to aid the crowdshipping platform in increasing its market penetration.

Figure 2 provides the summary of research methodology explained above. The boxes in "Process" row provides the chronological steps of the research. Above this row, listed the relevant methods used to conduct the respective research step. Beneath the "process" row, expected deliverables of the step, corresponding research questions to be answered, and the chapter within which the step is carried out is scrutinized.

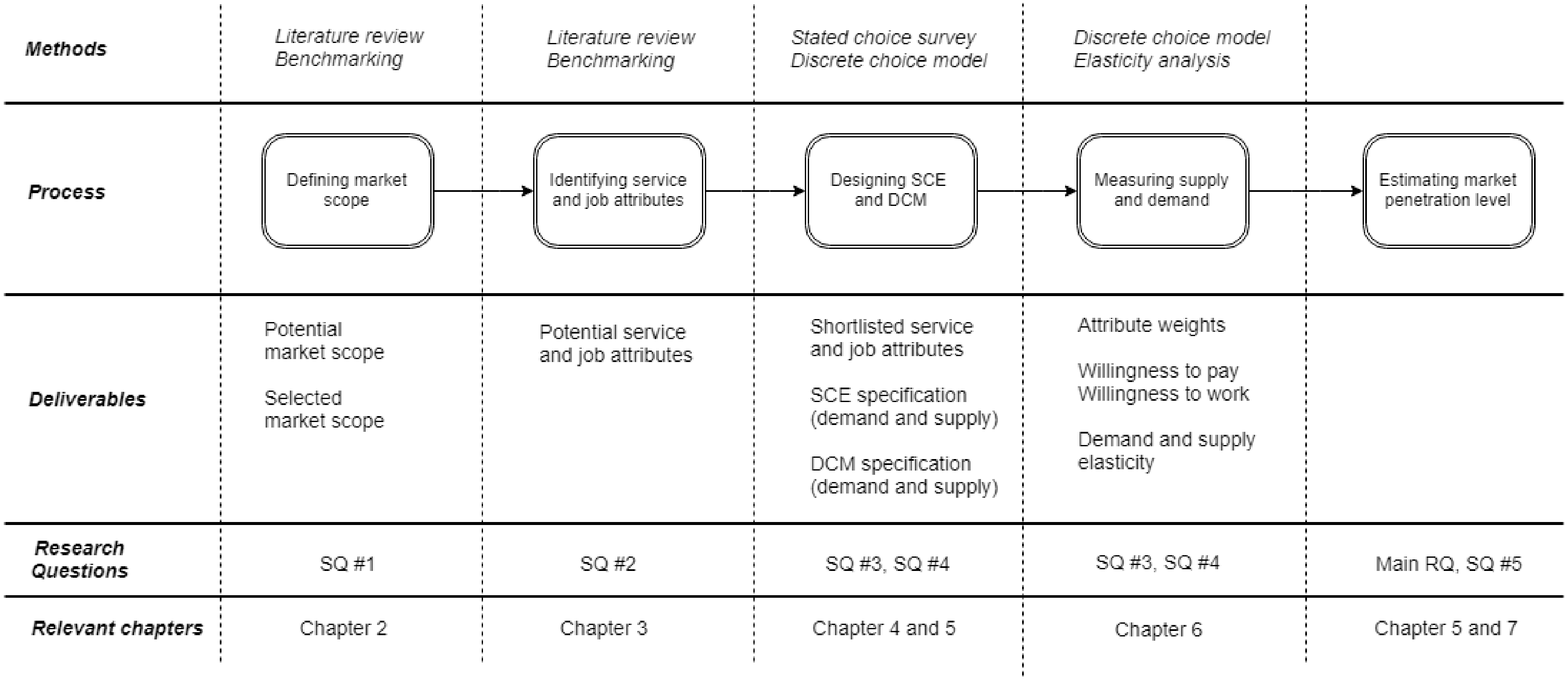

Figure 2 Research flow diagram

1.4 Scope and Limitations

Within this research, crowdshipping user/customer is defined as the person who placed an order for delivery in crowdshipping platform. This person assumes the role of package's end receiver. The origin and destination of the packages including the shipping context (e.g. spatial scale) will be defined accordingly on the first research sub-question, after which the prospective demand of bicycle crowdshipping will be clarified. The potential courier is defined as the person who travelled by bicycle in daily basis for commuting purpose (consists of work and school), or those who currently commute with other modes but are willing to use bicycle for commuting. The type of bicycle considered in this research including bicycle and e-bike. Therefore, motorcycle is left out of the scope. The research focuses on the role of behavioural aspects (i.e., choice making process), which implies that technical features such as vehicle routing and scheduling will not be given detailed attention. Consequently, time dimension of the order/delivery activity is not explicitly considered in this research. Nevertheless, the shipping context will be carefully designed to assure realism of the survey.

Due to selection of bicycle mode as the means for crowdshipping, the result of the research may not be representative if one would like to generalize to other transport modes. Therefore, another survey would be needed to explore the potential of other crowdshipping means. The study will take place primarily in the city of Delft, a small city with less than 150,000 inhabitants, of which around 20,000 of its population are university students (www.tudelft.nl). The selection is made to ease the burden of collecting respondents data. The over-representation of students may lead to favourable result to crowdshipping business model, as also found by the study of (Paloheimo et al., 2016). For practicality purpose, this study will focus only on crowdshipping attributes as the explanatory factors that indicate crowdshipping acceptance. Hence, sociodemographic profile will not be directly taken into account for the estimation of crowdshipping supply-demand function (choice model). Nonetheless, the detailed characteristics of the respondents (i.e., socioeconomic profile, travel behaviour) will be descriptively explained to provide transparency on the research samples. Due to limited time to conduct the research, competition between bicycle crowdshipping and other services (i.e. traditional shipment) will only be analysed from the choice model resulted from the survey.

The market for crowdshipping is neither closed nor perfect, hence the research assumption that supply-demand can be balanced by the price mechanism may not hold in reality (McKinnon, 2016). This is possible given that currently crowdshipping is still in its infancy and, in fact, there are many choices from which a user can choose how their package to be delivered. However, in this research this assumption is made under the expectation that in the future crowdshipping will increasingly gaining grounds amongst the internet shoppers, such that it holds a considerable share in parcel delivery market. The research serves as an initial exploration of bicycle crowdshipping potential. Hence, it is assumed that all web shops would provide bicycle crowdshipping as one of the delivery options. Because the main focus of the research is end user's acceptance towards bicycle crowdshipping, the propensity of online shops to be willing to cooperate with bicycle crowdshipping is left out of the research scope.

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CHAPTER 2: Scoping the Market

2.1 Introduction

Despite its dense and high-quality bicycle infrastructures, there is, thus far, virtually no research on the potential of bicycle crowdshipping in the Netherlands. This is surprising since among other countries, the high share of personal trip by bicycle and extensive cycle network in the Netherlands possess greater opportunity to stimulate freight modal shift from other motorized means through crowdshipping (McKinnon, 2016). The limitation of payload capacity and distance of bicycle, however, may confine this potential. Consequently, study on the potential market scope to be penetrated by bicycle crowdshipping would be needed to identify the opportunity.

This chapter aims to answer the following research sub-question: *What is the prospective market scope of bicycle crowdshipping, and what attributes characterise this market?* In this chapter, characteristics of the potential market for bicycle crowdshipping will be identified. Section 2.2 will uncover the spatial scale of delivery service that is relevant for bicycle crowdshipping. Section 2.3 will describe the shipment characteristics suitable for bicycle crowdshipping. The two sections that have been mentioned will refer to the existing literature on cycle courier and crowdshipping. Section 2.4 contains the benchmarking process from current market of bicycle courier and crowdshipping companies, which is deemed necessary to complement the limitation of bicycle crowdshipping literature. The resulting study from this chapter will be used as a reference to determine service attributes and value propositions in chapter 3, and also to define the survey context that will be used for stated choice experiment design in chapter 4.

2.2 Spatial scale of the service

Due to lack of research that examined the spatial scale of bicycle crowdshipping, the study results of cargo cycles area coverage is alternatively adopted. Referring into empirical evidence, mostly from *courier, express,* and *parcels* (CEP) companies that operate cargo cycles[3], some research suggested that the relevant area for cargo cycles to operate is urban centers that usually cover up to 5 km of distance (Lenz & Riehle, 2013; Rudolph & Gruber, 2017). The finding is comparable with the maximum acceptable commuting distance[4] of cyclist in The Netherlands, which spans from 5 to 7.5 km (KiM, 2016). For e-bike, the acceptable range could even stretch further. Average travel distance of e-bike in The Netherlands are approximately one and half time of a normal bike (KiM, 2016). This spatial coverage is especially fits for freight distribution in European city centers, where the density of the population is high, and restriction is often imposed on automobiles to enter this area. In this situation, cargo cycle provides a competitive advantage over other delivery modes. Another research by (Melo & Baptista, 2017) reported that in order to ease the movement and accessibility to the service area and to avoid negative impact to the existing traffic, the maximum linear distance of cargo cycles to operate is 2 km. However, in this case study, the bicycle delivery is assumed to utilize the same road space as cars, which will not be the case in the Netherlands. Hence, there is a possibility to reach delivery distance beyond 2 km.

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[3] Cargo cycle is a type of bicycle specified to carry a higher amount of loads, be it in terms of volume, or weight. Typical cargo bikes are capable of carrying 50 to 250 kgs, or 160-300 dm^3.

[4] Defined as the distance within which 90 percent of all bicycle trips take place (KiM, 2016)

In respect to its integration into the logistics network, referred to bike couriers study by (Maes & Vanelslander, 2012) and (Lia, Nocerino, Bresciani, Colorni, & Luè, 2014), spatial context of bicycle crowdshipping can be distinguished into two; last mile delivery and local delivery.

Last-mile delivery

Apart from local delivery, bicycle crowdshipping has the potential to be integrated as the part of a longer supply chain. Mimicking what has been done by bike messengers in the Netherlands, bicycle crowdshipping can serve last-mile delivery connection from urban hub located in the proximity of the city center. As can be seen in Figure 3, Trucks and delivery vans delivered the packages from central DC to the urban hub (1st tier trips), while the bike couriers provide the connection to the remaining miles (2nd tier trips). The 1st tier trips are commonly operated by established logistics carrier capable of handling big volumes. Carriers reap the benefits of transporting goods will full truck loads. In case the range is further than normal cycling distance, bike messengers use electric cargo bike to improve the reach. However, for bigger-sized cities this concept may not be feasible to implement. Placement of urban distribution center in the outskirt of the city might fall outside cycle courier's reach. Provided its low range and capacity, the presence of secondary hub or mobile hub is in some cases required to guarantee successful bicycle delivery operations (Lenz & Riehle, 2013; Schliwa et al., 2015). The application of mobile hub has been exemplified by UPS. To serve emission-free delivery, UPS placed a big truck serving as mobile depots just outside the city center and subsequently bicycle fleets handle the delivery to the final destinations. This practice, however, is only applied by UPS for areas that are difficult to reach with other vehicles. Hence, UPS only seen it as a complement of the existing delivery van's trips (Lenz & Riehle, 2013).

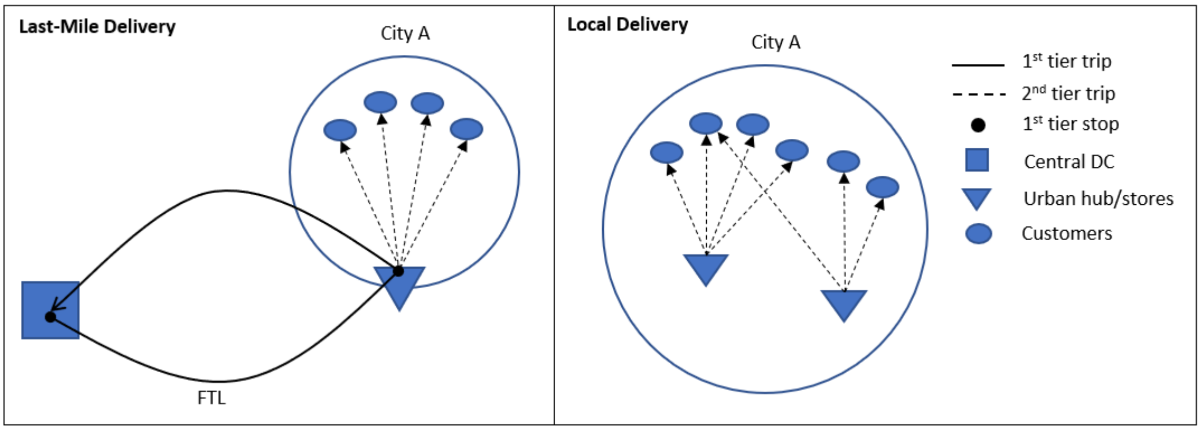

Figure 3 Spatial context of bicycle crowdshipping. Dotted line exhibits the leg to be served by bicycle crowdshipping. Adapted from (Quak & Tavasszy, 2011)

The emergence of parcel pickup point may become another potential avenue for last-mile delivery market for bicycle crowdshipping. The usage of pickup points enables the logistics carrier to operate more efficiently, by merely handling the high-load transport leg and let the last-mile handled by the customers. For customers, cheaper delivery cost will be gained in exchange to their travel time to the pickup points. However, for some customers pickup points may reduce the convenience of internet shopping (Allen, Thorne, & Browne, 2007) and their acceptance may be hindered if the pickup point location is not accessible (Weltevreden, 2008). In this case, crowdshipping service can step-in to provide last-mile connection from pickup points to the customers' homes, resembling the concept of DHL MyWays. This concept might work if a competitive cost can be offered by the bicycle crowdshipping service. If customers also value other factors besides monetary gains (such as CO_2 footprint reduction), the possibility to use bicycle crowdshipping may even be higher.

Execution of this concept requires integration between delivery information system of the logistics carrier (the carrier that perform 1st tier in *Figure 3*) and the crowdshipping firms.

The implementation of last-mile delivery for Dutch bike couriers is less of a problem because they have extensive network and infrastructures in big cities such that end-to-end supply chain can be handled; first and last mile are handled by bicycle courier, while the long-haul is handled by green-gas car (fietskoeriers.nl). For bicycle crowdshipping, it might be more challenging. In crowdshipping service, infrastructure is limited such that collaboration with logistics carriers/urban consolidation center is needed if not to invest for the facility by itself. In case pickup points concept is used, the bicycle crowdshipper needs to establish links with logistics carriers to know at what moment the package would be ready for pickup at the pickup points. However, there might be reluctance from the logistics carrier to share their real-time delivery milestones to the crowdshipping firms. In case that urban hub is used, there might also be hesitance of logistics carrier to share their 'mileage' with bicycle crowdshipping, given that the service may 'eat' part of their market share. Consequently, the end user and the ecommerce firm need to take part to 'force' the logistics carriers to collaborate with crowdshipping service. Within this context, the risk is also higher since the absence of sufficient number of crowdsourced couriers would disrupt the performance of the whole delivery chain.

Local Delivery

The spatial context for local delivery can be inspected in Figure 3, in which bicycle crowdshipper provides direct connection from local stores to customers. Bicycle crowdshipping provider that serves local area commonly takes the competitive advantages of brick-and-mortar stores (B2C delivery) to provide value propositions for potential customers. The proximity of the locations and the availability of stocks entice the crowdshipping provider to perform collaboration with local stores and restaurants to serve express home delivery. This advantage is amplified by the convenience of using bicycle for short distance travel. The main market for this delivery scope is retail stores that provides 'click and collect' service; the platform enabling customers to place an online order and to pick the products in-store.

Within the local delivery context also fits the conventional courier concept manifested in point-to-point delivery. Individual person can request for delivery and accordingly the crowdshippers will pick up and deliver the package to the end receiver. Knowing that it is a one-leg delivery, the distance between sender and receiver must be within the acceptable range for bicycle crowdshipping. This type of service has been practiced by bike couriers in the Netherlands (cycloon.eu). This concept normally works in niche market such as administrative spheres; legal industry, advertising company, and hospitals (Maes & Vanelslander, 2012).

Bicycle crowdshipping can capture the advantage of the *niche* market for local express delivery. Aside from the delivery speed, the local delivery service can help brick and—mortar stores to remain competitive in the market by aiding them with the capability to provide home delivery in an affordable way. The sufficient mass of local stores that favour express home delivery for their customers signifies the suitability of bicycle crowdshipping for local context, which also explains the fact that some crowdshipping services provide local delivery service as one of their main offerings. The motivation to focus on local service area is also supported by findings of (C. Wang, Ramirez-Rios, Rivera-Gonzalez, Holguin-Veras, & Schmid, 2018). It is observed that as the city area increases, the acceptance rate to crowdsourced delivery declined. This means that crowdsourced delivery is more preferred by citizens living in dense and compact urban area.

2.3 Shipment characteristics

Shipment characteristics in this context embody the possible commodity type and cargo characteristics (such as size and weight) that fits bicycle crowdshiping concept. In general, the shipment characteristics to be served by bicycle crowdshipping is comparable to that of bicycle couriers. Therefore, many of the literatures are sourced from the study of potential market for bicycle couriers.

Commodity Type

According to a study by (C. Wang et al., 2018), crowdshipping potential customers are likely to prefer using the service for delivery of household goods, clothing/apparel, and books. Other study found that crowdshipping requesters would favor having dry cleaning items, fresh foods, and groceries delivered by crowdshipper (Le & Ukkusuri, 2018a). It is apparent that most of the potential users prefer to avoid crowdshipping service to deliver valuable or delicate goods (C. Wang et al., 2018). Hence, commodity type that becomes potential market for crowdshipping are items that fall within low to medium price range. The aversion to use crowdshipping for valuable items may partly be caused by the the fact that trust issue remains a high concern of crowdshipping users (Le & Ukkusuri, 2018a; C. Wang et al., 2018). Interestingly, the potential commodity types for crowdshipping are also the items with highest sales figure in ecommerce. Statistics from Thuiswinkel Markt Monitor, as depicted in Figure 4, reveals that clothing, household items, and foods are among the most popular product groups and also have the fastest growth in sales within Netherlands' ecommerce market (EcommerceEurope, 2016). From the yellow bar on Figure 4 it is apparent that products that yield the most online transactions are low- to medium-priced items, which is the most potential market for crowdshipping. These facts suggest the potential of bicycle crowdshipping to penetrate into the Dutch internet shopping market.

Aside from the previously mentioned commodity types, there are also other promising *niche* sectors to be served by bicycle crowdshipping. (Maes & Vanelslander, 2012) mentioned five potential product sectors to be infiltrated by bicycle couriers; administration, advertisement, medical, and flowers. The first one is related to distribution of administrative documents for corporation, that usually requires fast delivery. This market could be found within urban areas dominated by offices/employment centers. The second is reasonable given that in cities advertisement spots are widespread and advertisement materials circulates in a fast pace. Medical product flows constitute relevant characteristics for bicycle crowdshipping; product sizes are small and delivery speed is essential. However, the high value of medical items could hinder the users tendency to use bicycle crowdshipping. The last, flowers, is potential in particular in the Netherlands. High consumption rate of flowers and perishability features implies the necessity of fast delivery.

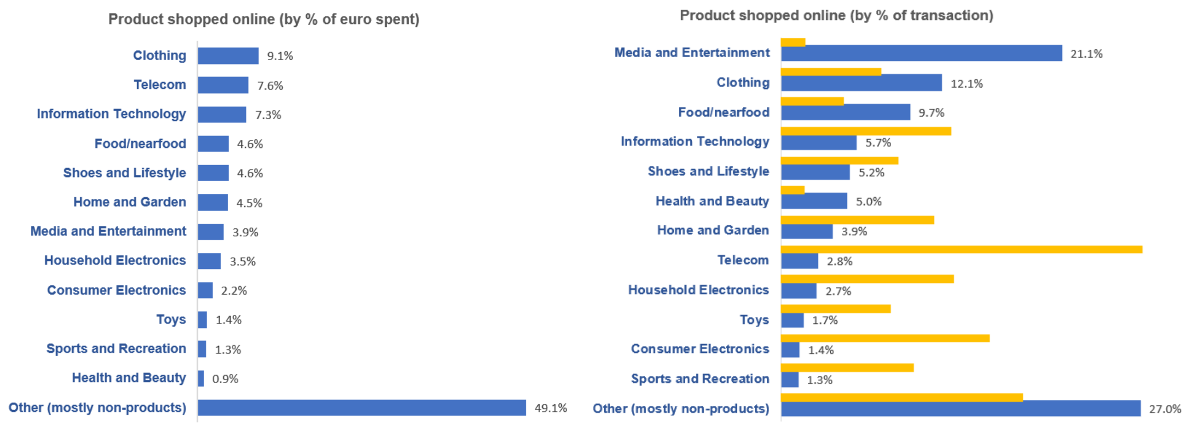

Figure 4 Ecommerce products sales in The Netherlands based on value (left) and number of transactions (right). Yellow bar on the right displays the relative unit value per product type. Source: (Z. Wang, Abraham, & Lone, 2017)

Product Size and Weight

In regards to product size and weight that can be carried by bicycle crowdshipping, one would need to consider the payload capacity of bicycle. Payload range (including the driver) of a typical city bike lies within 100-120 kg (Lia et al., 2014). According to (Lenz & Riehle, 2013) a standard bike can carry loads up to 25 kg. This capacity applies when the cargo is placed in the storage bin at the front or rear side of the bicycle or in a backpack. It is also possible that the goods are hand-carried by the couriers, which may entail less capacity compared to usage of storage. Performing hand-carry is, however, also prone to damaging the items and disrupting the driving ability of the couriers. Given these facts, performing hand carry would be less favorable for bicycle crowdshipping couriers. In terms of volume, bicycle is a little bit disadvantaged due to its small capacity. The volume of package that can be covered by a normal bicycle spans between 40 and 60 dm^3, while for cargo bike the volume can be around 160-300 dm^3 (Lia et al., 2014). However in this research the cargo bike is not considered, as its ownership rate within Dutch citizens is considered low in comparison to normal bikes and e-bikes. The small capacity implies that the point-to-point delivery mechanism is more suitable for bicycle crowdshipping instead of consolidated/multi-drop delivery.

2.4 Benchmarking

For benchmarking purpose, a database of crowdshipping companies are obtained from Venture Radar. A specific keyword ‘crowdsourced+delivery’ was entered to search engine (C. Wang et al., 2018), and 110 search results were generated. To avoid referring into a service that is unpopular or having a low users, the list is scoped only to the top 25 companies based on their reputation rank. The reputation rank measures the endorsements and recognition the company has obtained such as news coverage, awards, industry recognition, and investment raised (VentureRadar, 2017). From the result, the list is further shortlisted. Companies whose websites are no longer active are omitted. To ensure relevance with specific domain of crowdshipping (thus avoiding too generic scope), companies involved in crowdsourced task (such as house cleaning or plumbing) instead of crowdshipping are excluded. Afterwards, the crowdshipping companies that do not offer bicycle or electric-bike as part of the delivery modes were excluded. These filtering process resulted in 9 companies operating in crowdshipping domain. The list is expanded by adding bicycle courier company and crowdshipping service that already operate in the Netherlands. This last step is made to add a sense of ‘local context’ for the benchmarking study. In total, 12 companies in bicycle crowdshipping or bicycle courier services were identified. The detailed list can be found in appendix 15.

The benchmarking result is illustrated in Figure 5 and Figure 6. Figure 5 depicts the spatial scale distribution among the benchmarked companies. Aligned with categorization in section 2.2, the spatial scale is divided into two; local and last-mile. Company serving both of the types will be counted twice, one for each type. As can be seen, the majority of the crowdshipping companies prefer local delivery as their market context. Postmates, for instance, partnered up with groceries, pharmacists, and stores in proximity and promises express delivery within 30 minutes from order placement (postmates.com). In local delivery context, some crowdshipping firm comes up with the concept of personal shopper (such as Instacart and Saddl), while other applies the pure courier concept (such as Deliv) in which the items are ready for pickup when the couriers arrive. In the Netherlands, bike messengers such as Cycloon also offers delivery service from local shops, where it claims that delivery can be made within only one hour.

Only four out of twelve companies serve last-mile delivery context, and three out of them also cover local delivery context. Among the four companies serving last-mile delivery, three possess their own hub facilities. Trunkrs is the only last-mile provider who does not own dedicated hub; Instead, it uses gas station as a temporary hub (invest.trunkrs.nl). None of the companies serving local delivery context own a hub facility. This finding is thus consistent with spatial classification in section 2.2. In order to step into the last-mile delivery context, a crowdshipping service requires provision of hubs as transshipment point. Amazon Flex came as an interesting case, provided they performed vertical integration from ecommerce sales to the last-mile delivery. Crowdsourced delivery might be seen as an appealing delivery alternative for Amazon to cut down logistics costs and increase delivery speed (McKinnon, 2016). Such appeal makes it rationale for them to leverage their existing fulfillment facilities by having crowdshippers providing the last mile connection.

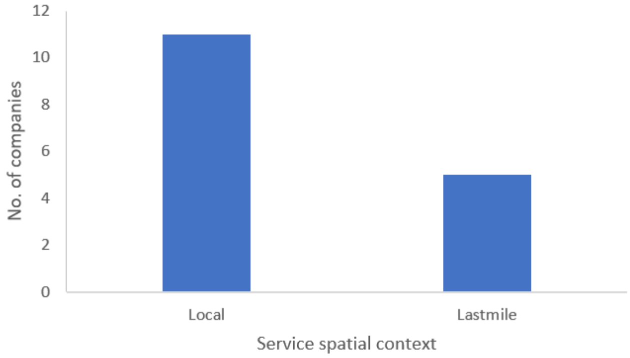

Figure 5 Spatial context of the benchmarked companies

Figure 6 illustrates the shipment type of the benchmarked companies. Most of the service provides delivery for all range of products as long as they are within the regulation terms (e.g., non-dangerous and non-illegal goods). The preference to deliver wider range of shipment type suggests that crowdshipping startups intend to enlarge their market share beyond only the food delivery service. Postmates, for instance, stipulated that they can deliver "Just about anything, from burritos, new headphones, or a fresh shirt for tonight's date" (Postmates.com). However, the range of products might be limited by the value of package covered by the service's insurance. An interesting pattern can be seen in which the company that depends only on bicycle mode, i.e., Deliveroo, specified the shipment type only on fresh foods. As mentioned in section 2.3, this may happen since food delivery perfectly fits the bicycle crowdshipping characteristics; it has more frequent demand, shops (restaurants) are within proximity of the destination, and delivery speed is of importance. Only few of the selected companies mentioned the maximum acceptable load to be delivered. Amazon Flex and Deliv as two highly known service stated that the weight of the products could not exceed 50 pounds or 23 kilograms, which is still within the acceptable load range for bicycle.

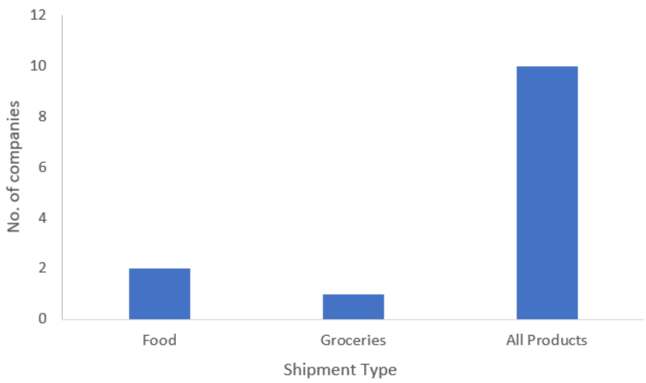

Figure 6 Shipment type of the benchmarked companies

2.5 Selecting the market scope for research context

After several dimensions of the market have been identified, market context to be focused within this study should be determined. Defining the context is important, since it affects the way the survey is conveyed to the customer. The result of the experiment is only applicable for the predefined context, thus the context selection has to be carefully made. In section 2.2, two possible markets for bicycle crowdshipping are identified; last-mile delivery and local delivery. The first entails collaboration with an urban hub, cycle courier hub, or parcel pickup points. The second covers point to point delivery (*niche* market) and partnership with a local store that provides *click and collect* service.

It is to be noted that the purpose of the study is to provide an insight on the market potential for bicycle crowdshipping both for short and long-term. As such, the study result should be applicable in the context of small (*niche*) market as well as large market (when the level of demand and supply are higher). Reflecting on this, it is decided that the context to be used for the study is **last mile delivery from parcel pickup points to customers' homes**. The shipment type to be chosen is parcel from an online shop, which comprises diverse product types as has been examined in section 2.3.

Several considerations were made to base this context selection, as can be seen below:

- Without losing the realism, last mile connection from pickup points is generic enough to cater all the possible market contexts (last mile and local delivery). In last mile context, the pickup location can be deemed as a parcel pickup point, in which the origin of the package could be a distribution center outside the city. In local context, the pickup location can be deemed as a brick and mortar store that provides 'click and collect' service.
- Parcel delivery accounts for a large market of online shopping. This means selecting online parcel delivery could maximize the benefits a bicycle crowdshipping service can bring. This is also supported in findings from section 2.4 that many of the benchmarked crowdshipping companies opt to serve generic parcels instead of *niche* products like foods or groceries.
- The average weight and size of the online shop package is manageable by a normal bicycle. Amazon indicates that 86% of its package weigh less than 5 pounds (2.5 kilograms). The same goes for the package size as these products can be dispatched even with a drone (Guglielmo, 2013).
- Within the selected context, bicycle crowdshipping can step in. For instance, serving last mile delivery from a distribution hub could be infeasible as the distance might be too far for cyclists.
- Within the selected context, it is also possible to model the future demand of bicycle crowdshipping. When the scale becomes sufficient, bicycle crowdshipping could be a reliable option for last-mile delivery in addition to local delivery.

Consequence of this context selection is that the study only consider delivery leg from the pickup point to the customers' home. The pickup/service point is perceived as a hub in which all main haul delivery leg (for instance, those originating from distribution center) will be ended. The leg before the pickup/service point (if applicable) is assumed to be homogeneous for all options and therefore is left out of the research's scope. To this end, it is assumed that delivery options for the customers consist of traditional delivery, crowdshipping, and self-pickup (no home delivery).

2.6 Chapter summary

Demand scope of bicycle crowdshipping were examined according two parameters; spatial context and shipment characteristics. The average commuting distance for bicycle is indeed a determining factor of area coverage for bicycle crowdshipping. Literature overview revealed that maximum acceptable distance for bicycle crowdshipping is up to 7.5 km for normal bicycle and 11 km for e-bike. Bicycle crowdshipping can fit within the spatial context in two ways; last-mile delivery and local delivery. The first focuses on integrating bicycle crowdshipping into the last part of e-commerce supply chain, which may involve transshipment in urban distribution center on the outskirt of the city (or can be extended to a smaller secondary hub). The second focuses on express delivery by equipping click-and-collect service from local web shops with home delivery capability and also by performing point to point conventional courier service. The size and weight that can be accommodated by bicycle crowdshipping is respectively around 50 dm^3 and 25 kilograms. The benchmarking on crowdshipping companies revealed that most of the (recognized) bicycle crowdshipping service prefer local delivery over last-mile delivery context.

The choice of which market context to be chosen for bicycle crowdshipping depends on the preference over market characteristics. Last-mile delivery provides interesting avenue to scale up the crowdshipping in a fast pace. This concept entails a greater coverage of logistics chain, in which bicycle crowdshipping serves the last-mile delivery from a relay point closest to the customers. However, this market context also poses big challenges. To ensure customer acceptance, reliability of the service has to be guaranteed to a high extent. This might necessitate the bicycle crowdshipping company to employ dedicated courier aside from occasional courier to assure service availability. Infrastructure such as transshipment hub is also required. In some cities bicycle crowdshipping might be able to collaborate with urban consolidation center, cycle courier hub facility, or parcel pickup points. The absence of these possibilities means the crowdshipping service needs to invest on its own infrastructure.

Local delivery context offers smaller demand volume which highly depends on the density and diversity of local shops in proximity. On the good side, local delivery service offers more practicality for starting a bicycle crowdshipping service. It requires less infrastructure as no hub facility is needed. It can be operated from a small scale, for instance by firstly focusing on serving certain local shops with modest sales volume. It also poses less pressure; any delivery failure will be bear only by the crowdshippping itself (aside from the reputation of the local shop). Local context can be a good starting point of bicycle crowdshipping to identify the market acceptance. Once the service is proven to be viable in a local scale, it can step further into the last-mile delivery context. In 2020, it is expected that around two-third of the brick and mortar shops in the Netherlands will be closed down due to competition with web shops (Visser et al., 2014). The presence of bicycle crowdshipping to assist local shops in home delivery service might help to reduce the adverse effect of such competition.

Based on the previous considerations, market scope to be focused in this study will be directed to last-mile delivery of online parcels from pickup points. The selection of this market scope brings advantage, as it is generic enough to cater the last mile and local delivery context. In addition, parcel delivery accounts for a large portion in online shopping: In 2016, it constitutes around 70% of the total online shopping transactions in the Netherlands. More importantly, by selecting this context, the result of the study would be useful not only in the early phase of the crowdshipping platform (where the market is still small), but also in the phase where it is upscaling to a higher level.

CHAPTER 3: Value Propositions and Attributes

3.1 Introduction

As already mentioned in Chapter 1, interest of this research falls into identifying stakeholder's acceptance towards crowdshipping which is essential to guarantee the success of its business model (Handke & Jonuschat, 2013). In order to understand the service acceptance, (Handke & Jonuschat, 2013) proposed four types of relevant market studies:

- *Market research studies*: Which are main consumers' requirements and needs with respect to the technical aspects of a product or service? Which are the main competitors and market niches? etc.
- *Studies on product and service characteristics:* Which product or service features enhance or impair user acceptance? Which characteristics are decisive for the user acceptance?
- *Marketing studies:* Which are the unique selling points of the product or service? Which are the best communication strategies for each target group?
- *Studies on customer relationships:* Which strategies result in a long-term customer binding? How can we strengthen the emotional binding to a product or service? etc.

The first bullet point has been examined in chapter 2, in which the market niches and shipment characteristics suitable for crowdshipping service was identified. This chapter will relate to the second bullet point, *studies on products and service characteristics that affects user acceptance*, which results in potential service features/attributes of bicycle crowdshipping. The result of this chapter would expectedly answer the following research sub-question: *What are the possible value propositions and service characteristics to be offered in response to the prospective market?*

The detailed mechanism under which the service attributes would affect the acceptance (read: the attributes weight) will further be explored in chapter 5 and 6. In section 3.2, a short review of business model of crowdshipping services will be provided to gain insights on key differentiation of crowdshipping services. It is to be noted that business model is not delved into deeply as this research aims to emphasize on the acceptance and willingness to participate of relevant stakeholders. Following this step, identification of relevant service and job attributes of bicycle crowdshipping will be explored through literature review and benchmarking. Section 3.3 will identify the service attributes, while section 3.4 will identify the job attributes. Section 3.5 will come up with the summary of the attributes identified. The resulting study from this chapter will become the basis to form the stated choice model in the following chapters.

3.2 Understanding the value propositions

Crowdshipping is unique in terms of stakeholder engaged in its operations and value propositions it offers. To better identify the service attributes and value propositions of crowdshipping, understanding the nature of crowdshipping business model would be of importance. Although it should be noted that the motivation behind crowdshipping is not merely related to business or monetary gains (as demonstrated by studies of (Paloheimo et al., 2016) and (Punel et al., 2018)), understanding the business model would be helpful to identify key differentiation of crowdshipping from other delivery services. Such a knowledge would provide insights on how crowdshipping could accelerate its penetration in urban parcel delivery market.

An interesting example of crowdshipping business concept is the study by (Rougès & Montreuil, 2014) that stipulated five components on crowdshipping; creation, offers, stakeholders, characters, and revenue model. This model is somehow comparable to business model canvas concept developed by (Osterwalder & Pigneur, 2010). The concept framework can be seen in Figure 7.

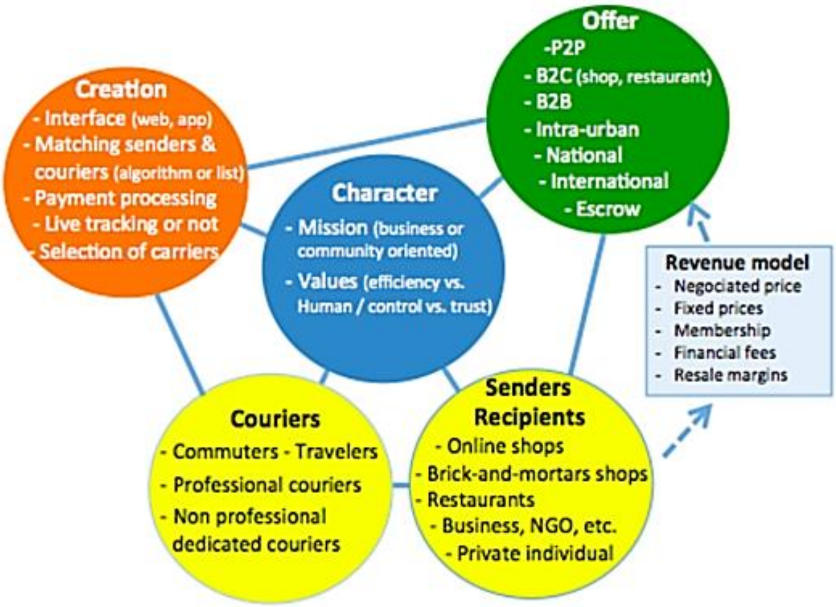

Figure 7 Components of crowdshipping business model. Source: (Rougès & Montreuil, 2014)

Creation

Creations refers to key activities to create the crowdshipping service. To generate a service, crowdshipping platform is responsible for online platform management, courier selection (vetting process), matching between couriers and senders, price determination, and payment processes (Punel & Stathopoulos, 2017). In most cases the platform is also responsible to handle any misconducts encountered during the delivery process such as damaged shipments and stolen packages.

Offers

Offers indicates value propositions offered to various stakeholders. In this case, two promising markets for crowdshipping are B2C (business to consumer) and P2P (peer-to-peer). Some other crowdshipping firms also started to explore the B2B market. The first concept could be in a form of partnership between crowdshipping platform with store owner, where crowdshipping will be one of the delivery options for customer during the online checkout process (Rougès & Montreuil, 2014). The second would take the form of "personal shopper" in which courier buy items at the stores referred by customers and subsequently deliver the goods to customers (Rougès & Montreuil, 2014). P2P service could also take a form of direct delivery service in which the courier send the package from individual sender to individual recipient. The B2C market brings benefits for small brick and mortar stores to practice "multi-channel logistics", because crowdshipping provide them cheaper shipping alternative to compete with online shops (Rougès & Montreuil, 2014).

(Punel & Stathopoulos, 2017) indicated offers based on benefits to be gained by each stakeholder. To the users (senders/recipients), crowdshipping would provide flexibility in pickup and delivery conditions. To logistics provider, crowdshipping would require lower cost in comparison to practicing traditional shipment. To potential carriers, crowdshipping would add income to compensate travel cost (or time) spent during the journey. For the society, crowdshipping would reduce the environmental burden caused by freight transport.

Stakeholders

Primary stakeholders of crowdshipping refers to couriers and sender/recipients (Rougès & Montreuil, 2014). Couriers for crowdshipping can be sourced from either a pool of professional courier (as practiced by Zipments) or occasional/non-professional courier (as practiced by Deliv) (Rougès & Montreuil, 2014). The second concept is more of interest for this research, as the main intention of the service is to gain benefits from an existing trip instead of generating new trips. Nevertheless, to ensure the reliability of the service, crowdshipping platform may still need to (partly) rely on professional courier (Sampaio Oliveira, Savelsbergh, Veelenturf, & van Woensel, 2017; van Cooten, 2016). Sender/recipients could be businesses such as corporates, shops, or 3PLs (as can be found in B2C and B2B services), or could also be individuals as can be found in P2P service.

Characters

'Characters' refers to underlying values that motivate the provision of crowdshipping service. This element can somehow represents 'brand image' of the crowdshipping provider. As a sharing economy concept, community becomes an essential part that cannot be separated from crowdshipping. Many of the crowdshipping providers aim to provide benefits for the society, by means of accommodating social interaction and helping each other. Amazon Flex is one of the crowdshipping provider that exposes this aspects in its website, citing the testimony of one of its courier: "With Amazon Flex, sometimes I deliver to people who can't get out to shop on their own. I know I am really helping them, and it's a great feeling". Other companies assert the characters on the business/monetary aspects, for instance by emphasizing that opting for crowdshipping would save the customer's invaluable time in exchange for a small amount of money (Rougès & Montreuil, 2014).

Revenue

The last components, revenue, takes several forms in current practice. For intra-urban delivery context, fixed price can be applied assuming that the deviation between actual and average delivery distance would be small. Zipment is an example of service that apply this pricing scheme (Rougès & Montreuil, 2014). The fixed price can be based on hours spent for delivery or number of packages to be delivered (Riccardo, 2016). Other platform such as TaskRabbit applies bidding system for any crowdshipping task posted. Other revenue possible revenue mechanisms are membership fee and resale margin (Rougès & Montreuil, 2014).

3.3 Crowdshipping service attributes

Crowdshipping service attributes should represent parameters that can affect acceptance (demand side) of crowdshipping service. The list of attributes is primarily based on prior studies in crowdshipping-related topics, complemented with benchmark on existing services to see how the current crowdshipping platform translate the service attributes into practice.

3.2.1 Literature Overview

To overcome the scarcity in crowdshipping acceptance literature, some research benchmarked important service attributes to similar service such as ridesharing. This has been done, for example, by the study of (Punel & Stathopoulos, 2017) and (Devari et al., 2017). These research observed that ridesharing users place highest value on travel time, flexibility, convenience, reliability, and perceived security (Agatz, Erera, Savelsbergh, & Wang, 2012; Furuhata et al., 2013). The important attributes of ridesharing indicate resemblance to crowdshipping. Flexibility is one of the key advantage of crowdshipping provided its personalized handling of packages. Perceived reliability and security remains an important feature to customers given that building trusts with customers to let unknown crowd to deliver their package is no easy job.

Departing from ridesharing literature, it would be interesting to see how crowdsourcing literature differentiate the service attributes. In this context the categorization from (Punel & Stathopoulos, 2017) will be used with some additions from other literatures. Shipping attributes are firstly based on three category; traditional attributes, control over delivery conditions, quality assurance. Other attributes that could be considered will be categorized as other attributes. The last three consist more specific attributes that characterize the crowdshipping service.

Traditional features

To identify important traditional shipping attributes for crowdshipping, one can consider the important aspects that drives the success of last-mile delivery. In last-mile delivery context, speed and cost are indeed the two obvious requirement to guarantee a successful service (Chen, Pan, Wang, & Zhong, 2016; Savelsbergh & Van Woensel, 2016). Delivery speed can be translated into lead time needed to get the package delivered, such as 3-hours, 6-hours, same-day, next day delivery, and so forth (C. Wang et al., 2018). In practice, delivery cost can take several forms such as negotiated price, hourly-based price, or parcel-based price (Riccardo, 2016; Rougès & Montreuil, 2014). (Punel & Stathopoulos, 2017) found in their research that for local delivery context, customers shown high willingness-to-pay sensitivity for reduction in delivery lead time. This implies that delivery speed is an important feature in crowdshipping.

Control over delivery conditions

As a key service differentiation, control over delivery condition is deemed important to attract crowdshipping customers. This attributes category is characterized by the ability to define preferred pickup time and delivery time. The ability to define pickup time is found to be a significant factor in the research by (Punel & Stathopoulos, 2017). However, it should be noticed that in their research the survey respondents assume the role of package sender. If the respondents take the role of package receiver, the result might be different (i.e., adjustable delivery time may become more significant). Potential users also showed concern towards the timeliness of delivery schedule (Le & Ukkusuri, 2018a; Punel & Stathopoulos, 2017). To ensure that the packages reach their delivery milestone as scheduled, crowdshipping provider can also provide track and trace feature (Rougès & Montreuil, 2014).

Quality and security

Research suggested that potential users showed high concern over the quality of their package when it is being delivered (Le & Ukkusuri, 2018a; C. Wang et al., 2018). Other studies also acknowledged that trust and reliability are essential requirements to build sufficient network of users (Paloheimo et al., 2016; Rougès & Montreuil, 2014). The mentioned facts necessitate the assurance of the quality of crowdshipping service. To account for this criteria, (Punel & Stathopoulos, 2017) used several service attributes; driver's performance rating, courier expertise, and courier experience. The choice on first feature is reasonable as it is a well-known feature among users and has been implemented by several crowdshipping services. Research revealed that the transparency of information regarding driver performance rating is significantly valued by customers, especially for local delivery context (Punel & Stathopoulos, 2017). Aside from driver rating, (Punel & Stathopoulos, 2017) included courier expertise level (divided as occasional or professional), and courier experience which is indicated by number of parcels that have been transported in the past. Driver vetting process which commonly covers personal background check is also frequently mentioned by companies to show their intention to guarantee qualified couriers (Rougès & Montreuil, 2014). Another attribute within this category is insurance provision to solve any liability caused by damaged or stolen packages (Rougès & Montreuil, 2014).

Other attributes

What is currently hindering the acceptance of bicycle as a cargo delivery modes is the lack of perception that bicycle is a suitable mode for city logistics (Lenz & Riehle, 2013). To encounter such perception, diffusion of information regarding the advantage of bicycle for freight delivery needs to be emphasized (Lenz & Riehle, 2013). As it is important to stress the reduction of air and noise pollution in cities as the key the contribution of cargo cycle (Lenz & Riehle, 2013), the same concern should also be emphasized for bicycle crowdshipping. Interestingly, what has been by far absent from the crowdshipping behavioral acceptance experiments is the inclusion of environmental features as part of the service attributes, despite the fact that it is one of the distinctive features of crowdshipping over other delivery services. Moreover, (Punel et al., 2018) found that crowdshipping potential users are motivated by their concern to the environment. In bicycle crowdshiping setting, this can be done, for example, by providing the information of potential CO2 emission savings by using the service. This information can resemble the trip summary of bike sharing app, in which the CO2 emission saving is shown to users according to the distance they have traveled with bicycle (mobike). For crowdshipping service relying on cars, this would be more challenging because it should be analysed whether the perusal of crowdshipping results in positive net balance of vehicle kilometers. Additional vehicle kilometers induced by rebound effect thus should be taken into account. For bicycle crowdshipping, this calculation would be more practical as the motorized delivery trips are completely eliminated.

3.2.2 Benchmarking crowdshipping service attributes

The same company list obtained from the benchmarking process in section 2.4 is used for benchmarking service attributes. From the listed services, the crowdshipping service attributes are identified based on four categories; traditional features, control over delivery conditions, quality and security feature, and other features. Other feature refers to specific feature possessed by a crowdshipping company that makes it unique compared to other crowdshipping services (not a common service attribute). The result of the benchmarking process will be valuable to differentiate between 'must' have' and unique attributes of crowdshipping. To ease respondents in identifying competitive advantage of crowdshipping, the latter will be the priority to be included in stated preference survey. Benchmarking also give a glimpse on realistic levels for attributes being considered. As an instance for the latter, benchmarking would give range for delivery speed (e.g., 1 hour, 3 hour, etc.) for certain delivery context.

Traditional Feature

In regards to cost, two types of delivery charging scheme appear within the benchmarked companies. The first type is fixed base price with incremental charging based on delivery conditions (speed, package weight and size, and distance) or service membership status. This price term is in practice preferred for intra-urban delivery, which is apparent considering that most of the services operating in the local context apply fixed base price (see Figure 8). Zipments imposes fixed minimum cost of $9 with incremental charges for rush service, larger/heavier loads, and longer distances travelled (zipments.com). Aside from the fixed base fee of $6, Postmates introduced additional fee that takes a fixed percentage of the value of the items delivered. In Netherlands, Saddl imposes base delivery fee of 5 Euro with incremental charge based on distance and weight while guaranteeing that total delivery fee would be 10 Euro at maximum. Fietskoeriers offers fixed price of respectively 12, 17, and 20 Euro for its same day, 4 hours, and 1 hour peer-to-peer local delivery. For the same delivery speed (i.e., same day or faster), using established courier would cost much higher. For instance, DHL Express costs 33.5 euro for its same day delivery, while UPS costs 24.9 euro.

In general, services within local delivery-fixed price quadrant serve mainly B2C market. If we made a comparison, pricing for B2C delivery seems more attractive than peer-to-peer delivery, which is probably resulted from diversified revenue source besides customer's fee such as resale margin and membership fee (Rougès & Montreuil, 2014). Other revenue sources 'subsidize' customer's fee, resulting in cheaper delivery cost. As for peer-to-peer shipment, diversified revenue source is not possible so that the company relies merely on the customer fee.

The second type of charging scheme is variable prices. Variable pricing is commonly applied for services involving a customized/personalized request that can be found in last-mile delivery (such as Trunkrs) and peer-to-peer delivery platform (such as Piggybaggy). The preference of last-mile delivery services towards variable pricing scheme is depicted in Figure 8. For last-mile delivery context, variable price is defined depending on the shipment characteristics (i.e., size and weight) and delivery frequency, as practiced by Fietskoeriers and Trunkrs. It seems reasonable that last-mile delivery services offer variable prices. Last-mile delivery with crowdshipping would require sufficient cost reduction to make it profitable for the customers. As such, the couriers company would have to pay attention to the volume and frequency of the shipment to enable efficient shipment (such as consolidation). In such situation the service fee would depend on case-by-case basis and thus imposing fixed price may not be a favorable option. It is also apparent that some platforms (such as Deliv and Amazon Flex) provide services for both last-mile and local delivery context.

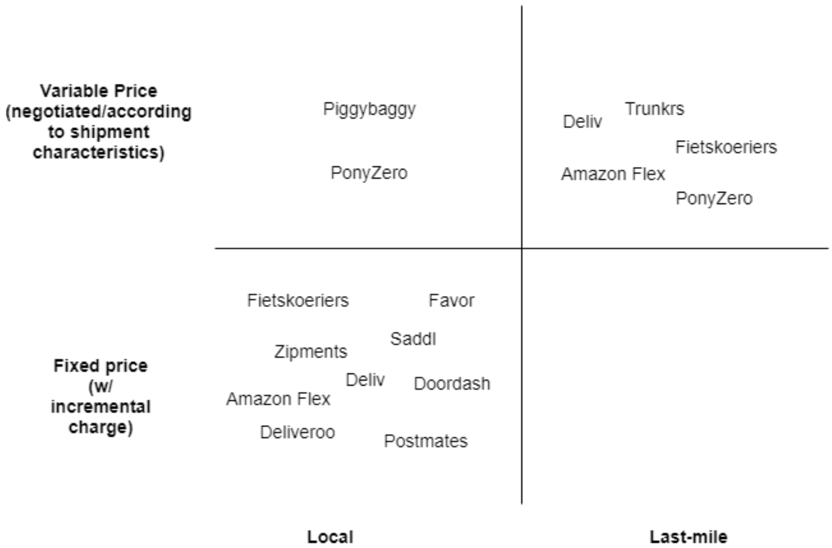

Figure 8 Pricing quadrant of the benchmarked companies

In regards to delivery speed, services specializing in local delivery context promise delivery lead time as short as thirty minutes, which is evident for services providing food delivery such as Deliveroo, Doordash, and Postmates. To respond high value of time characteristic of foods, express delivery might be deemed important for those crowdshipping services. The local delivery speed ranges 30 minutes up to a week from delivery order placement. On the other hand, companies serving last-mile delivery focus on promising same day and next day delivery. It might be reasonable since in last-mile delivery higher complexity exists if one to offer one hour delivery service. In order to do so, the delivery schedule must be aligned throughout the logistics chain, which is unlikely since carriers serving each leg of the delivery trips need to perform consolidation to some extent without which they cannot perform the delivery efficiently.

Control over delivery conditions

Track and trace feature is virtually available in all the benchmarked companies. Track and trace might be considered essential in default and companies has no choice but to provide this feature as minimum service requirements. From the observation, customer's ability to define pickup time is only found in the companies serving peer-to-peer shipment such as Piggybaggy, while for other it is up to the driver's decision. This is reasonable as defining pickup time may not be relevant for B2C platform, for which customers only paid attention to delivery time window. Customizable delivery time is apparent in all benchmarked companies, signifying that this feature remains a distinctive advantage of crowdshipping.

Quality and Security

Most of the benchmarked companies manage performance rating and delivery experience information of their drivers. However different approach appears when it comes to sharing this data to the customers. Zipments and Deliv keep track courier's performance information based on speed, package care, and overall delivery performance, and make this information accessible by the customers. Similar information is also recorded by Amazon Flex, Favor, Doordash, and Deliveroo. In these companies the information is undisclosed to customers and privately used to monitor and retain drivers with good ratings within the service. Most companies use star-rating to rate the courier performance, and establish a threshold under which the courier cannot participate in the crowdshipping platform any longer. For instance, Postmates applies minimum rating of 4.6 for its courier, while for Doordash the minimum rating depends on the competitiveness rate for each region. With respect to expertise, most of the crowdshipping company relies on occasional drivers. Trunkrs and Deliv use the combination between occasional and dedicated courier to guarantee service reliability when occasional courier is not available. Driver vetting and insurance are found in all the benchmarked services, which marked both features as 'must have' for the crowdshipping providers.

Other Features

Aside from the mentioned service attributes, some services also offered additional features that do not commonly appear in crowdshipping services. Zipments, for instance, enables customers to state the preferred transport mode to deliver the packages besides only offering bicycle . Trunkrs is currently exploring its capability to provide to-person delivery service as a complement of to-address delivery service (Climate-KIC, 2018). This offering elevates the flexibility of choosing delivery location to a new level. Ponyzero provides the feature that informs the user on the CO2 emission savings (Ponyzero, 2018). It claims that it can accurately calculate the CO2 emissions avoided by using their means of transportation.

3.4 Crowdshipping job attributes

Identical with service attributes, selection of job attributes is based on the criteria that these attributes should represent parameters that can affect commuter's willingness to participate (supply side) on crowdshipping service. The list of attributes is mainly based on prior studies in crowdshipping-related topics, complemented with benchmark on existing services.

3.3.1 Literature overview

The success of attracting sufficient couriers to perform crowdsourced delivery depends on the extent to which the penalty caused by crowdshipping could be offset (or outnumbered) by the rewards provided. It can be presumed that any crowdshipping job is likely to be accepted if the perceived value of time of the traveler can be paid off by the benefits associated with performing crowdshipping tasks. Aside from penalty and rewards, the travel setting (e.g., trip purpose or time of day) in which the crowdshipping job is carried out might also of importance. Although travel setting *per se* is not a service attribute, it may have direct influence to the job attributes. For example, job offerings during morning peak might penalize the couriers higher and as a response higher monetary compensation might be needed to maintain job acceptance rate. Literature in crowdshipping job attributes is still limited, hence in some parts this literature overview will make use the research on cyclist commuter's behavior as reference.

Travel Setting

(Paleti, Vovsha, Givon, & Birotker, 2015) found out that value of time of commuters vary as a function of trip patterns and schedule. This indicates that the setting of crowdshipping job will determine the success rate of assigning job into a prospective courier. Travel setting may include the trip direction such as to work or to home. The distinction between trip direction is supported by the finding of (Paleti et al., 2015) that within outbound trips (trips headed to workplace) perceived value of time of commuters are higher in comparison to inbound trips (trips headed towards home). This relationship is reasonable since travelers are under time pressure to arrive at workplace on time (Broach, Dill, & Gliebe, 2012).

The second travel setting could be the type of weekday the crowdshipping task should be done. The preference to work as crowdshipper might be different between workdays or weekend. (Ermagun, Shamshiripour, & Stathopoulos, 2018) observed that the percentage of successful delivery is less if the delivery request is posted during weekend, which is intuitive given that on weekend the availability of commuting trips are little due to less amount of people going to work.

Another travel setting according to literature is the time of day for crowdsourced delivery task (Miller et al., 2017). Time of day would be relevant to be considered as travelers would rather to perform crowdshipping task during their free time, for example before their departure to work or during their return trip to home. (Miller et al., 2017) revealed that trips performed in the evening (for male) are more likely to accept crowdshipping task. Time of day setting could work in combination with the setting of weekday. In their study, (Le & Ukkusuri, 2018a) identified that prospective courier preferred to work as crowdshipper in the evening during the weekdays and in the afternoon during the weekend. The finding is rationale as the preferred time of day is aligned with average schedule of working people (9 AM to 5 PM).

Penalizing Factors

Penalizing factors can be defined as the job attributes that deter prospective courier's away from performing crowdshipping. Research by (Broach et al., 2012) suggested that people that uses bicycle to commute are found to be more sensitive towards travel distance in comparison to people that uses bicycle for leisure. It should be noted that in bicycle network travel time is proportional with travel distance, assuming that congestion can virtually be neglected. Likewise, (Miller et al., 2017) also discovered that travel time would negatively influence utility of performing a delivery. (Miller et al., 2017) distinguished travel time-related penalizing factors for crowdshipping jobs into three types; original travel time, additional travel time due to detour, and travel time reliability. (Miller et al., 2017) observed that traveler with short distance original trips are more likely to perform crowdshipping compared to those with longer original commuting trip. They also revealed that the utility of monetary compensation is marginally decreased along with increased travel time. Additional travel time (due to detour/deviation from the normal route) is indeed a determining factor for crowdshipper's job acceptance, since it contributes to the total travel time experienced during the commute. Lastly, travel time reliability (depicted as percentage of travel time variability from additional travel time) is found to be another important aspects for travelers, as suggested by (Bhat & Sardesai, 2006).

Another penalizing factor that hinders crowdshipping job acceptance is package characteristics. (Le & Ukkusuri, 2018a, 2018b) argued that package size and weight would influence the willingness of crowdshipping couriers to deliver packages. In case of bicycle crowdshipping, a large-sized package might be problematic due to limited storage capacity and difficulty in handling. The revealed preference study by (Ermagun et al., 2018) is however contradictory to this statement, as they found that large sized shipments are more preferred by the crowdshipping couriers. This might be caused by correlation between parameters as implicated by revealed preference study; sizable shipments are commonly associated with higher delivery prices (Ermagun et al., 2018).

Lastly, delivery deadline is also an important penalizing factors for potential crowdshippers. Delivery deadline can be defined as the time gap between the placement of the delivery order and the targeted delivery time. Shorter delivery deadline means less flexibility for courier to adjust the pickup and delivery time with their schedule, thus courier may consider it as more demanding compared to those of longer delivery deadlines. A research by (Ermagun et al., 2018) supports this argument by showing that when tighter delivery deadlines are imposed, the orders for package delivery by customers are less likely to get couriers' bid.

Rewarding Factors

Rewarding factors are job attributes that improve the attractiveness of performing crowdshipping job. It is expected that when the rewarding factors are increased, the probability of travelers to be willing to perform crowdshipping task becomes higher. Profit is an important part of rewarding factor to encourage the participation of bicycle commuters to deliver packages (Le & Ukkusuri, 2018a; Miller et al., 2017; Paloheimo et al., 2016). Most of the research on crowdshipping job acceptance perceived profit as monetary benefits for which the travelers are willing to give up their travel time. As such, profit is commonly compared with value of travel time (VoT) of travelers. The logic is that when profit can offset or exceed the value of time, the traveler would accept the crowdshipping job offer.

In practice, the motivation behind the participation on crowdshipping platform is not merely related to monetary benefits. As stated by (Estellés-Arolas & González-Ladrón-de-Guevara, 2012), previous studies discovered that people participating in any crowdsourcing job are motivated by diverse reasons that fit some of Maslow's hierarchical needs; economic reward, social recognition, self-esteem, and willingness to develop individual skill. From their case study with one of the established crowdshipping companies, (Frehe et al., 2017) has shown that considerable amount of drivers acknowledged that they offered their service as courier to assist the neighborhood and to reduce CO2 emission. Likewise, (Paloheimo et al., 2016) discovered in their pilot project that monetary benefits only would be considered too small to entice the drivers' participation in the crowdshipping platform. Alongside the profit, the drivers considered that physical exercise is another factor that also contributed to encourage their participation[5] (Paloheimo et al., 2016).

Given the unique job attributes of crowdshipping in comparison to other delivery services, a rich combination of value proposition needs to be emphasized in the offering of crowdshipping jobs (Paloheimo et al., 2016). As already mentioned, bicycle crowdshipping should include not only monetary compensation as the benefits for the drivers. Another motivation such as physical exercise and environmental benefits through CO2 emission reduction should be taken into account. This can be materialized, for instance, by perusal of gamification concept which has been widely applied in the field of crowdsourced services (Morschheuser, Hamari, & Koivisto, 2016). Gamification[6] would increase intrinsic motivation

[5] As a matter of fact, majority of the drivers participating in pilot study by (Paloheimo et al., 2016) uses bicycle to deliver library books.

[6] "Gamification refers to design that attempts to, firstly, increase the intrinsic motivation of users or participants to engage in a given activity or behaviour and, secondly, to increase or otherwise change the given behavior.

of potential couriers alongside with extrinsic motivation (i.e., monetary gain) to induce their willingness to participate in crowdshipping. To translate gamification into this context, scoring system on the platform informing drivers how many calories have been burned through the delivery journey or how many CO2 footprints has been saved could be applied.

3.3.2 Benchmarking crowshipping job attributes

Travel setting

With respect to travel setting, all of the benchmarked crowdshipping services offer the convenience of flexible schedule which comes in two form. Firstly, the platform provides the ability to select the preferred time slot to work as crowdshipper. In this choice any gig-workers (another term to call the crowdshippers) can select any shift during the week that fits within their schedule. Accordingly, the crowdshipping provider will assign delivery blocks that are available as to the preferred dates. The second form of scheduling does not provide the crowdshippers access to book their delivery schedule. Instead, they should be online whenever they found the available time to perform crowdshipping tasks. The advantage of the first type is that the platform will have a visibility on the number of workers beforehand, thus making it easier for them to plan and distribute the tasks. However, this type of scheduling is more vulnerable when the demand pattern is fluctuated or unpredictable. Additional tasks would also be needed to manage the canceled delivery blocks. The second type brings advantage in the form of flexibility. As schedule booking is not necessary, any surge in demand can be accommodated when there are enough drivers in proximity. This scheduling type also comes at risk; since there is no planning beforehand, there might be courier shortage. For certain time of day where demand peak is evident, some crowdshipping platform offers surge pricing that is higher than normal pricing. Peak-pricing strategy is expected to increase courier participation during demand-critical period.

Penalizing Factors

To maximize job acceptance rate by potential crowdshippers, some crowdshipping services assign the delivery job within acceptable range of crowdshippers. Based on the distance, delivery job will be assigned accordingly to the modes available. Besides maximizing the acceptance, this assignment logic is also chosen to achieve reliable service lead time. For instance, Deliv stated in its website that the average distance to be traveled by a crowdshipper would be 15 miles, which reflects the distance that is likely to be achieved within one hour travel by car. For delivery with bicycle, the delivery range could take up to 3 miles (as practiced by Postmates) and 5 miles (as practiced by Doordash).

As for package characteristics, only few services specified in detail the maximum acceptable loads and size. Deliv and Zipments provide the delivery for items up to 50 pounds and a size of a ’42 inches TV’. Ponyzero serves delivery for items up to the size of 1 meter-square and 50 kgs in weight. These specifications are offered as these services provide car-delivery alongside with bicycle delivery. Zipments dispatched their deliveries to different vehicles based on the size and weights of items to be delivered, which is likely to be the case for other providers.

Concerning delivery deadline, it is obvious that food delivery service has the tightest delivery deadlines. All of the crowdshipping providers serving food delivery set up the deadline up to 30 minutes from the placement of the order. As for other types of packages, the delivery deadline range from 30 minutes up to a week. Services that has possibility to book a delivery schedule enables the crowdshipper to have a longer delivery deadline.

Rewarding Factors

Most gamification applications borrow design patterns from (video) games and, consequently, aim to give rise to similar experiences as games commonly do, e.g.,: feelings of mastery, autonomy, flow, suspense etc.” (Morschheuser et al., 2016)

In regards to rewarding factors, most of the companies offer reasonably competitive rate as their selling point to attract potential couriers, which can be seen from its difference from the minimum wage applies in respective region. Commonly, earning is calculated based on the number of delivery made. In some cases it is applicable to get additional income from bonuses (as applied by Deliveroo) and tips. Zipments and Deliv stated that in average the couriers can earn up to 20 USD/hr, much higher than minimum wage of 7.25 USD/hr in the US (DepartmentOfLabor, 2009). Likewise, Amazon Flex offered a range of benefit between 18 to 25 USD per hour. In the Netherlands, the rider of Deliveroo earn 5 euro per order, in which there is possibility to stack two orders from the same restaurants for 7.5 euro. In average, 2 to 3 orders can be made within an hour, yielding profit range of 10-15 euro per hour (metronieuws.nl). It should be noted that the numbers offered by the companies are depending on the actual delivery orders served by the respective courier, which may fluctuate time to time. The profit rate can be considered reasonable as it lies within the range of commuter's VoT of 12.58 euro per hour[7] (KiM, 2016).

Most of the companies promote flexible schedule as value proposition for the couriers. For instance, Deliv stated in its website the perks of "working when you want" by "scheduling yourself for the times that works for you" (Deliv.co). Only half of the benchmarked companies mentioned other benefits beside flexibility of schedule and potential profits to be gained. Benefits for the environment is stated by some companies such as Trunkrs, Fietskoeriers, and Piggybaggy. Trunkrs explains "We ensure less emissions and less crowds in the neighborhood" to underline its environmental concern. Benefits for the health is only stated by Amazon Flex and Deliveroo. Amazon Flex included the testimonial of one of its courier: "Amazon Flex allows me to get outside, breathe fresh air, and stay active". Benefits for the society through neighborhood assistance is emphasized by some services such as Trunkrs, Amazon Flex, and Piggybaggy. Interestingly, among all the crowdshiping providers, none of them applied a service feature which measures environmental footprints that can be reduced by using the service. An example only comes from Ponyzero, which is more of a bicycle courier than crowdshipping firm, where it states that CO2 footprint reduction by replacing the conventional truck services with Ponyzero will be calculated. Ponyzero claimed that this feature would be a great value when it is informed to the customers (ponyzero.com). It is also apparent that most of the services incorporate other rewarding factors beside profits through marketing medium (e.g., website) and none of them incorporate them in performance scoring system within the mobile apps/website.

3.5 Chapter summary

The study revealed five components that compose the business model of crowdshipping; creation, offers, stakeholders, characters, and revenue. (Value) creation means that crowdshipping is, among other tasks, responsible for matching between courier (supply) and customers/senders (demand). To achieve a good match between supply and demand, the crowdshipping provider is consequently required to recognize the system/service attributes that will either enhance or impair user's acceptance of the service and understand the mechanism (e.g., relative importance, direction of influence) in which these attributes affect service acceptance. This fact signifies the relevance of this research, especially with respect to managing the acceptance from supply and demand side. Offer portrays that the key differentiating feature of crowdshipping lies on its flexibility to define pickup and delivery condition, lower cost compared to traditional shipment, and benefits to environment and the society.

[7] This is the VoT for commuting by car. This VoT selection is made considering there is no specific VoT data for commuting by bicycle and due to the fact that many of the cyclist commuters use bicycle as an access/egress mode to train station.

On crowdshipping service attributes, attribute categories were distinguished into four; traditional feature, control over delivery condition, quality and security, and other factors. It is to be noted that aside from its competitiveness in regards to traditional feature (e.g., express shipment for a lower cost than average delivery service), the value of crowdshipping is predicated on other unique benefits it offers such as CO2 footprint reduction. Benchmarking results demonstrated that current practice has not been fully exposing the environmental feature of crowdshipping to attract customers. As such, it becomes interesting to 'test' in the research whether the integration of such unique attributes within crowdshipping apps/platform would be valued by its users.

As for crowdshipping job attributes, the attribute categories are distinguished into three; travel setting, rewarding factors, and penalizing factors. Travel setting represents the survey context which is beneficial to identify the job acceptance between different settings such as time of day and weekday. This is imperative to develop an effective context-based rewarding scheme. This approach has also been applied by many crowdshipping platform to mazimize job acceptance through concept such as surge pricing during peak hours. Rewarding factors implies that unique value proposition should be stressed by crowdshipping platform to entice participation from potential drivers. This could be a combination of external drivers (i.e., monetary compensation) and internal drivers (i.e., gamification).

The bicycle crowdshipping attributes are summarized in Table 1 and Table 2.

Table 1 Service attributes summary. These attributes represent parameters that affect customer (online shopper) acceptance towards bicycle crowdshipping.

Category	Attributes	Explanation	Supporting Literature/Source
Traditional Features	Cost	Delivery cost per units (order, package)	(Punel and Stathopoulos, 2017), (Chen, Pan, Wang & Zhong, 2016), (Savelsbergh and Van Woensel, 2016)
	Delivery Speed	Lead time between order placement and delivery	(Punel and Stathopoulos, 2017), (Chen, Pan, Wang & Zhong, 2016), (Savelsbergh and Van Woensel, 2016)
Control over Delivery Conditions	Pickup Time Window	The ability to specify pickup time	(Punel and Stathopoulos, 2017)
	Delivery Time Window	The ability to specify delivery time	(Le and Ukkusuri, 2018)
	Track and Trace Feature	Delivery progress milestones	(Rouges and Montreuil, 2014)
Quality and Security	Performance Rating	Delivery rating by customers/platform representing courier's speed, timeliness, package care, and overall delivery performance	(Punel and Stathopoulos, 2017)
	Courier Type/Expertise	Type of resource; professional, occassional	(Punel and Stathopoulos, 2017), (Rouges and Montreuil, 2014)
	Experience	Number of packages/orders delivered	(Punel and Stathopoulos, 2017)
	Courier Vetting Process	Background check for courier selection	(Rouges and Montreuil, 2014)
	Insurance Provision	Liability coverage due to accident/delivery misconducts	(Punel and Stathopoulos, 2017), (Rouges and Montreuil, 2014)
Other Attributes	Delivery to person	Delivery location according to a person's whereabout, instead of address	(Climate-KIC, 2018)
	CO_2 emission savings	Scoring system that shows amount of CO_2 emission saved by using crowdshipping	(Lenz et al, 2013), (Morschheuser, 2016), (Frehe, Mehmann, & Teuteberg, 2017), (Punel, Ermagun, and Stathopoulos, 2018)
	Flexible mode offerings	Ability to request preferred delivery mode	(Zipments, 2018)

Table 2 Job attributes summary. These attributes represent parameters that can affect bicycle commuter's willingness to participate in bicycle crowdshipping

Category	Attributes	Explanation	Supporting Literature/Source
Travel Setting (Context)	Trip direction	To home or to work/school	(Paleti, Vovsha, Givon, & Birotker, 2015), (Broach, Dill, & Gliebe, 2012)
	Type of weekday	Weekdays/weekend	(Ermagun, Shamshiripour, & Stathopoulos, 2018)
	Time of day	Morning/Afternoon/Evening	(Miller, Nie, and Stathopoulos, 2017), (Le & Ukkusuri, 2018a)
	Original Travel Time	The length of original trip	(Miller, Nie, and Stathopoulos, 2017)
Penalizing Factors	Additional Travel Time	The length of detour caused by delivery leg	(Miller, Nie, and Stathopoulos, 2017)
	Package size		(Le & Ukkusuri, 2018a, 2018b), (Ermagun, Shamshiripour, and Stathopoulos, 2018)
	Package weight		(Le & Ukkusuri, 2018a, 2018b), (Ermagun, Shamshiripour, and Stathopoulos, 2018)
	Delivery deadline	The time gap between task assignment and targeted delivery time	(Ermagun, Shamshiripour, & Stathopoulos, 2018)
Rewarding Factors	Profit	Monetary compensation	(Le & Ukkusuri, 2018), (Miller, Nie, and Stathopoulos, 2017), (Paloheimo, Lttenmeier, and Warris, 2016)
	CO2 emission savings	Scoring system that shows amount of CO2 emission saved by performing crowdshipping	(Frehe, Mehmann, & Teuteberg, 2017), (Ponyzero, 2018), (Morschheuser, Hamari, & Koivisto, 2016)
	Calories burned record	Scoring system that shows amount of calories burned by performing crowdshipping	(Paloheimo, Lttenmeier, and Warris, 2016), (Morschheuser, Hamari, & Koivisto, 2016)

CHAPTER 4: Choice Experiment Design

4.1. Introduction

Attributes that can potentially influence stakeholder's acceptance towards bicycle crowdshipping have been explored in chapter 3. The question that remains is to what extent those attributes would affect the level of acceptance. To answer this, a choice experiment survey will be designed to measure the attribute importance. This chapter scrutinizes the design process of such a choice experiment.

Before stepping into the survey, firstly service attributes and job attributes to be incorporated in the survey will be shortlisted. The shortlisting process can be found in section 4.2. Following the attributes selection, choice model specification that adapts the selected attributes to equation (1) and (2) will be presented. Afterwards, design of elements of the choice experiment survey will be described; starting from defining attributes level (section 4.3), constructing choice alternatives (section 4.4), determining choice sets (section 4.5), and finally designing questionnaire structure (section 4.6).

4.2. Selecting the attributes

Number of Attributes

Choice model relies on the integrity of choice making process which is based upon respondent's limited ability to digest the choice information (Carson et al., 1994). Consequently, a choice task involving too many attributes would result in a lower data quality, because it suffers in the sense of not containing the information required (Carson et al., 1994; Caussade, Ortúzar, Rizzi, & Hensher, 2005). When encountering too many information, a respondent would tend to perform heuristic strategy, that is, taking into account only partial information (attributes) to derive the decision instead of comparing the whole attributes (Arentze, Borgers, Timmermans, & DelMistro, 2003). To avoid this issue and further to achieve reasonable data collection process, not all of the attributes presented in chapter 3 will be used in the stated choice survey.

It is a popular belief that the number of attributes that a respondent can effectively handle should amount equal or less than 7 attributes (Molin, 2016a). On the other hand, presenting too little attributes would also bring disadvantages as realism of the choice representation might be forsaken. For a better realism, it is decided that the attributes should cover the whole range of the attribute category (as mentioned in Table 2 and Table 3). This entails at least one attribute should be included to represent each category. Therefore, a minimum of four and three attributes need to be incorporated for respectively service and job attributes. Considering these factors, the author decided to use five attributes to be included in each of the choice experiments.

Selection Criteria

As the number of attributes in Table 2 and 3 are higher than the defined maximum threshold, shortlisting process will be needed. To base the selection process, the following criteria will be used:

- **Distinctive/differentiation feature.** Preference or trade-off between alternative could be better identified when attributes that reflects distinguishing feature between alternatives are chosen (Molin, 2016a). As instance, it can be said that if one would like to identify the trade-off between crowdshipping and traditional shipment, distinguishing feature such as the ability to choose delivery time window should be included in the experiment. By including such feature, the respondents would have a clear idea on how the crowdshipping service differs from other delivery services, thus improving the accuracy of the survey responses.

- **Importance/significance of the attributes.** One of the means to avoid heterogeneity and bias from an experiment is to incorporate the most important attributes for respondents (Molin, 2016a). The risk of dismissing important attribute is that the respondents would likely to make their own assumption from the associated attributes in the experiment[8] (Molin, 2016a). For attribute selection referring to prior research, important attributes can be identified by the significance of the parameters within the choice/statistical model. Significant attributes/parameters represents the fact that there is a strong probability that respondent's choice of alternatives are truly affected by the feature of corresponding attribute instead of by coincidence. However, this criteria does not apply for any attributes that have not been explored in previous research.
- **Market realism.** It is unambiguous that in order to gain a reliable choice, the survey attributes should represent the situation that is likely to be found in the real market (Louviere et al., 2000). This does not necessarily means that the attributes should already be exist in reality, especially in the case of stated choice experiment. Instead, this can be achieved by presenting imaginable and practical choice situation.
- **The ability to influence the attribute (actionable attribute).** As stated in chapter 1, the aim of the research is to find the attributes that can affect the acceptance of stakeholders towards crowdshipping. By managing (or changing) the attributes, crowdshipping platform would expectedly be able to influence the level of acceptance to achieve a balance between supply and demand of crowdshipping. To accommodate these objectives, only attributes that can be changed/responded by the crowdshipping platform will be considered in the choice experiment. The usage of this criteria is following a study by (Molin, Blangé, Cats, & Chorus, 2017). It should be noted that exception for this criteria can be made for attributes describing the context of the survey (such as time of day) when they are considered to have significant impact on respondent's choice. In this case, one may not be able to change the context, but understanding its effect might help to formulate a proper measure to optimize service acceptance in certain context[9].

The first two criteria are based on the literature review and benchmarking in preceding chapter, while the last two criteria are mainly based on opinions from logistics and cycling expert (author's thesis advisors). It is to be noted that 'distinctive feature' and 'importance of the attributes' are deemed as substitutable, thus a service/job attribute only needs to fulfil either of those two criteria in order to be qualified.

4.1.1. Selection of service attributes

Each of the service attributes is evaluated according to the established selection criteria, as shown in Table 3. Any attribute that fulfills certain selection criteria is marked with a check mark (√). The finally selected attributes are marked with an asterisk (*).

[8] For example, this situation can be found when in a choice experiment one includes price attribute but exempt quality attribute. Most likely, the respondents would conclude that the alternative with a higher price is associated with a higher quality than the alternative with a lower price (Molin, 2016a).

[9] An interesting example on the benefit of understanding context effect is the concept of 'surge pricing' as one can find in Uber ride-hailing service. During peak demand periods, the system would adjust the pricing to a higher level to stimulate participation from drivers. This helps Uber to avoid shortage of drivers.

In traditional feature category, all the attributes (cost and delivery speed) were found significant in the previous study. Both of the features is also important given that the resulting parameters from both ‘cost’ and ‘delivery speed’ will be needed to calculate customer’s value of delivery time-saving. In ‘control over delivery condition,’ track and trace feature is found to be a profoundly basic feature that needs to be provided in any delivery service, hence it is excluded from the attribute selection. Although ‘pickup time window’ is qualified based on attribute selection criteria, in case of online shopping home delivery service it is considered irrelevant. The customer would pay attention to when the items would be delivered to their home, instead of when they will be picked up at store/pickup points.

In ‘quality and security’ category, both vetting process and insurance provision do not qualify according to the selection criteria. Courier expertise and experience are both qualified, however, the former is irrelevant to the study as the objective is to engage cyclist commuter as an occasional courier. This exemption left us with two attributes; performance rating and courier experience. As there is only one space available for the attribute (one remaining slot to be allocated for ‘other attributes’), 'courier experience' is excluded and assumed to be covered in performance rating. Performance rating is also chosen as it reflects reliability of the crowdshipping service. A discussion with a cargo cycle expert (Jos Sluijsmans) suggested that most customers opted for cycle courier due to its reliability.

In the last category, CO_2 footprint reduction is chosen as it is the only attribute that qualifies according to the criteria. Delivery to person, although sounds realistic, is deemed as non-actionable since it has the possibility to interfere with privacy concern of individual customers. In total, five attributes were selected for the service attributes. These attributes will be incorporated into the first choice experiment that examines demand side of the system.

Table 3 Evaluation of each service attribute according to selection criteria

Category	Attributes	DIF	SIG	MAR	ACT
Traditional Features	Cost*		√	√	√
	Delivery Speed*		√	√	√
Control over Delivery Conditions	Pickup Time Window	√	√	√	√
	Delivery Time Window*	√		√	√
	Track and Trace Feature			√	√
Quality and Security	Performance Rating*	√	√	√	√
	Courier Type/Expertise	√	√	√	√
	Experience	√	√	√	√
	Vetting Process		n.a.	√	√
	Insurance Provision		n.a.	√	√
Other Attributes	Delivery to person	√	n.a.	√	
	CO2 footprint record*	√	n.a.	√	√
	Flexible mode offerings		n.a.	√	√

Remarks
*****chosen attributes based on evaluation criteria
DIF : Differentiation/distinctive feature
SIG : Significance/importance of the attribute
MAR : Market realism
ACT : The ability to manage/influence the parameter (actionable)

4.1.2. Selection of job attributes

The same principle goes for the selection of job attributes (as can be seen in Table 4). Any attribute that fulfils certain selection criteria is marked with a check mark (√). The finally selected attributes are marked with an asterisk (*).

For 'Travel Setting/Context' category, most of the attributes were significant in prior study. 'Actionable' criteria is exempted in this category, as one cannot change the context (for instance, it is impossible to change the trip direction of the bicycle commuters). As context is actually not a service feature, 'distinctive feature' category is not applicable. Three context attributes were found significant. Trip direction and time of day is apparently intertwined each other; a trip made in the morning is commonly a trip heading for school/work, while a trip made in the evening is commonly a trip heading home. Hence, selecting either of these would suffice. Type of weekday is exempted because it has no significant effect in prior studies. Original travel time is decided to be excluded as within the survey it will be set as a fixed value (to be taken from the average commuting travel time from Dutch mobility study). At last, trip time of day is selected for 'Travel Setting' category.

For penalizing factors, additional travel time is chosen due to its alignment with the whole criteria and its importance to derive commuter's value of time. Subsequently, package size, weight, and delivery deadlines are also qualified. To shorten the attributes number, package size is assumed to be within the acceptable volume range for bicycle (hence, product with large and oversized dimensions will be directed for other delivery options). Package size is thus excluded from the selection. Despite its significance, delivery deadline should not pose a significant problem for bicycle crowdshipping. Especially in The Netherlands, short travel distance and dense cycle network could make it possible to deliver the products within as short as 30 minutes. Therefore, package weight becomes another selected criteria for the category.

For rewarding factors category, all the available attributes seem to qualify the criteria. Profit is an obvious choice as it is necessary to measure value of time of travellers. Since there are only two slots available for the last category, calories burned record is exempted given that CO2 reduction record can better qualify the selection criteria.

In conclusion, five parameters were selected for the job attributes. These parameters will be incorporated into the survey that examines supply side of the system.

Table 4 Evaluation of each job attribute according to selection criteria

Category	Attributes	DIF	SIG	MAR	ACT
Travel Setting (context)	Trip direction	n.a.	√	√	
	Type of weekday	n.a.		√	
	Time of day*	n.a.	√	√	
	Original Travel Time	n.a.	√	√	
Penalizing Factors	Additional Travel Time*	√	√	√	√
	Package size		√	√	√
	Package weight*	√	√	√	√
	Delivery deadline	√	√	√	√
Rewarding Factors	Profit*		√	√	√
	CO2 reduction record *	√	√	√	√
	Calories burned record	√		√	√

Remarks
*****chosen attributes based on evaluation criteria
DIF : Differentiation/distinctive feature
SIG : Significance/importance of the attribute
MAR : Market realism
ACT : The ability to manage/influence the parameter (actionable)

4.3. Attributes level

The selection of level values for the choice attributes is based on the benchmarking process performed in chapter 3. Such a selection is done to ensure that the choice alternatives can better represent the reality. To align with orthogonality principle, equidistance between level is applied when possible. To avoid unbalanced design, on which the number of levels in different attributes are not multiples of one another, the levels are based on the power of two (Louviere et al., 2000). This means that the number of levels should be two or its multiplication (2, 4, 6, and so forth). To enable the identification of non-linear effects of service/job attributes to the utility of bicycle crowdshipping, four levels of attribute is selected for attributes that have ratio measurement level (Molin, 2016a). Attributes that comprises binary level will use dummy coding (0 and 1 to represent each level).

Service attributes

Four levels is selected for both cost and delivery speed (1/3/5/7 hours). Two levels is selected to represent delivery time window (adjustable and non-adjustable), as is the case with performance rating (5 and 4 stars). Only two levels are selected for performance rating, given that in practice any courier performing less than 4 stars would likely to be suspended from the platform. CO_2 footprint reduction record also takes four levels. The calculation of emission reduction is based on emission rate per km from European Environment Agency (EEA, 2016) and average travel distance (round trip) from pickup point to customer homes (Weltevreden, 2008). Detailed assumption used to determine attribute levels can be found in Appendix 1.

Job attributes

Two levels are selected to represent time of day (morning and evening). Afternoon is exempted from the context to avoid unbalanced design and because it is less likely that people would perform delivery during the afternoon (lunch time). Additional travel time consists of four levels (6/10/14/20 minutes), which is calculated based on maximum acceptable bike travel distance in the Netherlands and bike cruising speed (KiM, 2016). Package weight, profit, and CO2 reduction record also has the same number of levels.

The summary of attribute levels can be found in Table 5 and Table 6. Detailed calculation and assumption regarding the value of attributes level can be found in Appendix 2.

Table 5 Levels of service attributes (for demand survey)

Category	Attributes	Levels	Units
Traditional Features	Cost	3/5/7/9	Euro
	Speed	1/3/5/7	Hours
Control over Delivery Conditions	Delivery Time Window	Adjustable/Non-adjustable	-
Quality and Security	Performance Rating	5/4	Star
Other Attributes	CO2 reduction record	0.9/1.3/1.7/2.1	Kilograms

Table 6 Levels of job attributes (for supply survey)

Category	Attributes	Levels	Units
Travel Setting (context)	Time of day	Morning/Evening	-
Penalizing Factors	Additional Travel Time	6/10/14/20	Minutes
	Package weight	1/3/5/7	Kilograms
Rewarding Factors	Profit	2/4/6/8	Euro
	CO2 reduction record	0.9/1.3/1.7/2.1	Kilograms

4.4. Choice alternatives

The choice experiment is intended to identify customer's trade-off between bicycle crowdshipping and other shipping options. Each of the alternatives may represent different attributes, therefore labeled alternative is used. Referring to market scope selection in section 2.5, home delivery options in the survey are confined into three types; 1) delivery via traditional courier, 2) delivery via bicycle crowdshipping platform, and 3) delivery via pickup/service point. The alternatives are composed by two alternatives that represent the bicycle crowdshipping choice, one alternative that represents the traditional shipping, and one opt-out alternative that represents self-pickup at a service point. In total, four alternatives are defined for the demand survey. Number of bicycle crowdshipping alternatives presented is higher to give the respondents more chance to review bicycle crowdshipping features before making their selection. Bicycle crowdshipping is a relatively new concept and thus more exposure is needed to help the respondents comprehending the concept.

For supply survey, two types of options are defined; 1) to accept the delivery job offer or 2) to decline the offer and proceed with the default commuting trip. Aligned with demand survey, two alternatives on delivery jobs will be given to give respondents more chance to consider the delivery job attributes. One opt-out alternative that represents rejection to the job offer is included as the last option. In total, three alternatives will be provided per choice set in supply survey. Figure 9 illustrates the choice alternatives (per question) to be used within demand and supply survey.

	Demand Survey *(selecting a delivery option)*			**Supply Survey** *(responding delivery job offer)*	
Options	Bicycle crowdshipping	Traditional shipping	Opt-out (self-pickup)	Accept delivery offer	Opt-out (decline offer)
# of choice alternatives	2	1	1	2	1

Figure 9 Choice alternatives for demand and supply survey

Inclusion of opt-out alternative in both surveys is needed to estimate the market penetration level that complies with demand theory (Carson et al., 1994; Kontoleon & Yabe, 2003). For which purpose, it is necessary that the experiment considers whether the consumers would like to purchase the products. Additionally, inclusion of opt-out alternative will improve task realism (Carson et al., 1994). In the real market, there are many cases where a choice is not mandatory to be made. In the context of demand side, opt-out option means that online shoppers would be able to collect the package themselves without using any of the offered home delivery services. Likewise, for the supply side, bicycle commuters can choose not to participate in delivering packages to customer homes if they consider that the benefits of performing crowdshipping jobs is too subtle.

4.5. Choice sets

Prior studies discovered that respondents face between one and sixteen choice sets, with the average being somewhere around eight choice set scenarios per respondent (Carson et al., 1994). Empirical study suggested that 9 choice sets provide the optimum response quality in terms of variance of error terms (Caussade et al., 2005). Above this level, the error term variance would likely to be increased as the effect of respondents increased fatigue level (Caussade et al., 2005).

The experiments for this research involve five attributes. Considering the attributes specification (number of attributes and number of levels) and number of choice alternatives, basic orthogonal design of 16 choice sets is selected (Molin, 2016b). To avoid an exhaustive choice making process, the choice sets are divided into two blocks. This means each respondent will be facing a maximum of 8 choice sets. This selection is made to align the questionnaire design with previous research findings on the optimum number of choice sets.

Choice Set Construction

The choice set construction is performed using efficient design approach. Unlike orthogonal design that minimizes correlation between attributes, efficient design is aimed to find a choice experiment design that yields the smallest standard error for its parameter estimates (ChoiceMetrics, 2014). Efficient design is more preferable for discrete choice (logit) model estimation, as it considers the S-curve relationship between utility and choice probability in logit model. This means, efficient design will not include choice sets that do not add much information on the trade-off between alternatives (Molin, 2016a). This results in a more efficient experiment design; the one with a lower number of choice sets without forfeiting the model quality.

Efficient design is deemed as a better alternative if there is knowledge on the priors of the parameter coefficient. Prior estimates are required to generate a utility-balanced design (read: non dominating alternatives) (Huber & Zwerina, 1996). Such balance is essential because choices between similarly-valued (competitive) alternatives would generate better information on the coefficient value (Huber & Zwerina, 1996). In efficient design, prior parameters serve as initial guesses on the relative importance of each attributes. Knowledge only on the correct parameter sign also counts for this purpose (ChoiceMetrics, 2014). The research objective is to obtain reliable parameter estimates for most of the attributes, hence D-efficient design is chosen (Molin, 2016a). The presence of dominating option is identified from estimated probability obtained from the efficient design. The simple rule of thumb is that probability of each alternative should not be higher than 0.9 (Molin, 2016a). When such dominance occurs, another design iteration is chosen. Ngene software is used to generate the efficient design (ChoiceMetrics, 2014). The detailed syntax code for choice experiment design can be found in Appendix 3 and Appendix 4.

Finding Prior Parameters

As to defining the prior parameters, two options are possible. The first option is to conduct a pilot study involving a small number of respondents (commonly around 30) (Molin, 2016a). Orthogonal design can be of good use for such pilot experiment. The second alternative is to adopt the result of prior choice experiment studies related to the corresponding attributes (Bliemer & Collins, 2016; ChoiceMetrics, 2014). The second option could be more beneficial and less time consuming if literature that examined similar attributes used in the study is available. For this research, the author adopted the second approach to cope with time limitation. The quality of the prior parameter is identified by examining the resulting D-error and Sp-estimate. The lower the D-error and Sp-estimate is, the better the design. Some parameters undergone manual scaling (i.e., manually adjusting the value) to generate better design specification (Bliemer & Collins, 2016). The detailed source of prior parameters being used can be inspected in Table 7 and Table 8. Note that in supply survey, the prior for 'time of day' is not specified in the design since it is incorporated as a context variable instead of attribute.

Table 7 Prior parameters for demand survey's efficient design

Attribute	Prior Parameter Value	Source
Cost	-0.131	(Punel & Stathopoulos, 2017)
Speed	-0.108	(Punel & Stathopoulos, 2017)
Delivery Time Window	0.395	(Punel & Stathopoulos, 2017)
Performance Rating	0.495	(Punel & Stathopoulos, 2017)
CO2 emission reduction	1.22	(Punel et al., 2018)

Table 8 Prior parameters for supply survey's efficient design

Attribute	**Prior Parameter Value**	**Source**
Additional Travel Time	-0.114	(Miller et al., 2017)
Package Weight	-0.78	(Le & Ukkusuri, 2018a)
Profit	0.885	(Miller et al., 2017)
CO2 emission reduction	0.92	(Punel et al., 2018)

4.6. Questionnaire structure

Demand Survey

The questionnaire is initiated with a short introduction on the study purpose and definition of bicycle crowdshipping. This helps the respondent in understanding the basic concept of bicycle crowdshipping.

Following the introduction, some questions on online shopping experience are presented. This includes frequency of online shopping, type of items purchased online, average value spend, preferred delivery location, and experience with crowdshipping. At this stage, respondents with no prior online shopping experience will be excluded from the survey, thus leaving only the relevant respondents to complete the questionnaire. Respondents are also asked to rate the importance of home delivery service attributes. The result will be used to crosscheck the resulting parameter estimates from the choice experiment. Questions on online shopping experience is placed before the choice experiment to raise respondent's initial awareness on the topic and attributes in the choice experiment part that will follow. This ordering mechanism is adopted from the research of (Miller et al., 2017).

In the next section, respondents will face home delivery choice experiment. To achieve balanced share between the question blocks, a respondent will be randomly assigned to any of the two blocks. Before the choice set is presented, a short paragraph explains the context of the choice (aligned to the market scope selection in section 2.5), the available alternatives, and the attributes that represent the trade-off between options. Every respondent will face 8 questions (also called choice set/scenarios). For each of which, respondents are required to choose the preferred home delivery service among four available alternatives including the opt-out. Opt-out options is deliberately not mentioned in the introductory paragraph to avoid respondents having this option in mind before carefully inspecting the available alternatives. If the respondent reads the question carefully, they will find the opt-out option clearly in each question. The order of the questions is randomized for each respondent to prevent bias due to fatigue effect. There would be a risk of choice information lacking if most respondents turned out to select the opt-out option. To account for the risk, a forced choice situation is provided when a respondent selects the opt-out alternative.

Following the choice scenarios, the last section comprises personal characteristics questions to identify socio-demographic attributes of the respondents. Literature has shown that some demographic characteristics such as education level, employment level, and income influenced the propensity to use or perform crowdshipping service (Miller et al., 2017; Punel & Stathopoulos, 2017). Inclusion of personal characteristics will also be valuable to recognize potential customer segment of bicycle crowdshipping and to compare the sample statistics with Netherlands population. The socio-demographic question covers age, gender, income, education level, household type, transport mode for daily commuting, and commuting period (peak or off-peak hours). Detailed format of the demand survey can be found in Appendix 5.

Supply Survey

The structure is in general equivalent to that of demand survey. The supply survey is initiated with a short introduction to help respondents getting an initial idea of bicycle crowdshipping. Subsequently, questions on travel behavior is presented. The purpose is to raise respondent's interest on the topic and to give first exposure to the attributes which will be used in the choice experiment that follows. The travel behavior question covers frequency of traveling with bike, daily transport mode and pattern, average commuting time, commuting period (peak/off-peak), working experience as bike messenger, crowdshipping use, and attribute rating questions. The attribute rating questions are aimed to provide an extra check of the relative attribute importance.

The following section consists of delivery job scenarios, in which respondents will decide to take any of the delivery job offerings or select the opt-out alternative. In this part, a slight difference with demand survey is evident. Supply survey makes use of 'choice experiment context' to identify if different preference exists between delivery time of day. Two contexts (morning and evening) and two blocks (block 1 and 2) are deployed in the survey. To accommodate this, the job scenarios is divided into four different context-block pairs. Any of the respondents will be assigned randomly to one of the pairs with equal probability for each pair.

An explanatory paragraph preceding the choice experiment stipulates the attributes to evaluate the job trade off and the travel context. The opt-out option is not explained, also by intention, to prevent respondents being stigmatized by this option before considering the available alternatives. The last section consists of socio-demographic questions with the same content as the demand survey, excluding the questions that have been asked in the travel behavior part. Detailed format of the supply survey can be inspected in Appendix 6.

4.7. Chapter summary

This chapter aims to design a choice experiment survey that can answer these questions: *1) What is the user's acceptance on bicycle crowdshipping, and what factors drive their acceptance toward such delivery service? How do this acceptance translate to the service demand? 2) To what extent bicycle commuters/travelers would be willing to participate in crowdshipping, and what are their motivations behind this decision? How do this willingness translate to the service supply?*

The initial stage to designing such experiment is defining the context to be focused in the study. Based on review from chapter 2, it was decided that the context to be used for the study is last mile delivery from parcel pickup points to customers' homes. The shipment type to be chosen is parcel from an online shop, which comprises diverse product types as indicated in section 2.3.

The second stage is selecting the attributes to be incorporated in the survey. The selection process was based on four indicators; differentiation feature, market realism, importance of the attributes, and the ability to influence the attribute. Careful examination led to five attributes selected for each of the surveys. For demand survey, the selected attributes are cost, delivery speed, delivery time window, performance rating, and CO_2 emission reduction. For supply survey, the selected attributes are delivery time of day (context), additional travel time, package weight, monetary compensation, and CO_2 emission reduction.

The number of attribute level is decided to be a multiplication of two in order to preserve orthogonality as much as possible and to avoid unbalanced choice sets design. Four alternatives will be assigned to each choice set in the demand survey, while three alternatives will be incorporated in the supply survey. Opt-out alternative is included to align the survey with demand theory and to improve choice task realism. Efficient design approach is chosen for choice set construction to generate lower amount of choice sets without forfeiting the model quality. The prior parameters are obtained from prior studies in related field. In some cases, manual scaling of prior parameters were performed to obtain a better design. Eight choice sets will be presented in each of the surveys. Table 9 summarizes the structure of the surveys.

Table 9 Structure of the surveys

Section	**No. of Questions**	**Purpose**	**Type**
Demand Survey			
I – Online Shopping Experience	9	To raise initial awareness on the topic and choice set attributes, extra check on weights	Questionnaire with categories, Likert scale
II – Choice Sets	8	To find the relative weight of the attributes	Choice experiment
III – Socio Demographic Properties	8	To check if the sample is representative	Questionnaire with categories
Supply Survey			
I – Travel Behavior	6	To raise initial awareness on the topic and choice set attributes, extra check on weights	Questionnaire with categories, Likert scale
II – Choice Sets	7	To find the relative weight of the attributes	Choice experiment
II – Socio Demographic Properties	8	To check if the sample is representative	Questionnaire with categories

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CHAPTER 5: Model Specification

5.1. Introduction

The previous chapter has specified the selected service/job attributes and design of the stated choice experiment (SCE). After these information is obtained, the discrete choice model (DCM) can be formulated. This includes, in particular, defining systematic utility function of demand and supply model, MNL model to estimate the demand and supply share, goodness-of-fit measurement that base the judgement as to whether the resulting model exhibits a good statistical fitness, and other essential indicators that are beneficial to derive further insights from the choice model. The utility specification in section 5.2 will serve as an input in BIOGEME to estimate the attribute weights. To answer the fifth research question, a methodology to derive market penetration level of bicycle crowdshipping will be proposed in section 5.6. This methodology will be applied within the case study performed in chapter 7.

5.2. Utility Specification

The systematic utility function is comprised of sum product between the observed marginal utility coefficients (also known as 'beta' values) and attribute values. Any attributes that improves the utility of an option (such as CO2 savings) would (expectedly) have a positive sign. Oppositely, attributes that reduces the utility (such as delivery cost) would (expectedly) have a negative sign.

5.2.1. Systematic utility function of demand

To represent systematic utility of each alternatives in demand survey, the utility specification postulated in equation (2) is adopted. As can be seen in equation (3), systematic utility function is specified in accordance to the number of alternatives; two for bicycle crowdshipping, one for traditional shipping, and one for opt-out option. Note that each alternative possesses an alternative-specific constant δ which denotes the utility associated with factors other than the observed attributes (Chorus, 2016). The coefficient for delivery cost β_1 applies to both bicycle crowdshipping and traditional shipping, given the same cost level were used for both alternatives. The coefficient for speed is different between crowdshipping and traditional shipping, as it is assumed that given the same price level, delivery speed of the latter would be lower (based on the benchmarking on chapter 2).

$$V_{CS1} = \delta_1 + \beta_1\, Cost_{CS1} + \beta_2\, Speed_{CS1} + \beta_3\, DTW_{CS1} + \beta_4\, Rating_{CS1} + \beta_5\, CO2_{CS1}$$

$$V_{CS2} = \delta_2 + \beta_1\, Cost_{CS2} + \beta_2\, Speed_{CS2} + \beta_3\, DTW_{CS2} + \beta_4\, Rating_{CS2} + \beta_5\, CO2_{CS2}$$

$$V_{Trad} = \delta_3 + \beta_1\, Cost_{Trad} + \beta_6\, Speed_{Trad} + \beta_3\, DTW_{Trad}$$

$$V_{NO} = \delta_4 \qquad (3)$$

where

V : systematic utility
δ : alternative specific constant
Cost : delivery cost (Euro)
Speed : delivery speed (hours)

DTW : delivery time window (0 if not adjustable, 1 if adjustable)
Rating : courier performance rating (0 if the rate is 4-star, 1 if the rate is 5-star)
CO2 : CO2 emission savings (kg)
β : marginal utility
ε : error term
CS : crowdshipping
Trad : traditional shipping
NO : opt-out option (self-pickup)

Given the specified utility function above, we can then calculate the probability at which an individual customer would opt for bicycle crowdshipping to deliver the package. The probability function can be seen in equation (8) below.

$$M_{Sn} = \frac{e^{V_{CS}}}{e^{V_{CS}}+e^{V_{Trad}}+e^{V_{No}}} \tag{4}$$

where

M_{Sn} : probability of selecting bicycle crowdshipping for individual *n*
V_{CS} : systematic utility of bicycle crowdshipping
V_{Trad} : systematic utility of traditional shipping
V_{No} : systematic utility of opt-out option

5.2.2. Systematic utility function of supply

Using the same logic as the utility of demand side, systematic utility of supply is also defined according to the number of alternatives presented in the choice set. Equation (5) below displays three separate utility functions; two functions for delivery job option and one function for the opt-out. There is no difference in attributes level between delivery job options, hence both alternatives use exactly the same marginal utility coefficients.

$$V_{Deliv1} = \delta_5 + \beta_7\ TOD_{Deliv1}\, TT_{Deliv1} + \beta_8\, TT_{Deliv1} + \beta_9\, Profit_{Deliv1} + \beta_{10}\, Weight_{Deliv1} + \beta_{11}\, CO2_{Deliv1}$$

$$V_{Deliv2} = \delta_6 + \beta_7\ TOD_{Deliv2}\, TT_{Deliv2} + \beta_8\, TT_{Deliv2} + \beta_9\, Profit_{Deliv2} + \beta_{10}\, Weight_{Deliv2} + \beta_{11}\, CO2_{Deliv2}$$

$$V_{NO} = \delta_7 \tag{5}$$

where

δ : alternative specific constant
TOD : delivery time of day (context parameter)
Profit : monetary compensation (Euro)
weight : package weight (kg)
TT : additional travel time (minutes)
CO2 : CO2 emission savings (kg)
β : attributes weight
ε : error term
Deliv : delivery job offer
No : opt-out option

Given the specified utility function above, we can then calculate the probability at which an individual commuter would accept bicycle crowdshipping delivery job. The probability function can be seen in equation (8) below.

$$P_{Sn} = \frac{e^{V_{Deliv}}}{e^{V_{Deliv}} + e^{V_{No}}} \quad (6)$$

where

P_{Sn} : probability of performing delivery job for individual *n*

V_{Deliv} : systematic utility of performing delivery job

V_{No} : systematic utility of opt-out option

5.3. Model fit

To assess whether the obtained model parameters significantly improve the model fit, a Likelihood Ratio Statistics (LRS) test will be performed. In principle, LRS test is used to examine if applying choice model to the dataset would generate a better fit compared to using null-model; a model in which all the parameters are zero. In null-model, the probability of each option is calculated in no different way than rolling a dice. To measure the model fit, log-likelihood output of both the null and the estimated model are used as inputs. Log-likelihood is calculated using equation (7). y_{in} is a binary variable which takes the value of 1 if option *i* is chosen, or 0 if option *i* is not chosen. P_{in} represents the probability of option *i* to be chosen by individual *n*.

$$LL\ (\beta) = \sum_n \sum_i y_{in}\ ln\ P_{in} \quad (7)$$

Suppose we are going to examine if the estimated model (let's call it model B) is significantly better than the null-model (let's call it model A). LRS test uses hypothesis testing to test the significance; the null hypothesis entails that the model with non-zero parameters (hence, the model being estimated) generate better fit due to coincidence or sample-peculiarities (Chorus, 2016). Therefore, the estimated model is considered to yield significantly better fit if the null hypothesis is rejected. The LRS is chi-square distributed across sample with *q* degrees of freedom, where *q* represents the number of parameters used in model B (Chorus, 2016). LRS is calculated using equation (8).

$$LRS\ =\ -2\ .(LL_A -\ LL_B) \quad (8)$$

Note that LRS test is not merely relevant to test if a model is better than null-model. It is also beneficial to test two models with different number of parameters. In this situation, *q* denotes the difference between the number of parameters deployed in the two models.

5.4. Marginal rate of substitution (MRS) or willingness-to-pay

MRS score measures the extent to which one attribute is valued in terms of a numerical attribute, especially the ones related to monetary value (Louviere et al., 2000). In the field of transportation research, this value is often called willingness-to-pay. In a market penetration analysis, that is the primary objective of this research, knowledge on willingness-to-pay is essential because it indicates the extent to which a customer place monetary value to a marginal increase in a service attribute. This gives an idea to the service provider as to what is the acceptable amount of fee to be imposed for any increment in service level (from customer perspective). If linear-in-parameter utility function is used, willingness to pay is simply derived from the ratio between other (non-monetary-related) parameters and monetary-related parameter (such as cost and profit), as shown in equation (9). Index *m* denotes the attribute that will be measured in terms of monetary value.

$$willingness\ to\ pay = \frac{\beta_m}{\beta_{monetary}} \quad (9)$$

5.5. Elasticity

To better comprehend how each attribute would affect the acceptance of bicycle crowdshipping, elasticity analysis will be conducted. Elasticity analysis would provide a 'feel' to the decision maker as to how each attributes affect the choice, given other parameters are held constant (Louviere et al., 2000). Normally, elasticity would be expressed by percentage of change in choice probability as a result of 1 percent change in a given attribute/parameter. This concept is called point elasticity, since the value is only applicable at the departure point (the reference value) of the calculation. The equation to calculate elasticity is depicted below.

$$E_{iz_{ni}} = \frac{\partial V_{ni}}{\partial z_{ni}} z_{ni} (1 - P_{ni}) \quad (10)$$

$E_{iz_{ni}}$ represents the elasticity of P_{ni} with respect to z_{ni}, a variable entering the utility of alternative i (Train, 2009). Because in this research utility definition is linear in explanatory variables, $\frac{\partial V_{ni}}{\partial z_{ni}}$ can simply be replaced by β_z. The point at which the elasticity takes a value higher than 1 is called demand-elastic point, meaning that an increase of 1% in the input variable would yield more than 1% of change in individual's choice probability. This is the area where it is more desirable to make changes in input variable, since the effect is more noticeable. The point at which elasticity equals to 1 is called unit elasticity. At this point 1% increase in the input variable would also yield 1% of change in individual's choice probability; thus, perfect balance between input and output change. Point where elasticity is less than 1 is called demand-inelastic point; 1% of change in input is followed by less than 1% change in individual's choice probability. This is the area where it is less desirable to make changes in input variable, as the effect is less prominent.

5.6. Identifying Market Penetration

To examine the market potential of bicycle crowdshipping, one has to take into account the relationship between its demand and supply side. This relationship will be represented by a single model to derive market share and equilibrium price, which will be described in section 5.6.1. Subsequently, section 5.6.2 will explain how the resulting DCM can be used to estimate aggregate supply and demand share (aggregation). Section 5.6.3 formulates the chronological steps for crowdshipping platform to apply the market share model.

5.6.1. Equilibrium Model

The derivation of market share/market penetration level of bicycle crowdshipping is grounded upon the assumption from economic science that parcel delivery market will reach equilibrium level at a certain price when demand of the service equals its supply. Although in practice this may not be completely correct, such proposition would be deemed reasonable if one assume that other factors beyond the crowdshipping service remain at a constant level (*cateris paribus*). At the equilibrium state, it is presumable that crowdshipping platform would be able to thrive and sustain its network of couriers and customers. Motivations behind this notion has been elaborated in chapter 1. Parameter coefficients obtained in chapter 6 are essential inputs for market share estimation.

Let us now step into the definition of the market equilibrium state (or market penetration model). Demand of bicycle crowdshipping could be translated as the amount of parcels n (or the amount of orders[10]) need to be delivered to the online shop customers multiplied by the market share ($\widehat{M}_S$) of bicycle crowdshipping. The left hand side of equation (17) denotes this statement. Supply of bicycle crowdshipping service could be defined as the amount of bicycle commuting trips available to deliver the packages. This translates to the right-hand side of equation (17), consisting of multiplication between the average probability that a cyclist would perform a delivery ($\widehat{P}_s$), number of bicycle commuting trips c in the respective area, and productivity per courier μ which denotes the number of packages that can be dropped in one place.

$$\widehat{M}_S\, n = \widehat{P}_s\, c\, \mu \tag{17}$$

$$or$$

$$\widehat{M}_S \ = \widehat{P}_s\, \gamma\, \mu \tag{18}$$

The constant n and c are dependent on the scope of market to be targeted by bicycle crowdshipping service. For example, if the bicycle crowdshipping platform would aim to serve delivery for online clothing shop within the city of Delft, then one shsould now how much online orders are to be delivered per day for that specific market segment and how many daily bicycle commuting trips are made within that area. The units of parameter n and c could be defined flexibly, either in terms of individual value (value per capita) or aggregate value, so long as the same measurement is used for c and n. For instance, c could be the average number of parcels of product Y to be delivered per day for each person in city X, or total number of parcels of product Y to be delivered per day in city X. The same treatment goes for $n.$ This rule applies because what matters in the equilibrium state is the ratio between c and $n,$ or denoted as γ in equation (18).

To summarise the relationship between parameters in the model, one can inspect the scheme in Figure 10. On the left part of the scheme listed the inputs that are required to calculate the market share. Note that the box in the middle denotes the constant parameters that have to be injected into the model; some of them are exogeneous, such as number of cyclist and number of online orders. The model perceives that profit comes as a function of price: it is equal to price subtracted by platform commission rate θ. In the center, lies the main model components of the calculation. It includes supply model to calculate individual commuter's probability to deliver a package, demand model to calculate individual online shopper's probability to choose bicycle crowdshipping for delivery, and the equilibrium model that accommodates the balancing mechanism between supply and demand. The arrows connecting supply and demand model to equilibrium model contains a term 'aggregation', indicating that aggregation would be needed to transform individual probability in both models to market share value. The aggregation process will be explained in the following sub-section. By solving for the equilibrium price level (in which the equilibrium state is fulfilled), we can obtain the market share of bicycle crowdshipping. The equilibrium state can be solved algebraically as well as using 'what-if' function in Excel. The latter will be applied in the case study.

[10] Assuming that one online order consists of one parcel.

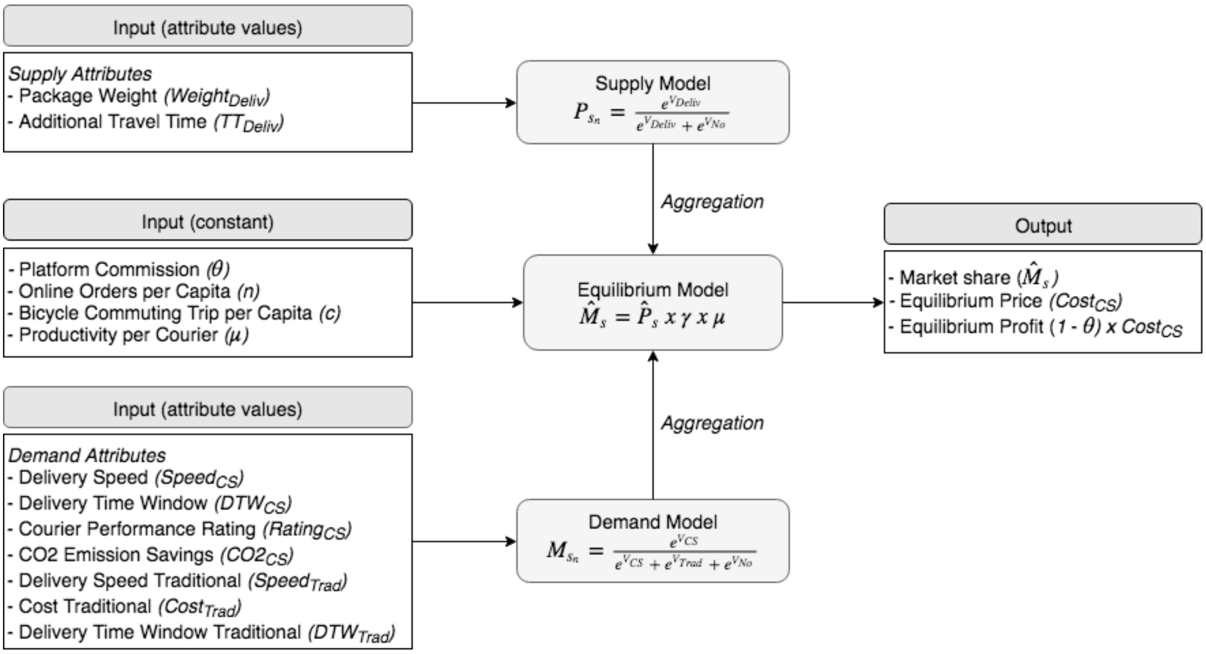

Figure 10 Input-output scheme for the market share model

5.6.2. Aggregation: approach to calculate market share

Provided the equilibrium state, the next question that arises is how to calculate the average probability of using bicycle crowdshipping ($\widehat{M}_S$) and average probability of delivery ($\hat{P}_S$). Unlike linear regression model, discrete choice model is not linear in explanatory attributes, implying that using average value as an input to estimate aggregate market share would not generate unbiased estimation (Train, 2009). When the choice probability is low, using average value as an input would tend to underestimate the market share value, and oppositely, when the choice probability is high, using average value would overestimate the market share value[11] (Train, 2009). To yield a more accurate average probability (or market share), there are two possible ways; sample enumeration, and segmentation. The following paragraph will explain both approaches, as adopted from (Train, 2009).

In the former concept, sample enumeration, the choice probability of every individual n (over a sample of decision makers N) are calculated according to the choice model and subsequently summated to obtain the average choice probability (hence, the market share). For every individual, the probability that he/she will choose an option (P_{in}) will be calculated. Subsequently, individual probability is multiplied with a weight w_n, which represents number of individual in the population with similar characteristics. The value is then aggregated over all decision makers sample, as depicted in equation (19).

$$\widehat{N}_i = \sum_n w_n P_{in} \quad (19)$$

The market share can be obtained from the ratio between $\widehat{N}_i$ and number of population. According to (Train, 2009), sample enumeration would be best applied when the number of explanatory variables are high. In many situations, these involve variables explaining individual socio-economic characteristics (such as age, income, and gender) that may take many values. In reality, disaggregated data such as private characteristics may be hard to find. To overcome this, the common approach is using representative characteristics over all individuals to represent the population segment, or also called segmentation. The principle is

[11] More detailed explanation on this can be found in (Train, 2009) page 29.

similar with sample enumeration. Only in this case, the individual n is replaced with segment s. All individuals in each segment is assumed to exhibit homogeneous properties (Train, 2009). To accommodate segment-based enumeration, equation (19) is modified into equation (20) as below.

$$\widehat{N}_i = \sum_s w_s P_{is} \qquad (20)$$

In case of the absence in disaggregated/segmented data, one can apply the pragmatic approach: using average/aggregate value of the parameters as the input to the model. This approach has been applied in the field of freight transport modelling where such difficulty in gaining disaggregated data is evident (de Jong, 2014). However, as already mentioned, there is a likelihood that the resulted market share estimates would be biased, due to the non-linearity nature of multinomial logit model. Given this limitation, implementing the model in the pragmatic way can only be done under a stricter assumption (e.g., homogeneity in population characteristics).

5.6.3. Model Implementation

Figure 11 shows the step-wise model implementation to estimate potential bicycle crowdshipping market share. The first step would be identifying the market segment to be served by the crowdshipping service. This selection will determine the constant n, the number of order to be delivered. Next, the order should be distributed among the city populations. In this study, the distribution is simply based on statistics of average online order per capita. Other alternative would be utilizing freight model to generate online orders, which is out of this research's scope. Subsequently, the commuting trips dataset needs to be obtained. This includes number of trips per OD and the corresponding distance matrix. Possible data sources are travel survey, which is used for this study, or the well-known four-step transport model. In this step, the constant c will be obtained. The following stage is to calculate the extent of detours per OD and delivery distance between pickup points and delivery destination. The latter will be used to calculate the CO_2 emission saved per customer. The detour variables as well as CO_2 emission saving are assumed to be varied among individual traveler.

Following the previous steps, attribute levels and constant are determined. Scenarios can be developed by varying these input parameters. For instance, the model can be used to identify the consequence of price change in competing options (i.e., traditional shipping) to bicycle crowdshipping market share, or the effect of increasing number of cyclist commuters to the market share. Once the service price *($Cost_{CS}$)* is determined, demand and supply share of crowdshipping can be calculated. This includes aggregation process mentioned in Figure 10, or otherwise if pragmatic approach is used. The market is in equilibrium (or converged) state when the gap between demand and supply approaches zero. As such, price will be continually changed until the market is converged; this is clearly indicated by the feedback loop in the chart.

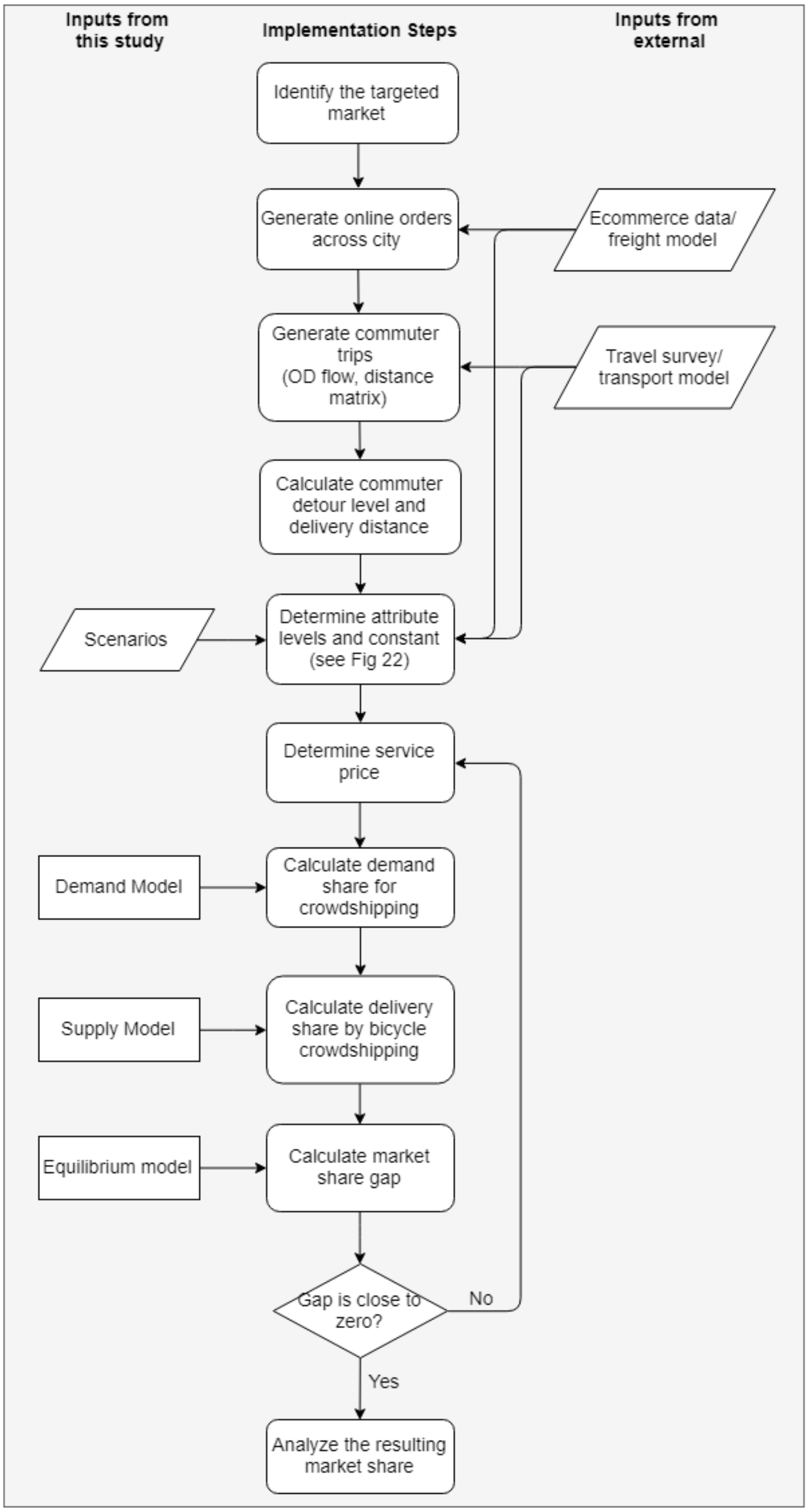

Figure 11 Steps to implement the market share estimation model

5.7. Chapter summary

In the beginning of the chapter, utility function of bicycle crowdshipping demand and supply is specified, including the respective logit model to calculate the individual probability to choose bicycle crowdshipping and to perform a delivery job. Following the utility function, several measurement methods to assess the discrete choice models are described. These includes model fit (LRS), marginal rate of substitution, and elasticity. These measurements will be valuable to examine statistical power of the model as well as to extract insights regarding demand and supply properties of bicycle crowdshipping.

On the last section of the chapter, a market equilibrium model is proposed. Bicycle crowdshipping market share can be obtained by solving for price level that fulfils the equilibrium state. Subsequently, the methods as to how the DCM result can be translated into aggregate market share were discussed. Two possible approach for aggregation are sample enumeration and segmentation. In case of data availability issue, pragmatic approach can also be applied. To ease the crowdshipping platform putting the concept into practice, a chronological step to implement the market share model was defined. Within the steps also described possible data sources and how the resulting DCM is injected as the inputs for market share estimation.

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CHAPTER 6: Model Output and Analysis

6.1. Introduction

This chapter aims to answer the following research question: *1) What is the user's acceptance on bicycle crowdshipping, and what factors drive their acceptance toward such delivery service? How do this acceptance translate to the service demand? 2) To what extent bicycle commuters/travelers would be willing to participate in crowdshipping, and what are their motivations behind this decision? How do this willingness translate to the service supply?*

This chapter uses the results of SCE specified in preceding chapter to estimate demand and supply model of bicycle crowdshipping. Section 6.2 describes the sampling scope and distribution, followed with section 6.3 that showcases the characteristics of respondents with regards to online shopping habit (for demand survey) and travel behaviour (for supply survey). Subsequently, section 6.4 will explain sociodemographic characteristics of the respondents. Section 6.5 and 6.6 showcase the main interest of this chapter; the output parameters and its interpretation with respect to demand and supply side of bicycle crowdshipping.

6.2. Sample collection

Before finalizing the survey content, a preliminary survey is conducted to gauge the feasibility of the survey assumptions and to recognize if the survey required a reasonable time length to complete. Based on the preliminary survey, the average survey length was 7 minute, which is aligned with the initial aim to design a survey that costs less than 10 minutes. Various inputs regarding survey content were also incorporated in the survey. Survey assumptions were validated by opinions from logistics expert and cycling expert.

The final survey were disseminated through online medium. For demand survey, the targeted survey distribution medium includes Facebook pages of TU Delft students community and email addresses of TU Delft employees and students. Survey dissemination through email addresses were carried out under the assistance of TU Delft IT Department with the means of bulk email. However, a change in university procedure implied such bulk emailing assistance could not be provided for the second survey. Alongside the previously-mentioned medium, the supply survey was also distributed to the members of Dutch Cycling Embassy LinkedIn group. It is preferable that responses for demand and supply survey are sourced from different respondents. Hence, this preference is stated in the survey introductory text to prevent the same person answering two surveys.

Three hundred and thirty completed responses were gathered for the demand survey while for the supply survey 141 responses were collected. Surveys with suspiciously short completion time, significant missing responses, and duplicated responses were removed from the datasets to eliminate potentially unreliable responses. Especially for supply survey, some uncompleted surveys were retained to maximize the number of responses, so long as the travel behavior and choice experiment section is completely filled out. Sanity checks resulted in 319 usable responses for demand survey and 136 usable responses for supply survey. Figure 12 exhibits survey length distribution of both surveys. The average survey length of demand and supply survey are respectively 9.02 and 8.11 minutes.

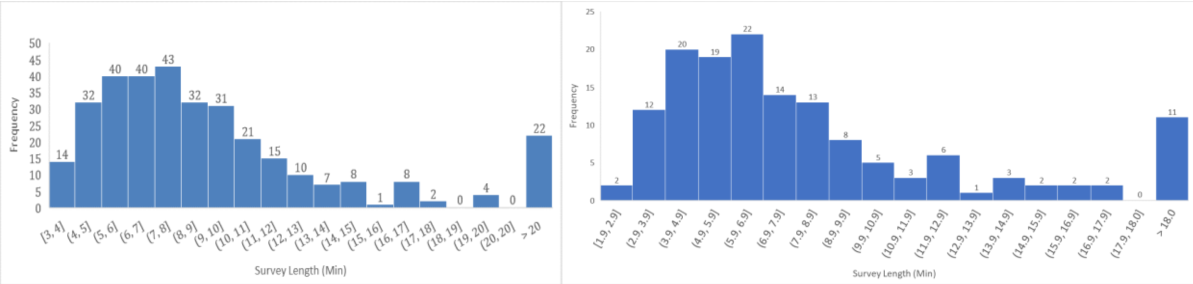


Figure 12 Survey length distribution of demand (left) and supply (right) survey

6.3. Preliminary question results

Demand Survey (Online Shopping Habit)

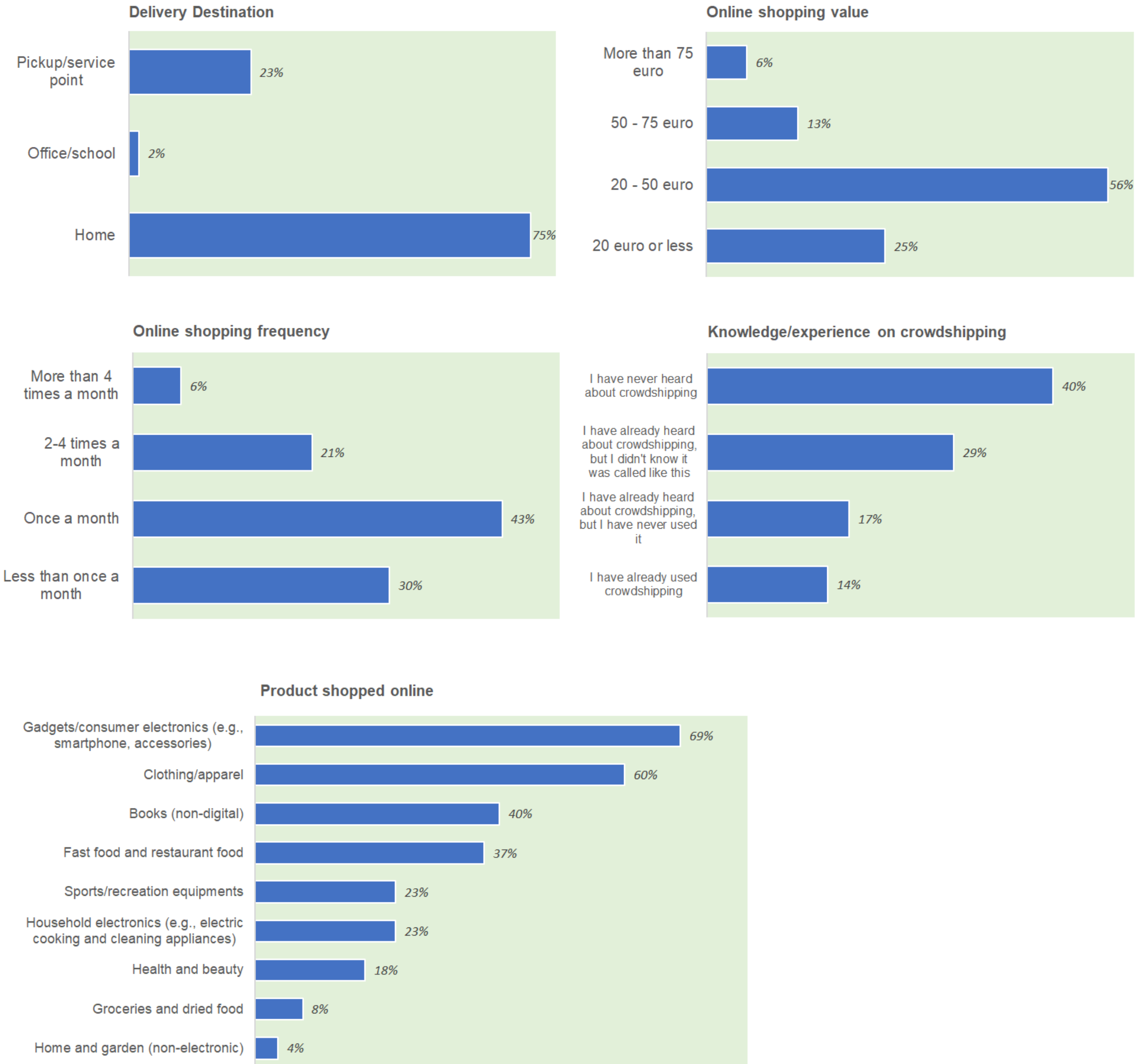


Figure 13 Online shopping habits of demand survey respondents

As can be inspected in Figure 13, majority of the respondents (75%) preferred to have their package delivered at home, while 23% of them would like to pick up the package at a parcel pick up/service points. The number is aligned with previous study which found that 74% of the online shoppers preferred their items to be delivered at home/residence and 18% of them preferred delivery at a pickup/service point (Statista, 2015). These figures suggest that home delivery remains the most favorable delivery option for online purchases.

More than 80% of the respondents spend less than or equal to 50 euro per online transaction. Juxtaposing this value with Netherlands' statistics could be misleading, as the latter includes transactions for service products such as flights and events tickets (CBS, 2016b), while this study focuses only on physical products. Nevertheless, our rough estimates constraining only on physical products concluded that 49% of the online transactions has a value below 51 euro, that is in line with the survey result (detail on Appendix 7). More than two-thirds of the respondents shop online more than once a month, comparable to the previous study in which 64% of the e-shoppers made one or more online purchases per month (Statista, 2017). Most of the respondents are inexperienced with crowdshipping; only 14% have ever used the service. However, this figure is still better compared to the US study by (Punel & Stathopoulos, 2017) in which less than 8% of the respondents have ever used crowdshipping. Gadgets and consumer electronics is the most popular product category, followed by clothing, books (physical), and restaurant/fast foods. The most popular product category (top 4 items) resemble the statistics on the country level as displayed in chapter 2.

Supply Survey (Travel Behavior)

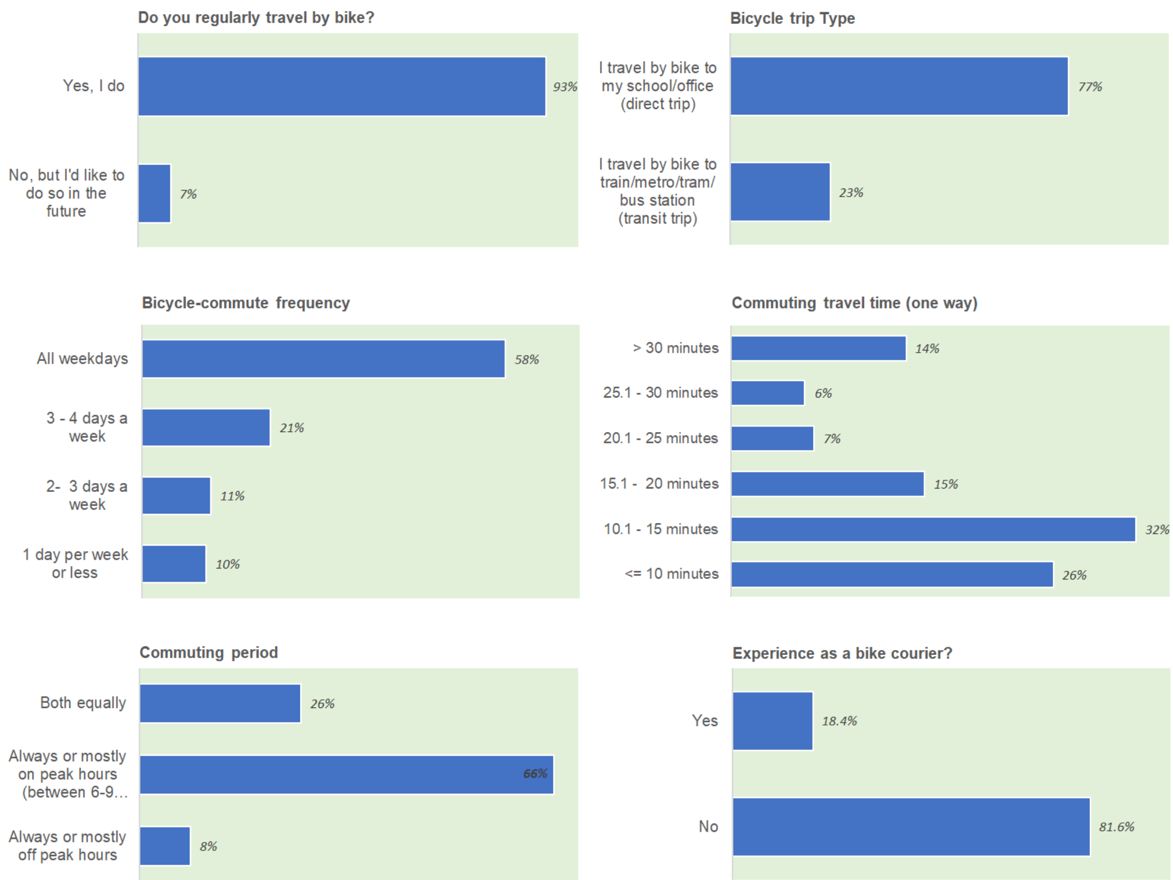
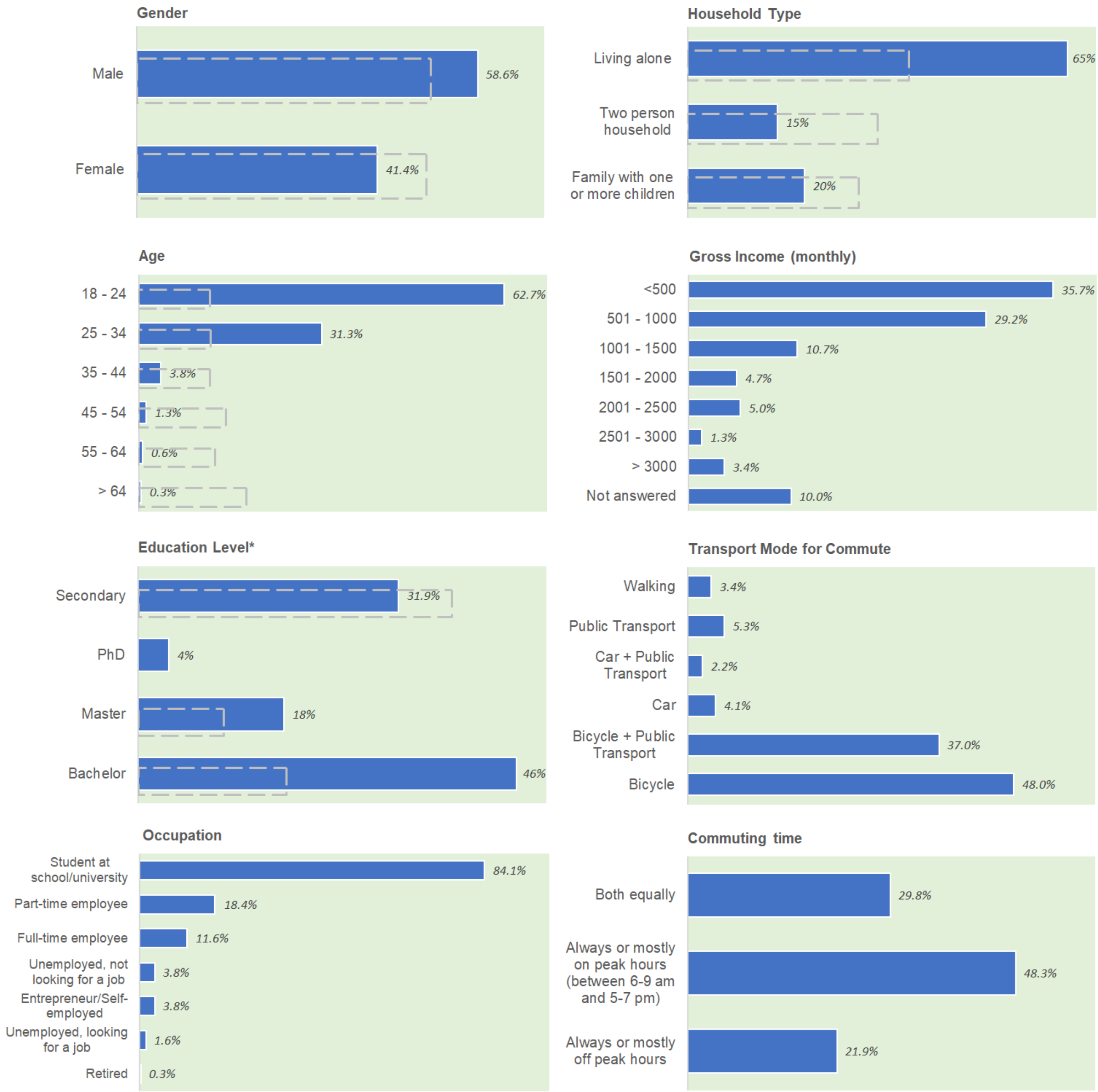


Figure 14 Travel behaviour supply survey respondents.

Figure 14 shows that majority (more than 90%) of the respondents travel by bicycle in a regular basis. Minority of them are interested to do so in the future. Respondents' outside the target group, those who do not regularly travel by bike or have no interest in it, were exempted from the datasets. Most of the respondents perform direct bicycle trip to work/school. Large portions of the respondents are frequent bike user; more than 80% commute by bike three days or more per week. Seventy three percent of the respondents commute in a relatively short distance (20 minutes or less), which is aligned with the assumption on average commuting distance conveyed in the survey. Because more working population is involved in the survey, higher percentage of people (66%) who always commute during peak times is evident. Nevertheless, percentage of people who do not strictly commute in peak hours is also significant (34%). Interestingly, there is a somewhat high percentage of respondents with prior experience as a bicycle courier/messenger. This could be attributed to participation of cyclist community members in the experiment.

6.4. Socio-economic characteristics

Demand survey



** CBS statistics (dotted line) do not differentiate between master's and PhD graduates*

Figure 15 Sociodemographic profiles of demand survey respondents.

Figure 15 represents sociodemographic properties of the survey respondents. Dotted lines indicate the national statistics from CBS. Respondent's gender is skewed towards men in comparison to country statistics, which is reasonable because most of the samples are TU Delft students which is dominated by male. The high percentage of university students on the sample also explains the over-representation of single-household type, young aged persons, low gross income level, and highly-educated persons. Bicycle accounts for 85% of transport modes for commuting (either as main or access/egress mode), which is considerably higher than Netherlands' statistics of 25% (CBS, 2016c). Noticeable differences with Netherlands's statistics implies that the result of the study should be treated cautiously if one would like to generalize the model to a different geographic scope.

Supply Survey

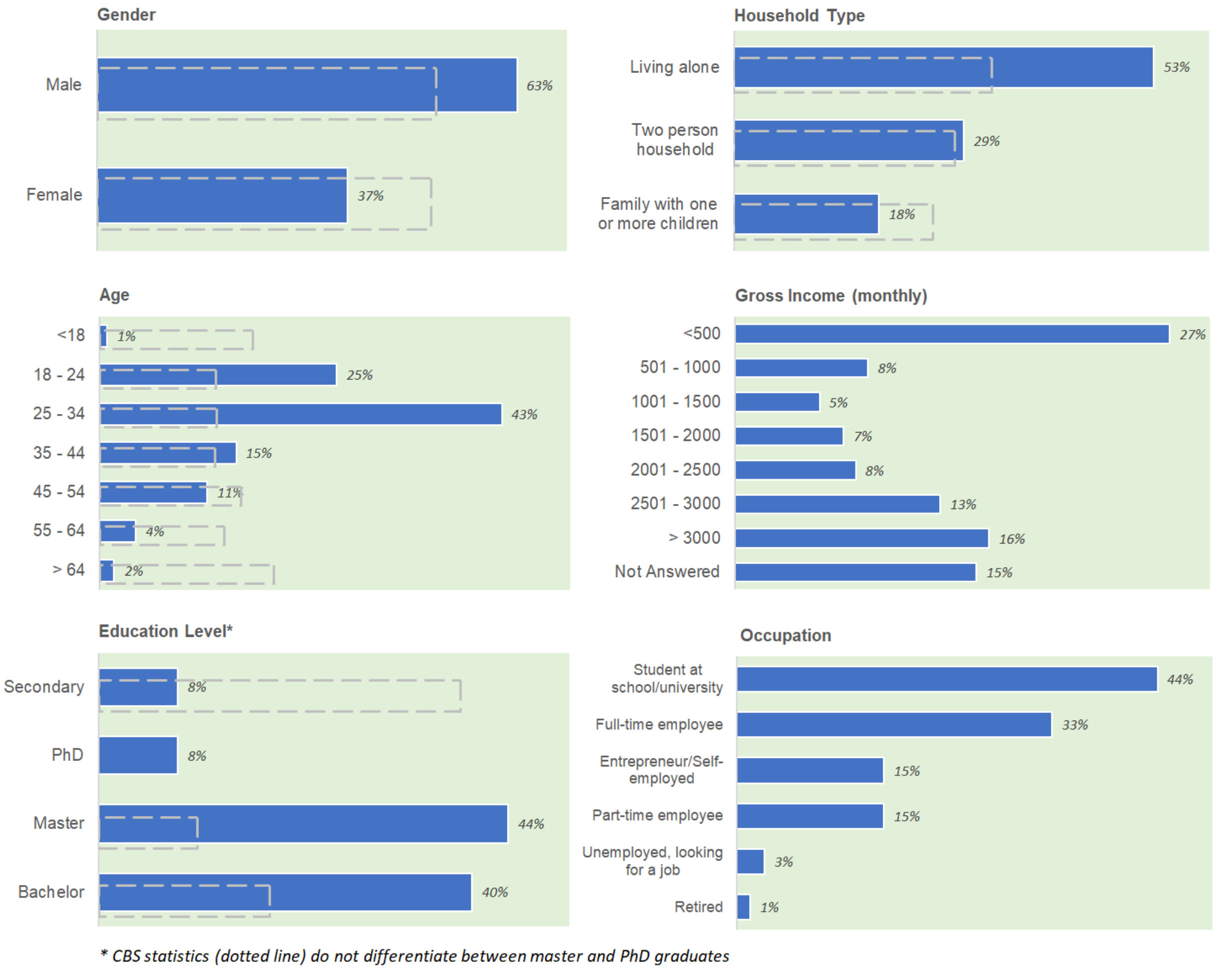


Figure 16 Sociodemographic profiles of supply survey respondents.

Figure 16 represents sociodemographic properties of supply survey respondents. Gender imbalance is still evident, in which male respondents account for nearly two-third of the respondents. There is, however, a better spread of income class in comparison to demand survey. Although the lowest level income (<500 euro per month) is still over-represented, the sample is not significantly skewed towards low income level. This is particularly contributed by sample portions from cyclist communities whose members are mostly working people (either full-time employee or self-employed). The pattern is clearly demonstrated by the more significant share of middle- to high-income people. Lesser gap to Netherlands' statistics also apparent in terms of respondents' age and household type. Older population is better represented; 32% of respondents are people aged 35 and above, compared to nearly 7% of the same age level in demand survey. Highly educated people still dominates the survey, with significantly higher percentage of bachelor and master/PhD graduates compared to Dutch national statistics. In general, the statistics show less gap with Netherlands' population, which is a good indication.

6.5. Estimating attribute weights

The importance of service and job attributes were estimated using the data from part II of the questionnaires. The estimation process is carried out with Bison BIOGEME software (Bierlaire, 2003). The detailed BIOGEME input code can be found in Appendix 8 and Appendix 9.

6.5.1. Demand Parameters Output

Initial parameter-estimation run resulted in significant parameters at 95% confidence level, except one parameter; δ_2 (detailed result of the first run can be found in Appendix 10). After fixing this parameter to zero, the second run generated the final parameters as depicted in Figure 17. Number of observations represents number of respondents multiplied by amount of questions answered per respondent. The Likelihood Ratio Statistics (LRS) score of the model is 2362, significantly higher than the corresponding chi-square value of 14. This indicates that the estimated model significantly improves the model fit compared to the null-model (model without parameters). In other words, there is nearly zero chance that better fit for estimated model is due to coincidence (Chorus, 2016). Pseudo rho-square value of 0.333 supports the former statement.

Model:	Multinomial Logit
Number of estimated parameters:	8
Number of observations:	2560
Null log-likelihood:	-3548.914
Cte log-likelihood:	-3317.52
Init log-likelihood:	-3168.251
Final log-likelihood:	-2367.457
Likelihood ratio test:	2362.913
Rho-square:	0.333
Adjusted rho-square:	0.331
Final gradient norm:	2.99E-03
Diagnostic:	Convergence reached...
Iterations:	13

Name	Symbol	Value	Std err	Rob. Std err	Rob. t-test	Rob. p-val
DELTA_CS1	δ_1	0	--fixed--			
DELTA_CS2	δ_2	0	--fixed--			
DELTA_Trad	δ_3	-0.888	0.347	0.334	-2.66	0.01
DELTA_OptOut	δ_4	-2.56	0.2	0.198	-12.92	0
BETA_Cost	β_1	-0.506	0.0166	0.0169	-29.9	0
BETA_SpeedCS	β_2	-0.124	0.0139	0.014	-8.89	0
BETA_DTW	β_3	1.16	0.0661	0.0655	17.7	0
BETA_Rating	β_4	0.137	0.0701	0.0675	2.03	0.04
BETA_CO2	β_5	0.507	0.0955	0.0951	5.33	0
BETA_SpeedTrad	β_6	-0.0352	0.0156	0.0149	-2.36	0.02

Figure 17 Final parameters output for demand model.

Robust *p-value* scores revealed that all of the parameters significantly influence the preference on delivery option at 95% confidence level. The sign of the parameters are aligned with expectation. CO2 reduction positively influence the preference, meaning that the more sustainable a delivery option is, the more inclined people towards it. This result reinforced the arguments that consumers are getting more environmentally-conscious, and this characteristic increases their likelihood to prefer crowdshipping over other delivery options. The same pattern applies for delivery time window. People assign positive value when there is a possibility to adjust delivery time. Cost and speed both have negative signs, which is intuitive given increased value in both parameters would reduce delivery convenience. As they exhibit different value ranges, one cannot infer the relative importance of each parameters from Figure 17 alone.

Alternative specific constant (ASC) for crowdshipping (δ_2) is not significant, meaning that the preference towards crowdshipping is strongly affected by the observed service attributes rather than other unobserved attributes. ASC for opt-out option (δ_4) is strongly negative, which might indicates that in general people are hesitant to pick up the package (in a parcel pickup point) themselves and instead prefer to have home delivery. Surprisingly, ASC for traditional shipping (δ_3) has a negative value as well. This might be related to respondents' unpleasant past experiences when using traditional shipping (such as failed or late delivery) which results in negative associations. After assigning the corresponding parameter coefficient, the final demand utility function is depicted in equation (15) below.

$$V_{CS} = -0.506\, Cost_{CS} - 0.124\, Speed_{CS} + 1.16\, DTW_{CS} + 0.137\, Rating_{CS} + 0.507\, CO2_{CS}$$

$$V_{Trad} = -0.888 - 0.506\, Cost_{Trad} - 0.035\, Speed_{Trad} + 1.16\, DTW_{Trad}$$

$$V_{NO} = -2.56 \qquad (15)$$

Another interesting finding is that performance rating turned out to give only a slight influence on the propensity to use crowdshipping. Concerns about trust apparently do not strongly evident amongst the respondents. This would make a perfect sense since within the survey it was stipulated that all couriers had undergone a background check and the package is covered by insurance in case of any delivery misconducts. Moreover, the lowest rating of the courier was 4-star, implying that from this point upwards customer's sensitivity towards performance rating improvement would be negligible.

The relative importance of the delivery attributes can be seen in Table 10. Cost appears to be the most important parameter, followed by adjustability of the delivery time window, delivery speed (crowdshipping), and CO2 emission reduction. It is interesting to know that people assign more value to delivery flexibility than delivery speed. The finding demonstrates that flexible delivery time window is one of the prominent features that entices people towards crowdshipping service, as has also been discovered in previous research by (Punel & Stathopoulos, 2017). Many of the online shoppers expressed that home delivery is sometimes inconvenient due to the chance of failed delivery when they are away, or the perception that they are 'forced' to stay at home (Francke & Visser, 2015). Adjustable delivery time window would certainly relieve these shortcomings. Delivery speed of traditional shipping has the lowest importance among all attributes, which is reasonable provided people may expect more of 'trust and reliability' when choosing traditional courier rather than speedy delivery.

Table 10 Relative importance of service attributes (ordered from high to low)

Attributes Name	Notation	Value Range	Parameter Coefficient	Relative Importance Score*
BETA_Cost	β_1	6	-0.506	3.036
BETA_DTW	β_3	1	1.16	1.16
BETA_Speed$_{CS}$	β_2	6	-0.124	0.744
BETA_CO2	β_5	1.2	0.507	0.608
BETA_ Speed$_{Trad}$	β_6	9	-0.035	0.315
BETA_Rating	β_4	1	0.137	0.137

**Relative importance score =|value range x parameter value|*

Willingness to pay (WTP) for service attributes

Table 11 showcases that customers are willing to pay an additional fee of 25 cents for every hour reduction in delivery lead time. It means a day of delivery time saved is worth to be paid as much as 6 euro. This number is lower than the finding of previous research by (Punel & Stathopoulos, 2017) that obtained USD 41 (33 euro) worth for a day of delivery time saved, yet 6 euro seems to be more reasonable from a practical sense. However, one should notice that baseline parcel shipment price in US market could be different with that of The Netherlands. By providing adjustable delivery time window, a customer would be willing to give up another 2.29 euro. For every kilogram of CO2 emissions saved, customer would pay for additional 1 euro. Customers show a higher WTP for delivery time saving in crowdshipping in comparison to traditional shipping. For traditional shipment, customers are only willing to pay for 0.07 euro per hour in delivery time reduction, or 1.68 euro per delivery day saved. One level improvement in performance rating would only be valued for 27 cents by customers.

Table 11 Willingness to pay (WTP) for each service attributes.

Willingness to pay for:	Value	Unit
Increased Delivery Speed (Crowdshipping)	0.25	Euro/hr
	6.00	Euro/day
Adjustable Delivery Time Window	2.29	Euro
CO2 emission reduction	1.00	Euro/kg CO2
Performance rating improvement	0.27	Euro/star rating
Increased Delivery Speed (Traditional Shipping)	0.07	Euro/hr
	1.68	Euro/day

Rating Test

Table 12 Rating test results for demand survey

Service Attributes	Respondents answer by %						Total	Mean Score	Std. Deviation
	N	1	2	3	4	5			
Adjustable delivery time window	319	2%	6%	9%	39%	45%	100%	4.18	0.96
Sustainable means of delivery	319	9%	19%	30%	26%	16%	100%	3.19	1.19
Delivery speed	319	3%	8%	18%	36%	34%	100%	3.90	1.07

The rating test was included in the first section of the survey that identifies the online shopping preference of the respondents. Respondents are asked to rate the importance of delivery attributes presented through a five-level Likert scale. Delivery cost and performance rating were unfortunately not included in the rating test, hence only three out of five attributes can be examined in the rating test. Total number of responses collected are 319. The result, as depicted in Table 12, shows consistent pattern with the relative importance of output parameters in Table 10. Adjustable delivery time window comes at the first place with an average importance rating of 4.18, followed by delivery speed with average score of 3.9 and sustainable means of delivery which averaged on 3.19. The consistency of parameter importance between choice experiment and rating tests signifies the reliability of the survey outcomes.

6.5.2. Supply Parameters Output

Initial parameter estimation resulted in four (out of seven) attributes which are significant at 95% confidence level (as can be seen in Appendix 11). The three non-significant parameters (p-value > 0.05) include CO2 emission reduction, time of day, and ASC for bicycle crowdshipping. Final log-likelihood on the initial run is -793.75, with model fit (adjusted rho-square) of 0.132. A second estimation run was performed after exempting the non-significant attributes, which result in attributes coefficients depicted in Figure 18**.** The new model, however, yield a slightly lower model fit: 0.131, with final log-likelihood of -797.58. Following the exclusion of insignificant parameters, a LRS test is conducted to see if the model from the second run, with less number of parameter, is not statistically worse than the first model with more parameters. Provided the log-likelihood score and number of parameter of both models, a LRS score of 7.6 is obtained. The LRS score is lower than the corresponding chi-square value of 7.81, implying that, given 95% confidence level, the difference in model fit between the initial and final model is not statistically significant.

According to Figure 18**,** the sign of all the final parameters seems intuitive. Positive influence on preference to crowdshipping was found for profit. As also expected, additional travel time and package weight reduces the propensity towards crowdshipping. Comparable with demand survey, the preference towards crowdshipping is strongly influenced by the observed attributes value rather than other unobserved attributes, as indicated by the non-significance of its ASC (δ_6). The ASC for opt-out option (δ_7) is negative, which suggests that in default cyclist commuter would be in favor of participating in crowdshipping job when it is convenient. After assigning the corresponding parameter coefficient, the final supply utility function is depicted in equation (16).

```
                         Model: Multinomial Logit
Number of estimated parameters: 4
        Number of observations: 840
           Null log-likelihood: -922.834
            Cte log-likelihood: -849.579
           Init log-likelihood: -1084.063
          Final log-likelihood: -797.583
         Likelihood ratio test: 250.502
                    Rho-square: 0.136
           Adjusted rho-square: 0.131
           Final gradient norm: 6.69E-03
                    Diagnostic: Convergence reached...
                    Iterations: 12
```

Name	Symbol	Value	Std err	Rob. Std err	Rob. t-test	Rob. p-val
DELTA_Deliv1	δ_5	0	--fixed--			
DELTA_Deliv2	δ_6	0	--fixed--			
DELTA_OptOut	δ_7	-1.88	0.155	0.157	-11.98	0
BETA_Profit	β_9	0.215	0.0398	0.0381	5.63	0
BETA_TT	β_8	-0.0852	0.0087	0.00801	-10.63	0
BETA_Weight	β_{10}	-0.217	0.0375	0.0355	-6.13	0

Figure 18 Output parameters for supply model.

$$V_{Deliv2} = -0.0852\ TT_{Deliv} + 0.215\ Profit_{Deliv} - 0.217\ Weight_{Deliv}$$

$$V_{NO} = -1.88 \qquad (16)$$

When it comes to relative attribute importance, additional travel time has the highest importance score, followed by package weight and profit. However, one should notice that there are only slight differences in importance score between the three attributes, as displayed in Table 13, suggesting that cyclist commuters placed relatively comparable utility value to those parameters.

Table 13 Relative importance of job attributes (ordered from high to low)

Attributes	Notation	Value Range	Parameter Coefficient	Relative Importance Score*
BETA_TT	β_8	14	-0.0852	1.15
BETA_Weight	β_{10}	6	-0.217	1.08
BETA_Profit	β_9	6	0.215	1.01

**Relative importance score = value range x parameter value*

Willingness to work (WTW) for job attributes

Willingness to work represents the profit or compensation level under which commuters would be willing to give up its travel time for performing delivery job. Unlike the conventional VoT measurement, in which trade-off between time and cost is analysed, WTW examines the trading of time for profit (Miller et al., 2017). If in VoT travelers would save travel time by spending money, in WTW traveler would give up travel time in exchange for profit. Table 14 shows WTW based on the job attribute values. For every minute increase in travel time, bicycle crowdshipper would need a compensation of 40 cents. This translates to 24 euro per hour increase in travel time. The value sounds realistic as it is higher than Dutch commuting VoT of 10.12 euro[12] (KiM, 2016).

[12] This is the VoT for commuting by car. This VoT selection is made considering no evidence of specific VoT for commuting by bicycle in the Netherlands.

Table 14 Willingness to work (WTW) for each service attributes.

Willingness to work for:	Value	Unit
Additional travel time	0.39	Euro/min
	23.76	Euro/hr
Package weight	1.00	Euro/kg

The relative difference between VoT and WTW supports previous proposition that people would generally like to gain more than they spend (Miller et al., 2017). The noticeable gap between WTW and commuting VoT is possibly caused by several reasons. Firstly, the respondents might overstate the value as a result of hypothetical bias which is often the nature of stated choice experiment studies. Secondly, travelers no longer perceive the additional travel time as purely part of their commuting journey, meaning that the detour caused by any delivery task is deemed as commercial-based trip (instead of commuting trip). This may explain why the resulting WTW value is closer to VoT for business trip, as clearly illustrated by Figure 19. Thirdly, cyclist commuters appears to have more aversion towards detour than car commuters. As also depicted in Figure 19, (Miller et al., 2017) discovered a WTW value of 19.61 euro/hr on their study that involved only car commuters. Although this value is higher than KiM's VoT of commuting trip, it is still lower than WTW obtained within this study. However, one should be cautious in comparing WTW between US and European context, as the standard of wage could be different between both market.

For every kilogram increase in package weight, cyclist commuters require additional one euro as a compensation. This supports the argument that from a cyclist's point of view, increase in package weight diminishes the convenience of delivering package. However, no comparison can be made with car commuter's sensitivity towards package weight, as this attributes thus far have not been examined in preceding studies.

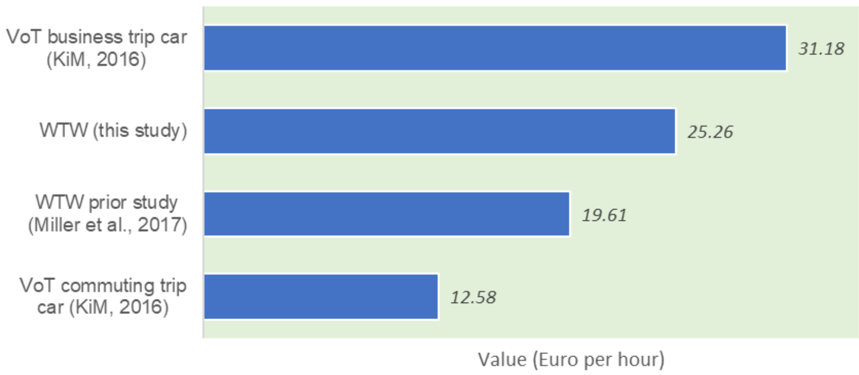


Figure 19 WTW-VoT comparison. Source: (KiM, 2016; Miller et al., 2017)

Rating Test

In line with demand survey, respondents were requested to rate the importance of job attributes presented through a five-level Likert scale, by firstly asking them to imagine having a role as a bicycle crowdshipper. As can be seen in Table 15, monetary compensation appears to be the most important job attributes, followed by package weight and additional travel time. The order of importance is not entirely the same with the degree of attributes importance obtained from the parameter coefficients. Nevertheless, this difference does not significantly impair the consistency, given the negligible importance score differences within the three attributes as illustrated in Table 13. CO2 emission reduction has a substantially less score in the rating tests than other job attributes, which is acceptable knowing that it does not significantly influence the preference to perform crowdshipping job.

Table 15 Rating test results for supply survey

Job Attributes	Respondents answer by %						Total	Mean Score	Std. Deviation
	N	1	2	3	4	5			
Additional travel time	136	3%	8%	20%	39%	30%	100%	3.85	1.04
Package weight	136	2%	8%	18%	45%	27%	100%	3.87	0.98
Monetary compensation	136	1%	4%	18%	37%	40%	100%	4.09	0.94
CO2 emission reduction	136	13%	15%	26%	26%	18%	100%	3.21	1.28

6.6. Elasticity analysis

Elasticity analysis is performed individually for each demand and supply market share model. As explained in chapter 2, elasticity is calculated by changing the value of a variable while holding the other variables at constant level. Therefore, for each model, assumption on baseline situation (the variables that is held constant) will be defined beforehand. Baseline situation will try to resemble 'average' situation in real case. The effect of adjusting service price to bicycle crowdshipping choice probability would be an obvious interest in this study. A crowdshipping platform may need to avoid reducing price to a point where it does not give any noticeable impact for the market gain. With elasticity analysis, such 'critical' point could be identified.

6.6.1. Demand elasticity with respect to price

Before conducting elasticity analysis, parameter value is defined. As to traditional delivery, all its attributes are set to constant level. The shipping price is set as 4 euro for a next day delivery service (Climate-KIC, 2018), with assumed lead time of 30 hours. This means any order made during the day before 12pm, will be delivered the next day by the end of business day (18pm). Delivery time window is non-adjustable, according to typical standard shipment in the Netherlands. For bicycle crowdshipping, the input variable is shipment cost, hence any attributes besides cost will be fixed as well. The delivery speed is assumed to be 8 hours, while the CO2 emission savings is set at 1 kg, assuming that the distance between store/pickup point and customer is 3 km (Weltevreden, 2008)[13]. Three elasticity test scenarios are made. A detailed variable setup can be seen in Table 16.

Table 16 Scenarios for demand elasticity test

Scenario	Parameter Values				
	$Cost_{CS}$	$Speed_{CS}$	DTW_{CS}	$Rating_{CS}$	$CO2_{CS}$
Default	varied	8	0	0	1
Adjustable delivery time window	varied	8	1	0	1
5-star performance rating	varied	8	0	1	1

[13] If there is around 175 grams CO2 emitted per van km, then 3 km distance (roundtrip: 6 km) would yield: 6 x 175 / 1000 ≈ 1 kg of CO2.

Figure 20 shows the crowdshipping choice probability as a function of price. A subtle difference is evident between the default and 5-star rating scenario; the latter add merely around 3.5% probability gain at the highest extent. It implies that imposing all 5-star couriers would not bring any considerable market gain. In contrast, adjustable delivery time window leads to substantial improvement in choice probability. It brings roughly 28% of probability gain at maximum when juxtaposed against the default scenario. The probability-price relationship would be the most sensitive at 50% choice probability[14] (Train, 2009); for the default and 5-star scenario it lies in the price level of around 4 euro, and for the adjustable time window scenario it lies in the price level of 6 euro. Changes on price about these points would bring a larger effect to crowdshipping choice probability compared to other points within the curve.

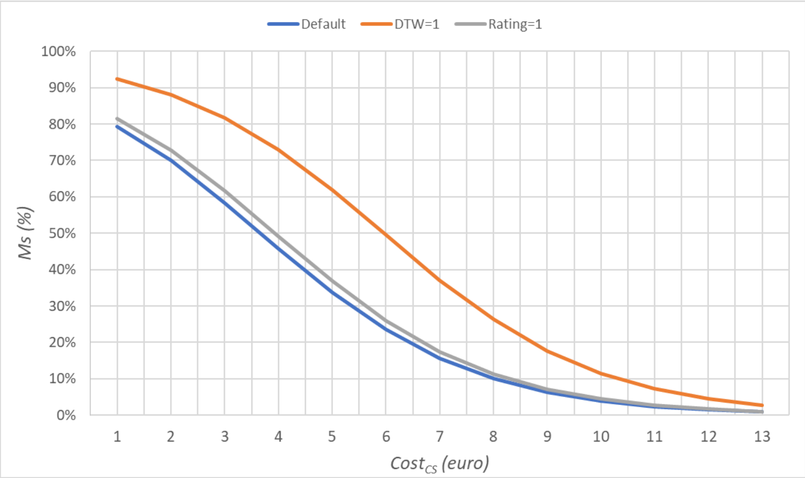


Figure 20 Price vs crowdshipping choice probability comparison

As can be referred to Figure 21, the elasticity takes a negative value due to converse relationship between price and choice probability. Overall, one can recognize that crowdshipping choice probability is elastic towards price. Scenarios with lower service level (default scenario) are more elastic towards price change. This means when the service level is higher, customers would be more indifferent towards price increase. Unit elasticity, where the absolute elasticity value is 1, occurs at a price level of around 4 euro for the default and 5-star scenario and at a price level of 5 euro for the adjustable time window scenario. For default and 5-star scenario, reducing the service price down until 4 euro would give more significant impact, because in this range the demand is elastic. Consequently, customers would show less concern for any price decrease below this point. The same logic also applies to another scenario. Interestingly, in the unit elasticity price, the revenue would be the maximum amongst other locations in the curve. One can prove it by multiplying the price level and the respective choice probability in Figure 20.

[14] Theoretically, this is because at probability of 50% partial derivative of the MNL function (wrt. entering variable) is at the highest level. More detailed remarks can be found in (Train, 2009) page 59.

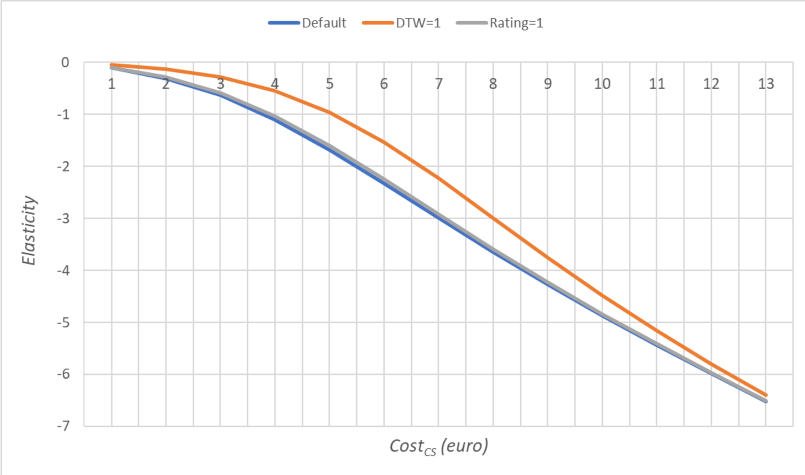


Figure 21 Price vs elasticity comparison

6.6.2. Supply elasticity with respect to profit

For supply elasticity analysis, three scenarios are made, with additional travel time as the parameter varied between scenarios. The weight is assumed to be 3 kg, which characterises the majority of ecommerce parcel, following the information from (Guglielmo, 2013). The variable setup can be inspected in Table 17.

Table 17 Scenarios for supply elasticity test

Scenario	Parameter Values		
	$Profit_{Deliv}$	TT_{Deliv}	$Weight_{Deliv}$
Additional travel time 10 min	varied	10	3
Additional travel time 15 min	varied	15	3
Additional travel time 20 min	varied	20	3

Unlike demand choice probability that is highly sensitive towards price, the supply probability is less sensitive to profit, which is characterised by a flatter curve as shown in Figure 22. This fact might be associated with relatively less prominent role of profit in supply survey (as can be referred to its relative importance score), compared to the dominating role of cost in demand survey. Nonetheless, there is a pattern that sensitivity towards profit (steeper line) is more evident for a lower price range. Additional travel time has indeed a noticeable effect towards the market gain. For every additional 5 minutes in travel time, there is a maximum decrease of around 10% in choice probability. This choice probability gap diminishes along the increase of profit.

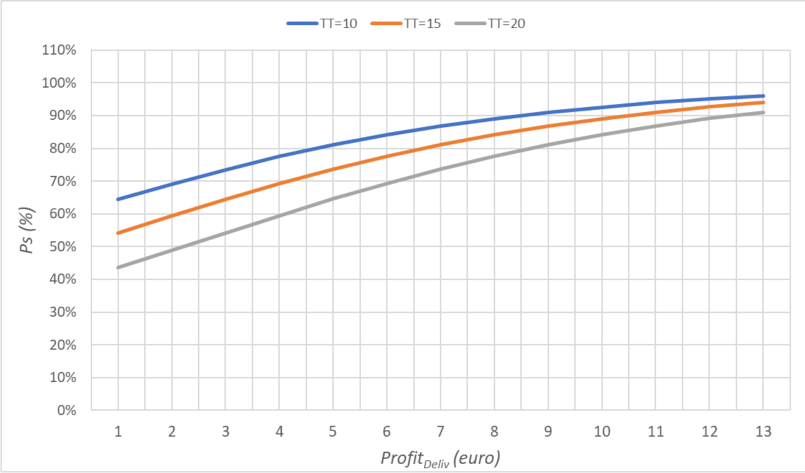


Figure 22 Profit vs delivery probability comparison

Delivery probability is somewhat more inelastic to attribute (profit and travel time) change compared to demand. Figure 23 indicates that elasticity value is never higher than 1 throughout the curves. As a consequence, one should not expect a massive gain in delivery probability share by adjusting the profit level. Such condition is acceptable given that cyclists perceive delivery jobs to be performed as a voluntary decision (i.e. no liability or obligation to take any delivery job). Delivery probability is the most elastic within the profit range of 5-8 euro. If we take the maximum elasticity value as a reference, for 10 minutes additional travel time, 1 percent increment in profit would only be followed by 0.2 percent increment (at maximum) in delivery probability. Interestingly, delivery probability would be higher than 30% even if the profit value is zero. This might be attributed to altruistic motivations of cyclists that have not been incorporated in this study. Another appearing pattern is that overall elasticity towards profit tends to increase when the travel time is longer. A practical implication is that when courier's delivery routing can be optimized by the platform (thus additional travel time could be lowered), reducing the profit would not cause as much courier resistance as if it is imposed when additional travel time is longer.

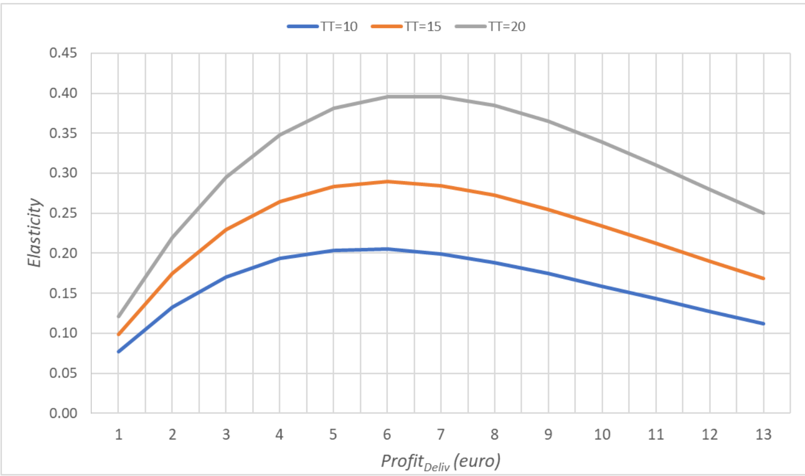


Figure 23 Profit vs elasticity comparison

6.7. Chapter summary

The DCM estimation result demonstrated the significance of all the selected service attributes. Price appeared to be the most important attribute, followed by adjustable delivery time window, delivery speed, CO2 savings, and performance rating. As for the supply attributes, only three out of the five selected attributes proven to be significant; additional travel time, delivery profit, and product weight. To give a feel on how the attributes affect demand and supply, elasticity analyses were conducted. The analysis discovered that demand is highly elastic towards changes in price and other service attributes, while supply is rather inelastic towards profit and other job attributes. In the proceeding chapter, the relationship between demand and supply will be further elaborated.

CHAPTER 7: Market Case Study

7.1. Introduction

Demand and supply elasticity study performed in previous chapter gave us a feel on how the market share could be influenced by either demand and supply attributes. However, the prior analysis only capture the market share response from one perspective. For a more realistic market share estimate, one need to comprehend the influence of both (supply and demand) sides. This chapter will provide such analysis in a detailed manner through a real case study. Section 7.2 explains how the chronological steps can be implemented with real data, with city of Delft chosen as the sample. Section 7.3 discusses the study results.

7.2. Scenario development

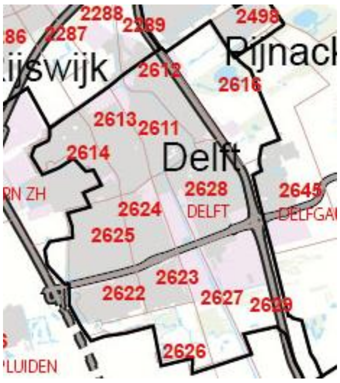


Figure 24 Postcode map of Delft (courtesy of www.reclamedienstverspreidingen.nl)

To obtain a tangible representation of how the market share is estimated, a case study is conducted for the scope of Delft by applying the chronological steps in Figure 11. This selection is made because majority of the respondents are population of Delft. By doing so, better data consistency will be obtained and bias could also be minimized. For practicality of the analysis, the city area is divided into several zones according to four-digit postal code (see Figure 24). In this way, all the commuting trips as well as delivery demand is defined based on postcode. Firstly, the market scope of generic parcel delivery is selected. This means, all type of products purchased via online shop and delivered either via stores or pickup points will be served by bicycle crowdshipping. It is assumed that 85% of the packages fits to the carrying capacity (volume and size) of a normal bicycle (Guglielmo, 2013). Next, online order data is gathered. For this study, data from various sources is combined to calculate the number of parcels to be delivered in each zone. In essence, average parcel per online population is calculated at country level, and then multiplying this rate with the number of population in each zone would give us delivery demand per zone. The step is indicated in Figure 25.

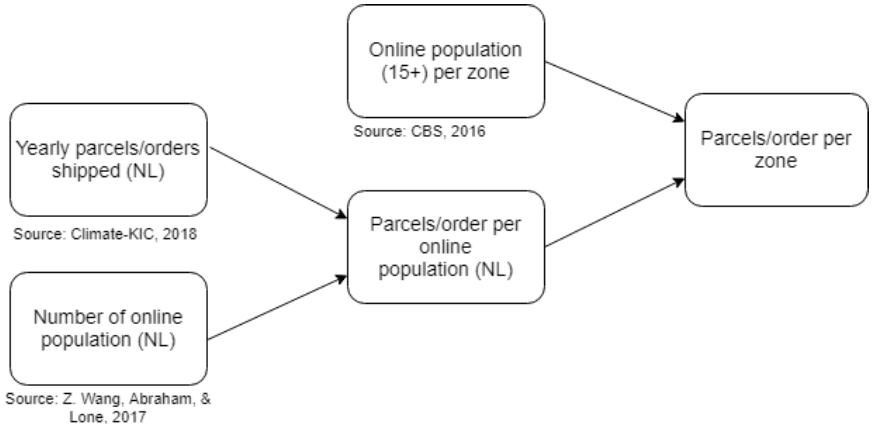


Figure 25 Steps to generate number of parcels to be delivered

The resulting delivery demand per zone can be seen in Figure 26 below. Most demands are concentrated in densely-populated area such as 2613 (Hof van Delft), 2624 (Voorhof), and 2625 (Buitenhof). Delft centrum is not included since it is assumed that when the pickup point and destination is located at the same zone, people would prefer to do self-pickup. Notice that several zones are excluded as delivery destination because the amount of delivery demand is too low. In such case, equilibrium between demand and supply cannot be achieved. The excluded zones are 2616, 2626, 2627, and 2629.

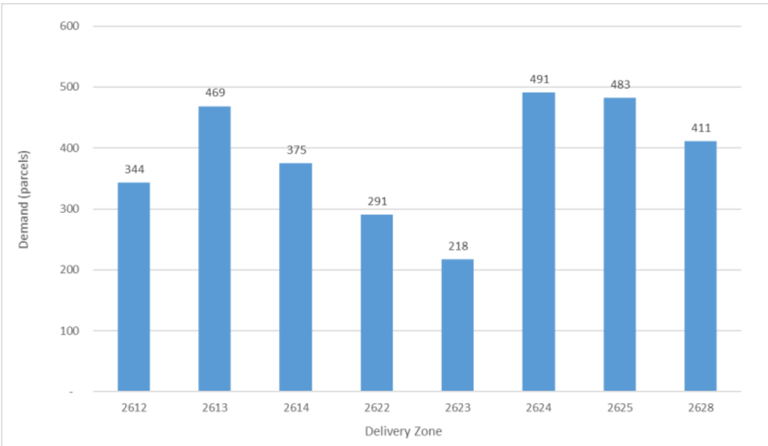


Figure 26 Daily delivery demand (parcels) per zone

Following the order generation, commuting trips of cyclist will be generated. For this purpose, the research refers to the work of (Jafino, 2018), in which GPS trips data from Fietstelweek survey is translated into OD matrix of cyclists. For simplicity, the scope for the area is limited into postcodes of Delft. Therefore, any trip originating/heading from/to postcode area outside Delft will not be included. The resulting OD matrix of the cyclist commuters is depicted in Figure 27. As appear in the figure, most of the trips are made from or to the city center (postcode 2611), which is rationale given that most of the stores, supermarkets, and restaurants are agglomerated in this area. Moreover, city center also houses a considerable amount of Delft's population (CBS, 2016a). For the same reason, postcode 2611 is also selected as the zone where the store/pickup point is located. Single store location is selected to solve the market share estimation in an uncomplicated manner. Intra-zonal trips are neglected for delivery. It is because when the original trip is very short, travelers would tend to be hesitant in making a long detour only to deliver a package. The detailed steps as to how the OD matrix is derived can be found in Appendix 12.

Origin \ Destination	2611	2612	2613	2614	2616	2622	2623	2624	2625	2626	2627	2628	2629
2611	1572	511	725	389	107	99	145	343	267	8	153	1679	84
2612	588	122	145	31	31	38	61	31	61	0	38	267	8
2613	778	107	359	381	23	38	23	122	160	0	53	259	38
2614	488	84	389	290	31	38	38	122	69	0	53	38	8
2616	153	38	31	53	84	0	15	23	31	0	0	46	0
2622	122	15	23	15	0	92	46	99	122	15	23	15	23
2623	114	61	8	15	0	84	122	198	69	0	114	99	23
2624	313	92	145	84	15	61	99	183	191	0	122	511	15
2625	267	23	130	53	31	99	61	214	214	0	99	107	8
2626	0	8	0	0	0	8	0	0	0	0	0	8	0
2627	114	15	107	46	8	53	15	160	84	15	84	305	38
2628	1694	313	244	61	76	23	99	496	130	0	343	946	114
2629	160	15	23	0	0	38	15	38	15	0	38	153	0

Figure 27 OD matrix (no.of trips) of cyclist commuters in Delft (green: high, red: low)

The next step is to estimate the potential detour if a commuter has to deliver a package. Since this research does not put detailed attention to vehicle routing, several simplifications were introduced. Firstly, the delivery trip is divided into three legs as indicated in Figure 28. From the original trip (A to D), the cyclist should take a detour through point B (pickup point) and C (delivery point) before ending their trip in destination D. The distance between point is simply the OD distance. In case that delivery pickup/delivery point coincides with the origin/destination, then the corresponding leg would take a zero value (e.g., if trip origin is equal to point B then leg A-B would be zero). Secondly, the distance between OD-pair is calculated based on great-circle distance between zone centroid. The centroid is defined by selecting an arbitrary point around the center of each postcode area. For every OD-pair, total detour distance is calculated for all possible delivery destinations.

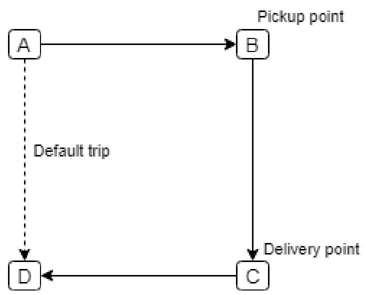


Figure 28 Detour illustration

An example of the resulting detour matrix can be seen in Figure 29. The calculation result seems intuitive; all trips originating from the pickup point location (postcode 2611) have the lowest additional distance to deliver package, while those originating from further areas from pickup point (e.g., 2622 and 2626) have a higher additional travel distance. Weighted average of delivery distance (pickup point to destination) is also calculated to obtain the CO2 emission savings. From the datasets, average distance between pickup point (postcode 2611) to delivery destination is found to be 3.1 km. This translates to 1 kg of CO2 emission savings per delivery.

	2611	2612	2613	2614	2616	2622	2623	2624	2625	2626	2627	2628	2629
2611	1.45	0.00	1.42	1.38	0.07	1.37	1.25	1.32	1.42	1.22	1.14	0.88	0.96
2612	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45	1.45
2613	1.45	0.03	3.10	3.05	0.08	2.65	2.25	2.38	2.83	2.22	1.95	1.27	1.56
2614	1.45	0.07	3.09	4.59	0.09	3.46	2.77	2.83	3.73	2.79	2.32	1.34	1.82
2616	1.45	1.38	1.42	1.40	3.15	1.76	1.94	1.78	1.63	2.01	2.08	2.24	2.34
2622	1.45	0.08	2.70	3.47	0.46	8.79	6.95	5.34	6.82	7.67	6.01	3.16	5.43
2623	1.45	0.20	2.42	2.90	0.77	7.07	7.68	5.36	5.81	7.65	6.74	3.66	6.13
2624	1.45	0.13	2.47	2.89	0.54	5.39	5.29	5.42	5.07	5.26	4.90	3.10	4.32
2625	1.45	0.03	2.82	3.69	0.28	6.77	5.63	4.97	7.04	5.87	4.85	2.66	4.18
2626	1.45	0.23	2.42	2.95	0.86	7.81	7.67	5.36	6.07	9.69	7.11	3.81	7.03
2627	1.45	0.31	2.23	2.57	1.02	6.24	6.85	5.08	5.14	7.20	7.29	3.98	6.61
2628	1.45	0.57	1.80	1.84	1.43	3.65	4.02	3.54	3.20	4.15	4.24	4.40	4.40
2629	1.45	0.50	2.03	2.24	1.46	5.85	6.42	4.69	4.65	7.30	6.80	4.33	8.45

Figure 29 Additional distance matrix (in km) for performing a delivery in zone 2612 (green: low, red: high)

The subsequent step is to define the input values which cover supply and demand attributes as well as the constants. At this end, several scenarios were made. Two perspectives are deployed to define the scenarios. The first perspective would see how the improvement of bicycle crowdshipping service attribute affect its market share (sensitivity analysis). The second would identify how the improvement of service attribute in competing alternative (i.e., traditional shipping) affect the market share of bicycle crowdshipping (cross-sensitivity analysis). Each of the scenarios has different set of supply and demand attribute values, as can be seen in Table 18 and Table 19. It is noteworthy that the determination of default scenario is using the same approach as elasticity analysis in section 6.6.

Table 18 Scenarios where bicycle crowdshipping attributes are varied

	Demand Attribute							Supply Attribute	
	Traditional			Bicycle Crowdshipping				Weight	Remarks
Scenario	Cost	DTW	Speed	Speed	DTW	Rating	CO2		
A	4	0	30	8	0	0	1	3	Default Scenario
B	4	0	30	8	1	0	1	3	Adjustable DTW
C	4	0	30	8	0	1	1	3	All 5 star rating
D	4	0	30	6	0	0	1	3	Speed increase by 2 hr
E	4	0	30	4	0	0	1	3	Speed increase by 4 hr
F	4	0	30	2	0	0	1	3	Speed increase by 6 hr
G	4	0	30	8	0	0	1	3	Detour decrease 10%
H	4	0	30	8	0	0	1	3	Detour decrease 10%
I	4	0	30	8	0	0	1	3	Detour decrease 10%

Table 19 Scenarios where traditional shipping attributes are varied

	Demand Attribute							Supply Attribute	
	Traditional			Bicycle Crowdshipping				Weight	Remarks
Scenario	Cost	DTW	Speed	Speed	DTW	Rating	CO2		
J	4	1	30	8	0	0	1	3	Adjustable DTW
K	4	0	28	8	0	0	1	3	Speed increase by 2 hr
L	4	0	26	8	0	0	1	3	Speed increase by 4 hr
M	4	0	24	8	0	0	1	3	Speed increase by 6 hr
N	3	0	30	8	0	0	1	3	Cost decrease by 1 eur
O	2	0	30	8	0	0	1	3	Cost decrease by 2 eur

The next step after setting up the attribute levels is calculating individual probability and aggregating the probability value to obtain the market share. In this case study, only individual probability on the supply side will be aggregated. The approach is segmentation, where it is assumed that every individual in the same OD-pair will experience the same detour distance. While the CO2 emission may also be varied among individual customer, the effect is subtle (as has been demonstrated by relative importance & elasticity analysis) and therefore it can be perceived as constant. The rest of the supply and demand attribute values are assumed to be homogeneous.

Next, to obtain the market penetration level, one need to find the price level at which the equilibrium state can be achieved. This can be done by solving equation (7). The market equilibrium will be solved per delivery destination because only by doing so every individual traveler in the same OD-pair would experience the same detour distance. Such solving method will ensure consistency with discrete choice model theory. For the sake of practicality, the market share model will be implemented in Excel spreadsheet. Goal-seek function will be utilized to find the equilibrium price level and the respective market share. With spreadsheet, it would also be easier to experiment with the parameters value and perform sensitivity analyses. To do so, initial guess on service price is determined beforehand. Then, the goal-seek function will repeatedly change the price value until the level of demand equals to the supply. Detailed information on the spreadsheet model can be seen in Appendix 13.

Model calibration

Model calibration is performed by assigning parameter values for default scenario to the demand model. After inputting the parameter values, the default scenario yielded a market share of 17.5% for bicycle crowdshipping. The value is on par with market share of traditional shipping; 16.3%. Opt-out option accounts for the highest share; 66.1%. These results seems conflicting with prior market studies, in which only around 18-23% of the online shoppers prefer to retrieve their package at a pickup point (Statista, 2015; Weltevreden, 2008). This is no surprising; SCE data, in nature, do not reflect the real market situation because it represents as many markets as choice sets exposed to the respondents according to design intent (Louviere et al., 2000). This would not be the case if revealed preference data is applied for the study. Thus, one needs to recalibrate the model in order to obtain the desired market share results. One of the methods is to calibrate the alternative-specific constant (Train, 2009) to match the revealed market share. Unfortunately, we have no information on real share of crowdshipping as it is still in early stage. Therefore, we use the real share of opt-out alternative as a reference. Consequently, we adopt the proposition that the share of delivery pickup point would not be affected by the emergence of crowdshipping. We assume that bicycle crowdshipping will compete mainly with other home delivery options (traditional shipping). This assumption may not be entirely true, however as far as data availability is concerned, there is no better alternative. The calibration mechanism is following the method proposed by (Train, 2009), as can be found in Appendix 12.

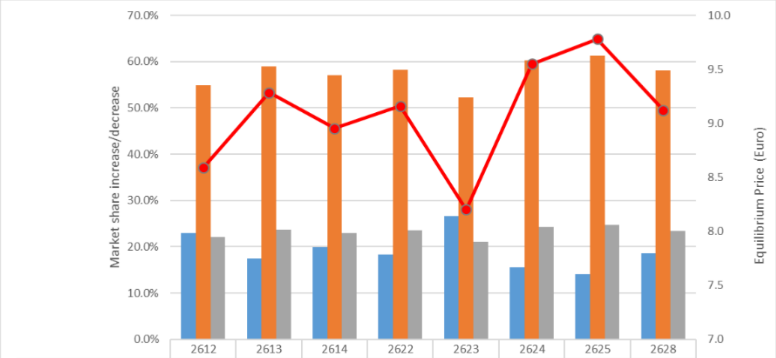
7.3. Results and Discussion

Market share results for diverse membership rate (default scenario)

Solving the market equilibrium for every possible demand OD-pair entails that all travellers within the city network will be dedicated to serve a single delivery route. Although in practice this is not entirely true (as delivery job offers are coming simultaneously from all possible delivery routes), such approach is needed to align the analysis with discrete choice theory. In the Delft case study, this approach leads to demand-supply imbalance, in which the amount of supply (trips available to perform a delivery) is too plenty such that it could not be balanced with the demand. This results in negative equilibrium price. As a workaround, a membership factor α – representing the percentage of cyclist registered as a crowdshipping member – was defined as a multiplier to the amount of cycle commuting trips. This implies that not all the cyclist within the network would have the access to delivery job information. This assumption is deemed feasible as in real life one would not expect the entire commuters to be willing to apply for a crowdshipping platform membership. The value of membership rate is assumed to be comparable with ridesharing industry, which is less than 2%[15]. As such, three arbitrary values of α are chosen for the analysis; 0.5%, 1%, and 1.5%.

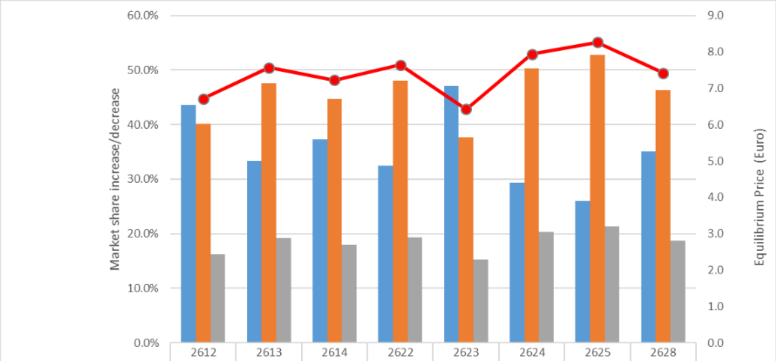
Figure 30, Figure 31, and Figure 32 respectively illustrate the resulting market share and equilibrium price for the three membership rate, all for default scenario in Table 18. A generic pattern appears; the extent of market share is higher when more commuters are registered as member in the crowdshipping platform, which is rationale. Moreover, the equilibrium price level tend to decrease along with the increased membership rate, as a result of higher availability of supply (delivery trips). For 0.5% membership rate, equilibrium price is ranged between 8.2 to 9.8 euros, while for the remaining scenarios (1% and 1.5%) the equilibrium price are ranged respectively between 6.4 to 8.3 euros and 5.1 to 7.3 euros. The market share value is dependent on the amount of demand in each of the delivery destination and its spatial location. It is noticeable that zone with a closer distance to the pickup point will have a higher market share. Within 0.5% membership rate, bicycle crowdshipping market share ranges from 14.1% to 26.7% in various zones. As for 1% and 1.5% membership rate, market share ranges between 26% to 47.1% and 36.7% to 63.6%. Nevertheless, blindly accepting these numbers would not be wise because the results were quite dependent on the assumptions that have been made. Therefore it is wiser to focus on the resulted pattern that represents the market properties.

[15] This number is taken from the US context, given it is a more established market for crowdsourced transport service. Our estimation from several market surveys data suggested that total number of registered drivers in ridesharing platform in the US (hence, the membership rate) is, roughly, less than 2% of its total car commuters (Katz, 2018; PYMNTS, 2018; Statista, 2016).



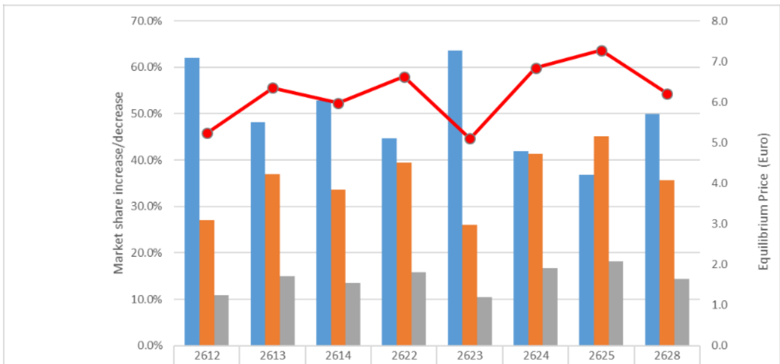
	2612	2613	2614	2622	2623	2624	2625	2628
Market Share CS	23.0%	17.4%	19.9%	18.3%	26.7%	15.5%	14.1%	18.6%
Market Share Trad	54.9%	58.9%	57.1%	58.2%	52.3%	60.2%	61.2%	58.0%
Market Share Opt-Out	22.1%	23.7%	23.0%	23.5%	21.1%	24.3%	24.7%	23.4%
Eq. Price CS	8.6	9.3	9.0	9.2	8.2	9.5	9.8	9.1

Figure 30 Market share result for α = 0.5%



	2612	2613	2614	2622	2623	2624	2625	2628
Market Share CS	43.6%	33.3%	37.3%	32.5%	47.1%	29.3%	26.0%	35.0%
Market Share Trad	40.2%	47.5%	44.7%	48.1%	37.7%	50.4%	52.7%	46.3%
Market Share Opt-Out	16.2%	19.2%	18.0%	19.4%	15.2%	20.3%	21.3%	18.7%
Eq. Price CS	6.7	7.6	7.2	7.6	6.4	7.9	8.3	7.4

Figure 31 Market share result for α = 1%



	2612	2613	2614	2622	2623	2624	2625	2628
Market Share CS	62.0%	48.2%	52.8%	44.7%	63.6%	42.0%	36.7%	49.9%
Market Share Trad	27.1%	36.9%	33.6%	39.4%	26.0%	41.4%	45.1%	35.7%
Market Share Opt-Out	10.9%	14.9%	13.6%	15.9%	10.5%	16.7%	18.2%	14.4%
Eq. Price CS	5.2	6.3	6.0	6.6	5.1	6.8	7.3	6.2

Figure 32 Market share result for α = 1.5%

Scenario results

To limit the size of the analysis, scenario analysis is confined to only one of the delivery destinations. In this case, postcode with the highest demand is chosen (2624). The membership rate used in the scenarios is 1.5%. Through deploying diverse scenarios, one would be able to see the relative impact of changing the service/job attributes to bicycle crowdshipping market share.

Figure 33 and Figure 34 respectively illustrate the market share sensitivity as a response to each scenarios. Figure 33 suggests that changing the service attributes of bicycle crowdshipping would generate moderate impact to its market share. Most impactful service attribute change is providing adjustable delivery time window which gives 3.56% raise to the market share. Similarly, changing job attribute by reducing the detour travel time (30% reduction) would increase the market share by 3.86%. It is also apparent that bicycle crowdshipping mainly competes with traditional shipping. By looking at the scale of changes in share, we can conclude that bicycle crowdshipping's market share is not that sensitive towards service and job attributes improvement. This brings an interesting insight. If one examine only the demand side, one would expect a massive leap in demand share when offering adjustable delivery time window[16]. However, in practice the crowdshipping market is also reliant on supply. As we also have seen in section 6.6., supply side of crowdshipping is much more inelastic than demand side. Ultimately, such inelastic property is likely to suppress the market expansion.

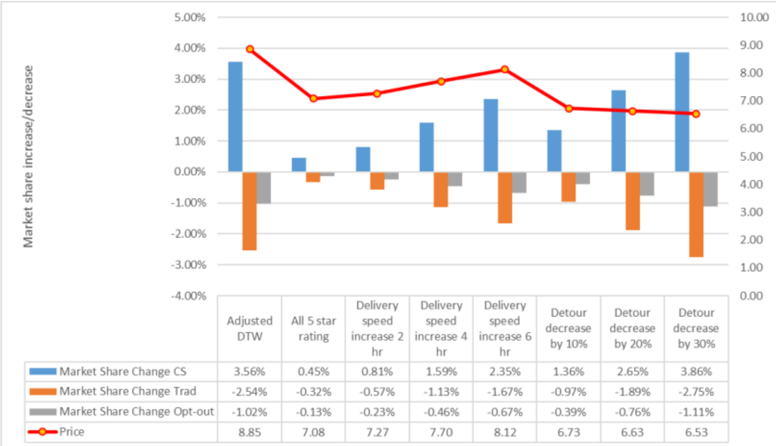


Figure 33 Sensitivity analysis result of scenario A to I (delivery zone 2624)

Figure 34 suggests that changing the service attributes of traditional shipping would bring a significant impact to its market share; the change ranges from 1% up to 13%. Adjusted delivery time window and cost reduction turned out to give the most impact. The opt-out alternative will be the most impacted option, which is apparent from its huge reduction in share. On the other hand, market share of bicycle crowdshipping is also impacted. In the greatest extent traditional shipping eats out crowdshipping market share by 3.25%. Massive improvement in traditional shipping market share could be linked to the fact that traditional shipping is not as strictly limited by its supply of courier as bicycle crowdshipping. More flexibility in supply implies higher market sensitivity towards change in service attributes. Another finding is that bicycle crowdshipping changes its price level as a response of the attribute change of traditional shipping (i.e. lowering its price when service attribute of traditional shipping is improved). It indicates that in order to be competitive, bicycle crowdshipping should be responsive to the market dynamics.

[16] More than 10% market share increase within the price range of 9 euro and below. See section 6.6

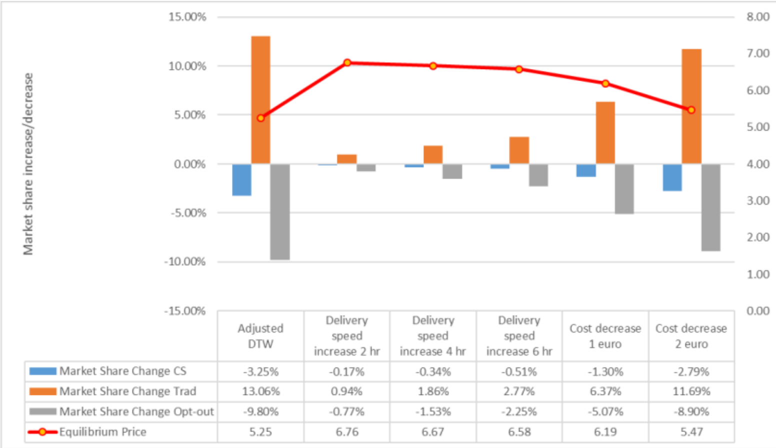


Figure 34 Sensitivity analysis result for scenario J to O (delivery zone 2624)

7.4. Chapter summary

To provide a tangible result for market share estimation, a case study was conducted for city of Delft. Solving the market equilibrium for every delivery destination implied imbalance between supply and demand, therefore assumption on crowdshipping membership rate was introduced. Afterwards, several scenarios were proposed to capture two types of insights; effect of change in bicycle crowdshipping service level on its market share, and effect of change in competing alternative's service level on bicycle crowdshipping market share. Case study results indicated that market share of bicycle crowdshipping can be (slightly) increased by improving its service attributes. Market expansion of bicycle crowdshipping was somehow constrained by the inelastic properties of the supply function. Although the extent is moderate, it was also revealed that change in service attribute on the competing alternative (traditional shipping) would eat out part of bicycle crowdshipping share. Diverse equilibrium price were found between different scenarios, implying that in order to remain competitive, bicycle crowdshipping would need to be responsive on the market changes.

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CHAPTER 8: Conclusion and Recommendation

8.1. Introduction

This research focuses on the impact of behavioural acceptance towards crowdshipping market penetration, considering demand and supply side of the system. The main differentiation of this study is the simultaneous evaluation of supply and demand in determining potential market share. Such an approach is the first of its kind given that prior studies on the field applied merely one-sided approach when examining crowdshipping potential. This study also provides the first initiative to identify market opportunity of bicycle crowdshipping in the Netherlands, a place in which typical service would likely to flourish due to its embedded cycling culture and infrastructure. The study brings insights in regards to influential service and job attributes to crowdshipping (supply-demand) acceptance and the implication of the acceptance on the potential market penetration level.

In this chapter, the conclusions of the research will be presented in section 8.2. In section 8.3, recommendations for practice and future research will be discussed.

8.2. Conclusions

The main research question to be answered by this study is: ***What is the market potential of bicycle crowdshipping, taking into account bi-level behavioural acceptance?***

Several research sub-questions were proposed to address the main question in sequential stages. The research sub-questions will be addressed firstly, and later the answer to the main research question will be provided.

8.2.1. Answers to research sub-questions

SQ #1: What is the prospective market scope of bicycle crowdshipping, and what attributes characterise this market?

To identify the prospective market scope, literature review and benchmarking was conducted in chapter 2. The market scope of bicycle crowdshipping can be distinguished with regards to two parameters; the spatial context and shipment characteristics. Prior studies suggested that bicycle-based delivery services can serve up to 7.5 km of delivery distance. This delivery range is aligned with the acceptable travel distance of cyclist commuters. With such range limitation, two possible spatial contexts could be explored by bicycle crowdshipping; local delivery and last mile delivery. The former implies that bicycle crowdshipping can serve home delivery by cooperating with local stores in proximity that provide click and collect service. The latter requires bicycle crowdshipping to integrate its operations with delivery hub (urban DC) or parcel pickup points in cities. Concerning shipment characteristics, bicycle crowdshipping can carry up to 25 kilograms of package with a volume up to 60 dm^3. Benchmarking on the current services discovered that most crowdshipping services provide home delivery for all ranges of products (as can be referred to Figure 4). Few of them focuses on groceries and fresh food delivery. Considering the potential future applications, it was concluded that last-mile delivery from parcel pickup points and local stores would be the selected market scope for this study.

SQ #2: What are the possible value propositions and service/job attributes to be offered in response to the prospective market?

Literature overview performed in chapter 3 found that the differentiating feature of crowdshipping lies on its flexibility to define delivery condition, lower cost in comparison to traditional shipment, and benefits to the environment and society. Among other tasks, bicycle crowdshipping platform creates value by matching between couriers and customers and manage the balance between these stakeholders. Such value creation signified the relevance of this thesis, in which the main goal is to understand the influence of supply and demand attributes to the potential market share of bicycle crowdshipping.

Through benchmarking and literature overview, various service attributes have been explored according to four categories; traditional feature, control over delivery condition, quality and security, and other differentiation factors (as can be seen in Table 1). Surprisingly, current crowdshipping practice has not been explicitly incorporated unique attribute (i.e., CO2 emission savings) as part of the crowdshipping features to attract potential customers. Hence, it was interesting to test in this study whether such attribute would be valued by customers. Several job attributes were also discussed and distinguished based on three categories; travel setting, rewarding factors, and penalizing factors (as can be seen in Table 2). Previous research showed that incorporating travel setting into job attributes might be valuable to develop context-based compensation that fits commuter's changing delivery preference between diverse contexts. Study on the rewarding factors implied that unique value proposition for courier needs to be emphasized by crowdshipping platform, for example by combining monetary compensation with gamification (e.g., provision of CO2 savings record).

SQ #3: Which service attributes contribute to customer's acceptance on crowdshipping, and what is the relative importance of these factors? How do this acceptance translate to the service demand?

To limit the size of the study, criteria-based shortlisting were carried out to select five most relevant attributes from Table 1, representing demand side of crowdshipping. The selected attributes were delivery cost, delivery speed, delivery time window, performance rating, and CO2 emission savings. At least one attributes are taken from each category (traditional features, quality and security, etc.) to ensure complete representation of crowdshipping properties. An efficient-design stated choice experiment (SCE) was conducted to identify the significance of these attributes and their relative importance. The parameter coefficient result (indicated in equation 15) revealed that all the five selected attributes proved to have significant influence on crowdshipping acceptance. Delivery cost (price) appeared as the most important attribute (importance score 3.03), followed (in order of importance) by adjustable delivery time window (importance score 1.16), delivery speed (importance score 0.74), CO2 savings record (importance score 0.61), and performance rating (importance score 0.14). To assess the attribute importance in terms of monetary value, MRS value (willingness to pay) were also derived for each of the service attributes.

$$V_{CS} = -0.506\, Cost_{CS} - 0.124\, Speed_{CS} + 1.16\, DTW_{CS} + 0.137\, Rating_{CS} + 0.507\, CO2_{CS}$$

$$V_{Trad} = -0.888 - 0.506\, Cost_{Trad} - 0.035\, Speed_{Trad} + 1.16\, DTW_{Trad}$$

$$U_{NO} = -2.56 \tag{15}$$

The service demand – measured by the probability at which a customer would select crowdshipping as a delivery option – was calculated by deploying the obtained parameter coefficients to the logit model postulated in section 5.2 (i.e., equation (4)). Subsequently, elasticity analysis was performed to examine how the attribute change affects the demand. Imposing all 5-star courier adds 3.5% of demand share (at maximum), while offering adjustable delivery time brings 28% gain on demand share (at maximum). The demand share was found to be elastic to price change, in particular within the price range above 4 euro. The most sensitive points to price change are located within the range of 4 to 6 euro.

SQ #4: Which job attributes influence bicycle commuters' acceptance to participate in crowdshipping, and how do they weight these factors? How do this acceptance translate to the service supply?

The same process applied to answer SQ #3 is also used to address this sub-question. Firstly, five most relevant attributes were selected to represent supply side of bicycle crowdshipping. The selected job attributes include delivery time of day, additional travel time, package weight, profit, and CO2 savings record. The parameter estimation result showed that time of day context and CO2 emission savings do not significantly influence courier's acceptance. The parameter coefficients (shown in equation 16) indicated additional travel time as the most important job attributes (importance score 1.15), followed by package weight (importance score 1.08) and profit (importance score 1.01). However, the difference of importance score between these parameters is not prominent, implying that cyclist commuters placed relatively comparable value to these parameters. Moreover the role of monetary attribute is less dominating compared to that of demand side. To assess the attribute importance in terms of monetary value, MRS value (willingness to work) were derived for each of the job attributes.

$$V_{Deliv2} = -0.0852\ TT_{Deliv} + 0.215\ Profit_{Deliv} - 0.217\ Weight_{Deliv}$$

$$V_{NO} = -1.88 \tag{16}$$

The service supply – measured by the probability at which a cyclist commuter would accept a delivery job – was calculated by deploying the obtained parameter coefficients to the logit model specified in section 5.2 (i.e., equation (6)). Subsequently, elasticity analysis was performed to examine how the attribute change affects the supply. The result showed that for every additional 5 minutes in travel time, delivery probability would be decreased by 10%. However, this effect diminishes along the increase of profit. Unlike the demand function, the supply function was found to be rather insensitive and inelastic to profit change, which is apparent from its flatter curve and elasticity value that never reach a point above 1.

SQ #5: Given the bi-level acceptance, how could one determine potential market penetration level of bicycle crowdshipping? Which factors would contribute to improve the market penetration?

The derivation of market share/market penetration level of bicycle crowdshipping is grounded upon the assumption from economics science that parcel delivery market will reach equilibrium level at a certain price when demand of the service equals its supply. By using this principle, an equilibrium model showcasing the relationship between supply and demand was developed. The equilibrium state is shown in the equation (11) below. Note that the market share $\widehat{M}_S$ is dependent on the number of cyclist commuting trips available $c,$ as well as number of online orders to be delivered n. These values are dependent on the market scope to be penetrated by bicycle crowdshipping. Also notice that the market share is affected by the productivity parameter (or drop-factor[17]) μ. By solving for the equilibrium price level (in which the equilibrium state is fulfilled), we can obtain the market share of

[17] The number of parcel dropped per stop

bicycle crowdshipping. The step-wise model implementation to estimate potential bicycle crowdshipping market share is illustrated in Figure 11.

$$\widehat{M}_S \; x \; n = \widehat{P}_s \; x \; c \; x \; \mu \qquad (11)$$

Market share can be improved by increasing the level of service (i.e., bettering the attribute value). As has been discussed in demand elasticity analysis, this can be achieved most effectively by offering the adjustable delivery time window and increasing delivery speed. Deploying all 5-star courier would also help but this would only give a slight increase in market gain. The precise amount of market share increase resulted from increasing the service level will be discussed in detail in the answer of main research question, in which a case study will be developed for city of Delft.

8.2.2. Answer to main research question

What is the market potential of bicycle crowdshipping, taking into account bi-level behavioural acceptance?

In answering the main research question, one needs to specify the market scope in order to acquire real data for deriving market share potential. To ensure data consistency and minimize bias, parcel delivery in city of Delft will be chosen as the market scope. Market share is estimated following the step-wise model implementation postulated in chapter 5. The demand-supply logit model as well as the equilibrium model serves as the inputs. OD matrix of cyclists were derived from Fietstelweek data, whereas demand matrix were developed using Dutch ecommerce statistics. To ensure consistency with discrete choice theory, market equilibrium is solved for each delivery destination. This solving method necessitates assumptions on crowdshipping membership rate to assure supply-demand balance (0.5%, 1%, and 1.5% membership rate were used). Subsequently, market share estimation scenarios was carried out with two perspectives; first perspective will see the effect of bettering service attribute of bicycle crowdshipping, while the second will examine the effect of improving service attribute of competing alternative (traditional shipping).

For 0.5% membership rate, bicycle crowdshipping has the potential to acquire 14% to 26% market share, depending on the delivery destination. Increasing the membership rate will be followed by increase in bicycle crowdshipping market share and decrease in equilibrium price point, which is aligned with common demand-supply principle. The first perspective of market share scenarios showed that bicycle crowdshipping can only moderately increase the market share by bettering its service attributes (less than 4% increase). Inelasticity of crowdshipping supply function suppressed the expansion of its market share. In contrast, the second perspective showed that traditional shipping would gain considerable amount of share by improving its service attribute (up to 13% increase). Interestingly, the effect towards market share of bicycle crowdshipping is small; most of the impact will be experienced by opt-out option through reduction in its share. This is especially true if bicycle crowdshipping adjust its price to retain its competitiveness with traditional shipping.

8.3. Recommendations

This research is built on several assumptions and simplifications that may lead to imperfect results. However, it does not refute the fact some important insights can still be inferred as a learning points for practice, which will be detailed in the following section. Subsequently, the scientific limitation of this study will be discussed as an opportunity to conduct further research.

8.3.1. Recommendation for practice

- Customers placed relatively high appreciations when a delivery service offers adjustable time window, even higher than delivery speed. This implies that when there is a trade-off between flexibility in delivery time and delivery speed, crowdshipping platform may want to prioritize the former. Although the effect is not extensive, CO_2 savings record has as well proven to influence customer preference. Crowdshipping platform must emphasize these two features to allow differentiation with other shipping options.

- The result has shown that bicycle crowdshipping would be the most competitive when being responsive to the market situation (i.e., changing its price level between diverse scenarios). Bicycle crowdshipping should not merely focusing on its own service level, because any change in the service level of competing alternative would also impact its market share.

- The model provides interesting insights on the effect of incorporating diverse service level scenarios to the resulting market share and pricing. The model result could serve initial insights on the effect of company's decision before implementing the solution in real-life. As the output is highly reliant on the assumptions being used, the estimated result should be treated with caution. As such, establishing a plausible input values would be essential before implementing the model. The model results could also be used as a rough pricing reference for bicycle crowdshipping platform. Further adjustment might be needed for such a purpose because the price determination from this thesis is not defined from a cost-by-cost basis. In particular, this study has not identified whether the equilibrium price would pay-off the investment, operational, and overhead cost (i.e. any cost beside courier's fee) of crowdshipping service.

- The market share pattern showed that crowdshipping market share is constrained by the rather inelastic supply function. In practical point of view, this means crowdshipping platform will face more difficulty in enticing potential couriers to perform deliveries than attracting potential customers to use the service. To stimulate the supply, crowdshipping platform should therefore embrace itself to explore more creative solution than just adjusting profit level. An instance would be optimizing the supply operations by improving the productivity per courier (drop factor). Figure 35 below shows that increasing courier productivity would be as effective to increase market share. This can be materialized, for example, by assigning two deliveries in proximity to a single courier. Other alternative to be considered is optimizing the routing system such that the amount of additional travel distance could be minimized.

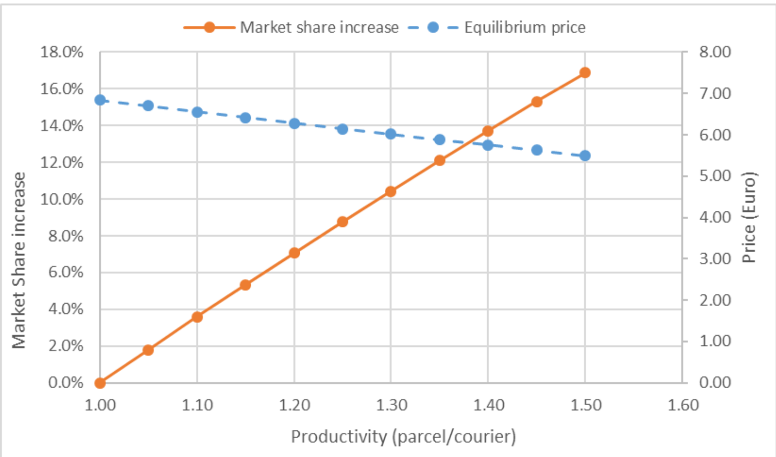

Figure 35 Market share and equilibrium price in response to delivery productivity (zone 2624, α=1.5%, default scenario)

8.3.2. Recommendation for future research

Sample selection

As revealed in section 6.3 and 6.4, the study sample exhibits some biases from statistics on the country level. The most striking one is the abundant amount of students as the respondents which causes over-representation of young-aged as well low-income people. As a consequence, such bias implies the results of this study to be strictly limited by the characteristics of its sample. It remains questionable whether the result of this thesis would apply to other cities with profound difference in sociodemographic properties. Hence, equivalent studies need to be conducted in different spatial areas in order to infer the generalizability of the model.

Other travel purpose than commuting

This thesis confines the scope of trips to perform delivery job to commuting. Dutch mobility survey shows that other trip purposes such as shopping and leisure also constitutes a significant percentage of cycling trips in the Netherlands (CBS, 2016c). Involving more than one trip purposes may complicate matters, however it could possibly reveal a higher potential market share. To examine other trip purposes, different selection of attributes may be needed. For example, people doing leisure trips might be more sensitive towards route characteristics (such as the presence of green areas, the quality of cycle path) than additional travel time when making a delivery decision.

Membership rate

This research assumes some arbitrary levels of crowdshipping membership rate at which cyclist commuters would have the possibility to access information on delivery job offers. In practice, this choice could be affected by explanatory factors such as socioeconomic characteristics of the commuters. To account for such factor, further research would be needed to define a function measuring the probability at which a cyclist would be a member of a crowdshipping platform. A stated choice experiment might be a method of choice for such purpose.

Acceptance of online shop towards bicycle crowdshipping

The study emphasizes the acceptance of end user (package receiver) towards bicycle crowdshipping to determine its potential market share. In this study, it is assumed that all online shops would provide bicycle crowdshipping as one of the delivery option. However, the possibility of having bicycle crowdshipping as a delivery option is determined by willingness of online shops to cooperate with the platform. To incorporate this aspect, a future study can be carried out. An instance could be a qualitative study involving online shops to identify their preference to cooperate with crowdsourced couriers.

Delivery routing and scheduling

The research neglects essential parts of crowdshipping system; delivery scheduling and routing. In fact, time dimension plays an essential role if a person would like to make a delivery choice. A high probability to perform a delivery does not necessarily imply that an individual commuter would be ready to perform the delivery; one may not find the suitable time span to carry out a delivery job. Hence, further research will be needed to incorporate the scheduling activities. In addition, within this study the detour level for delivering a package was simply calculated by using OD distance. It would be more realistic if a real transport network could be applied to measure the detour trip. By incorporating these two elements, the model would generate a more realistic market share. Incorporating the model into an agent based simulation would be a suitable option for further study. For instance, the model can be combined with the research of (Devari et al., 2017) that applied activity-based model to estimate the market potential of a crowdsourced delivery.

Other price structure

This study makes complete separation between delivery cost and item purchase price. In real market, delivery cost is often partially compensated by other revenue sources such as purchase price (by imposing marked-up price to the products) or fixed membership price (Rougès & Montreuil, 2014). These type of pricing have been applied by some crowdshipping services, yet there is still lack of research on this area. By incorporating other pricing concepts in the market share model, a more representative result could be obtained.

E-bike effect

There is an increasing trend of e-bike adoption amongst cyclist in the Netherlands, especially for adult aged under 50s (KiM, 2016). People who cycle with e-bike would tend to travel longer distance and less frequently use other modes (KiM, 2016). This mobility shift would likely to have some implications towards bicycle crowdshipping. For instance, e-bike users might have less aversion towards delivery detour and travel by bike more frequently. It is therefore would be interesting to investigate how e-bike users would differently perceive crowdshipping delivery job in comparison to normal bike users.

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Appendices

Appendix 1 Assumptions/sources used for determining service attributes level

Attributes	Levels	Units	Source/Assumptions
Cost	3/5/7/9	Euro	Based on benchmarking performed in chapter 3
Speed	1/3/5/7	Hours	Based on benchmarking performed in chapter 3
Delivery Time Window	Adjustable/Non-adjustable	-	Prior studies (Punel & Stathopoulos, 2017)
Performance Rating	5/4	Star	Based on benchmarking performed in chapter 3
CO2 reduction record	0.9/1.3/1.7/2.1	Kilograms	CO2 emission per km: 0.175 kg (European Environment Agency, 2015). Delivery distance by van is assumed to be return trip distance from pickup point/store to customers. Assumed one way distance is: 2-6 km.

Appendix 2 Assumptions/sources used for determining job attributes level

Attributes	Levels	Units	Source/Assumptions
Time of day	Morning/Evening	-	Prior study (Miller et al., 2017)
Additional Travel Time	6/10/14/20	Minutes	Based on max. travel distance by bike: 7.5 km, converted to travel time in minutes. This additional travel distance excludes original travel time of 15 minutes.
Package weight	1/3/5/7	Kilograms	Expert opinion (cycling expert) and benchmark to other services.
Profit	2/4/6/8	Euro	Based on benchmarking performed in chapter 3
CO2 reduction record	0.9/1.3/1.7/2.1	Kilograms	Same assumption with demand attribute

Appendix 3 Ngene input syntax (demand survey)

```
? Bicycle Crowdshipping - Service Attributes
design
;alts = CS1, CS2, Regular, No
;rows = 16
;con
;block = 2
;eff = (mnl,d)
;model :
U(CS1)   =        b1 [-0.131]* cost[3,5,7,9] + b2 [-0.108] * speed_CS[1,3,5,7]  + b3 [0.395] *
delivtw[0,1] + b4 [0.495]* rating[0,1] + b5 [1.22]* CO2[0.9,1.3,1.7,2.1]/
U(CS2)   = b6 [-0.07] + b1 * cost          + b2 * speed_CS          + b3 * delivtw        + b4
* rating        + b5 * CO2          /
U(Regular)= b7 [0.917] + b1 * cost          + b8 [-0.108]* speed_reg[15,18,21,24]+ b3 * delivtw/
U(No)    = b9 [-4.28]$
```

Appendix 4 Ngene input syntax (supply survey)

```
? Bicycle Crowdshipping – Job Attributes
design
;alts = Job1, Job2, No
;con
;block = 2
;rows = 16
;eff = (mnl,d)
;model :
U(Job1) =         b1[-0.114] * AddTravelTime[6,10,14,20] + b2[-0.78] * PackageWeight[1,3,5,7] +
b3[0.885] * Profit[2,4,6,8] + b4[0.92] * CO2[0.9,1.3,1.7,2.1]/
U(Job2) = b5 [0.103] + b1      * AddTravelTime      + b2      * PackageWeight      + b3      *
Profit      + b4      * CO2/
U(No)   = b7 [-0.197]$
```

Appendix 5 Demand survey questionnaire

Bicycle Crowdshipping Demand Survey

Introduction

This survey is part of my graduation research for MSc Transport, Infrastructure, and Logistics at TU Delft. The research is aimed to identify the preferences of online shoppers for the choice of bicycle crowdshipping as the mode for home delivery service.

Bicycle crowdshipping is a platform that connects online shoppers to a crowd of bicycle commuters (people going to work/school by bike) that are willing to pick up and deliver packages in addition to their journey. These cyclist commuters are willing to deliver packages due to various reasons; it could be monetary compensation, willingness to help the neighbours, preserving the environment, or a combination of these. All bicycle crowdshippers have undergone a background check and are considered safe and reliable.

This survey consists of **3 sections**; the first section contains preliminary questions to identify your online shopping experience. The second section presents scenarios where you choose the preferred home delivery service. The third section is where your personal characteristics will be asked. All the information you give will be kept confidential and will only be used for this research.

In average, the survey would take 10 minutes of your time. Please complete all pages and click 'submit' at the end. By participating in this survey, you will get the chance to win a 7 Euro bol.com (digital) voucher. There are 85 vouchers to be given away for the lucky draw.

Thanks for your participation,
Satrio Wicaksono
MSc Student at TU Delft

Online Shopping Experience

1. Have you made an online purchase before? *

- ○ Yes
- ○ No

2. How frequently do you usually make an online purchase? *

- ○ Less than once a month
- ○ Once a month
- ○ 2-4 times a month
- ○ More than 4 times a month

3. What are the most frequent items that you purchase online? Multiple choices possible. *

- ☐ Clothing/apparel
- ☐ Gadgets/consumer electronics (e.g., smartphone, accessories)
- ☐ Books (non-digital)
- ☐ Household electronics (e.g., electric cooking and cleaning appliances)
- ☐ Home and garden (non-electronic)
- ☐ Groceries and dried food
- ☐ Fast food and restaurant food
- ☐ Sports/recreation equipments
- ☐ Health and beauty
- ☐ Other (write down)

4. What is the average value you spend when you shop online? *

- ○ 20 euro or less
- ○ 20 - 50 euro
- ○ 50 - 75 euro
- ○ More than 75 euro

5. From your experience, what is your preferred delivery location when you do online purchase? *

- Delivery to pickup/service points
- Delivery to my home
- Delivery to my office/school

6. Select one of the statements below that best represents your knowledge/experience on crowdshipping service.
E.g. of crowdshipping: Pickthisup.nl, Uber Eats, Deliveroo.nl, Bun.run, Saddl.nl *

- I have already used crowdshipping
- I have already heard about crowdshipping, but I have never used it
- I have already heard about crowdshipping, but I didn't know it was called like this
- I have never heard about crowdshipping

7. How important do you consider online shopping delivery features as presented below? *From low to high: 1: Not Important, 5: Very Important* *

The ability to choose the preferred delivery time window (e.g., deliver between 6-7 pm)

	1	2	3	4	5	
Not Important	○	○	○	○	○	**Very Important**

Home delivery is made using an eco-friendly and neighbourhood-friendly (low-noise) vehicle (such as bicycle or electric cargo bike)

	1	2	3	4	5	
Not Important	○	○	○	○	○	**Very Important**

Delivery is made within a short time (same day or faster)

	1	2	3	4	5	
Not Important	○	○	○	○	○	**Very Important**

Imagine that you are shopping an item from one of your favorites online shop such as bol.com and hema.nl. Assume that the price you pay for the item also includes delivery service to one of the parcel pickup points in your city (e.g., DHL/UPS/PostNL service point, supermarkets, or drugstores).

During checkout process on the website, you are given several delivery options to manage the last-mile (last delivery leg) of your package from the parcel pickup point to your home. You will need to consider the feature of each option to base your selection:

1. **Delivery time window**, in which you can customize/adjust your preferred delivery timing (if it shows 'adjustable'). E.g., delivery between 3-4 pm.
2. **Courier performance rating**, representing courier's reliability which includes timeliness, package care, and overall delivery performance (applicable for crowdshipping).
3. **Delivery cost**
4. **Delivery speed,** the time it takes to deliver the package from a pickup point to your home.
5. **CO2 emissions saved,** resulted by replacing delivery vans with bicycles (applicable for crowdshipping). As your reference, 1 km of delivery van trip emits 0.2 kg CO2.

All delivery options provide package insurance and track & trace feature. Traditional shipping is handled by established courier (such as UPS or DPD) and uses delivery vans. Average distance from pickup point to your home is between 3 to 4 km.

Note that all the features presented apply only for the delivery leg between pickup point and your home.

8. From the available delivery options below, pick up one that suits your preference best.

	Delivery Options		
Service Features	Bicycle Crowdshipping 1	Bicycle Crowdshipping 2	Traditional Shipping
Delivery Time Window	adjustable	non-adjustable	non-adjustable
Courier Performance Rating	★★★★★	★★★★☆	N/A
Cost	5 euro	5 euro	9 euro
Delivery Speed	3 hours	3 hours	18 hours
CO_2 emissions saved	1.7 kilograms	1.7 kilograms	N/A

Which delivery option would you choose? *

- Bicycle Crowdshipping 1
- Bicycle Crowdshipping 2
- Traditional Shipping
- None of the above (I will pick up the package myself)

For the above case, given you have no time to pick up the package yourself, which delivery option would you choose? *

- Bicycle Crowdshipping 1
- Bicycle Crowdshipping 2
- Traditional Shipping

9. From the available delivery options below, pick up one that suits your preference best.

Delivery Options

Service Features	Bicycle Crowdshipping 1	Bicycle Crowdshipping 2	Traditional Shipping
Delivery Time Window	non-adjustable	adjustable	adjustable
Courier Performance Rating	★★★★☆	★★★★★	N/A
Cost	7 euro	7 euro	3 euro
Delivery Speed	3 hours	7 hours	15 hours
CO_2 emissions saved	0.9 kilograms	0.9 kilograms	N/A

Which delivery option would you choose? *

- Bicycle Crowdshipping 1
- Bicycle Crowdshipping 2
- Traditional Shipping
- None of the above (I will pick up the package myself)

For the above case, given you have no time to pick up the package yourself, which delivery option would you choose? *

- Bicycle Crowdshipping 1
- Bicycle Crowdshipping 2
- Traditional Shipping

10. From the available delivery options below, pick up one that suits your preference best.

Delivery Options

Service Features	Bicycle Crowdshipping 1	Bicycle Crowdshipping 2	Traditional Shipping
Delivery Time Window	adjustable	non-adjustable	non-adjustable
Courier Performance Rating	★★★★☆	★★★★★	N/A
Cost	3 euro	9 euro	7 euro
Delivery Speed	3 hours	3 hours	21 hours
CO_2 emissions saved	1.3 kilograms	2.1 kilograms	N/A

Which delivery option would you choose? *

- Bicycle Crowdshipping 1
- Bicycle Crowdshipping 2
- Traditional Shipping
- None of the above (I will pick up the package myself)

For the above case, given you have no time to pick up the package yourself, which delivery option would you choose? *

- Bicycle Crowdshipping 1
- Bicycle Crowdshipping 2
- Traditional Shipping

11. From the available delivery options below, pick up one that suits your preference best.

Delivery Options

Service Features	Bicycle Crowdshipping 1	Bicycle Crowdshipping 2	Traditional Shipping
Delivery Time Window	non-adjustable	adjustable	adjustable
Courier Performance Rating	★★★★★	★★★★☆	N/A
Cost	9 euro	3 euro	5 euro
Delivery Speed	7 hours	1 hours	24 hours
CO_2 emissions saved	2.1 kilograms	0.9 kilograms	N/A

Which delivery option would you choose? *

- Bicycle Crowdshipping 1
- Bicycle Crowdshipping 2
- Traditional Shipping
- None of the above (I will pick up the package myself)

For the above case, given you have no time to pick up the package yourself, which delivery option would you choose? *

- Bicycle Crowdshipping 1
- Bicycle Crowdshipping 2
- Traditional Shipping

12. From the available delivery options below, pick up one that suits your preference best.

Service Features	Bicycle Crowdshipping 1	Bicycle Crowdshipping 2	Traditional Shipping
	Delivery Options		
Delivery Time Window	adjustable	non-adjustable	adjustable
Courier Performance Rating	★★★★☆	★★★★★	N/A
Cost	5 euro	5 euro	5 euro
Delivery Speed	7 hours	1 hours	15 hours
CO_2 emissions saved	1.7 kilograms	1.3 kilograms	N/A

Which delivery option would you choose? *

- Bicycle Crowdshipping 1
- Bicycle Crowdshipping 2
- Traditional Shipping
- None of the above (I will pick up the package myself)

For the above case, given you have no time to pick up the package yourself, which delivery option would you choose? *

- Bicycle Crowdshipping 1
- Bicycle Crowdshipping 2
- Traditional Shipping

13. From the available delivery options below, pick up one that suits your preference best.

Service Features	Bicycle Crowdshipping 1	Bicycle Crowdshipping 2	Traditional Shipping
	Delivery Options		
Delivery Time Window	non-adjustable	adjustable	non-adjustable
Courier Performance Rating	★★★★★	★★★★★	N/A
Cost	5 euro	7 euro	9 euro
Delivery Speed	3 hours	5 hours	18 hours
CO_2 emissions saved	2.1 kilograms	1.3 kilograms	N/A

Which delivery option would you choose? *

- Bicycle Crowdshipping 1
- Bicycle Crowdshipping 2
- Traditional Shipping
- None of the above (I will pick up the package myself)

For the above case, given you have no time to pick up the package yourself, which delivery option would you choose? *

- Bicycle Crowdshipping 1
- Bicycle Crowdshipping 2
- Traditional Shipping

14. From the available delivery options below, pick up one that suits your preference best.

Service Features	Bicycle Crowdshipping 1	Bicycle Crowdshipping 2	Traditional Shipping
	Delivery Options		
Delivery Time Window	adjustable	non-adjustable	non-adjustable
Courier Performance Rating	★★★★★	★★★★☆	N/A
Cost	9 euro	3 euro	7 euro
Delivery Speed	1 hours	7 hours	21 hours
CO_2 emissions saved	1.3 kilograms	2.1 kilograms	N/A

Which delivery option would you choose? *

- Bicycle Crowdshipping 1
- Bicycle Crowdshipping 2
- Traditional Shipping
- None of the above (I will pick up the package myself)

For the above case, given you have no time to pick up the package yourself, which delivery option would you choose? *

- Bicycle Crowdshipping 1
- Bicycle Crowdshipping 2
- Traditional Shipping

15. From the available delivery options below, pick up one that suits your preference best.

Delivery Options

Service Features	Bicycle Crowdshipping 1	Bicycle Crowdshipping 2	Traditional Shipping
Delivery Time Window	non-adjustable	adjustable	adjustable
Courier Performance Rating	★★★★☆	★★★★☆	N/A
Cost	7 euro	9 euro	3 euro
Delivery Speed	5 hours	5 hours	24 hours
CO_2 emissions saved	0.9 kilograms	0.9 kilograms	N/A

Which delivery option would you choose? *

- Bicycle Crowdshipping 1
- Bicycle Crowdshipping 2
- Traditional Shipping
- None of the above (I will pick up the package myself)

For the above case, given you have no time to pick up the package yourself, which delivery option would you choose? *

- Bicycle Crowdshipping 1
- Bicycle Crowdshipping 2
- Traditional Shipping

Personal Characteristics

24. What is your gender? *

- Male
- Female

25. What is your age? *

- <18
- 18 - 24
- 25 - 34
- 35 - 44
- 45 - 54
- 55 - 64
- > 64

26. What is your average monthly gross income (in Euro)? *

- <500
- 501 - 1000
- 1001 - 1500
- 1501 - 2000
- 2001 - 2500
- 2501 - 3000
- > 3000
- I prefer not to answer

27. What is your occupation? Multiple choice is possible *

- ☐ Student at a school/university (PhD is not considered as student)
- ☐ Part-time employee
- ☐ Full-time employee
- ☐ Entrepreneur/Self-employed
- ☐ Unemployed, looking for a job
- ☐ Unemployed, not looking for a job
- ☐ Retired

28. What is your type of household? *

- Living alone (this includes living in a shared house/student house)
- Two person household without children
- Family with one or more children
- Other

29. What is your highest completed education? *

- Primary School
- VMBO/MAVO
- HAVO
- VWO
- MBO
- Bachelor
- Master
- PhD
- Other (write down)

30. Please indicate the transport mode you use for daily commuting. ('+' means combination) *

- Bicycle
- Bicycle + Public Transport
- Car
- Car + Public Transport
- Public Transport
- Walking

31. When do you normally perform your commuting trip? *

- Always or mostly on peak hours (between 6-9 am and 5-7 pm)
- Always or mostly off peak hours
- Both equally

32. Would you like to participate in the bol.com voucher lucky draw? If yes, fill in your email address below. If you are selected, the digital voucher will be sent to your email.
Note: this information will be stored separately and will be deleted after the lucky draw

Thank You!

Your response has been recorded.
If you have any interest in knowing the result of this research, you can contact me through satriowicak.1992@gmail.com.

Best,
Satrio Wicaksono

Appendix 6 Supply survey questionnaire

Bicycle Crowdshipping Supply Survey

(untitled)

This survey is part of my graduation research for MSc Transport, Infrastructure, and Logistics at TU Delft. The research is aimed to identify bicycle commuter's willingness to participate as an occasional courier in a bicycle crowdshipping service.

Bicycle crowdshipping is a platform that connects online shoppers to a crowd of bicycle commuters (people going to work/school by bike) that are willing to pick up and deliver packages in addition to their main journey. Cyclist commuters get some benefits in return for their effort in delivering the package: it could be monetary compensation, social/community cohesion (by helping the neighbors to get their package), preserving the environment (through CO2 emission saving), or improving physical activity.

This survey consists of **3 sections**; the first section contains preliminary questions to identify your travel behavior. The second section presents scenarios where you state your preference to perform a delivery for bicycle crowdshipping. The third section is where your personal characteristics will be asked. All the information you give will be kept confidential and will only be used for this research.

This survey will be most suitable if you live (or have ever lived) in The Netherlands. In average, the survey would take 7 minutes of your time. Please complete all pages and click 'submit' at the end. By participating in this survey, you will get the chance to win a 7 Euro bol.com (digital) voucher. There are 85 vouchers available for the lucky draw.

Thanks for your participation,
Satrio Wicaksono
MSc Student at TU Delft

---

1. Do you travel to work/school by bike in regular basis? *

- Yes, I do
- No, but I would like to do so in the future
- No, I prefer other transport modes to commute

2. How frequently do you travel to work/school by bike? *

- All weekdays
- 3 - 4 days a week
- 2- 3 days a week
- 1 day per week or less

3. Please indicate the transport mode you use for daily commuting. ('+' means combination) *

- Car
- Car + Public Transport
- Public Transport
- Walking

4. Select one of the options below that represents your bicycle commuting pattern: *

- I travel by bike to my school/office (direct trip)
- I travel by bike to a train/metro/tram/bus station (transit trip)

5. What is your average commuting travel time by bike? (This is the travel time for one-way trip, such as home to work) *

- <= 10 minutes
- 10.1 - 15 minutes
- 15.1 - 20 minutes
- 20.1 - 25 minutes
- 25.1 - 30 minutes
- > 30 minutes

6. When do you normally perform your commuting trip? *

- Always or mostly on peak hours (between 6-9 am and 5-7 pm)
- Always or mostly off peak hours
- Both equally

7. Do you have any experience working as a bike courier/messenger? (E.g., mail, newspaper, food, or package delivery) *

- Yes
- No

8. Select one of the options below that represents your knowledge/experience on crowdshipping.
E.g. of crowdshipping: Pickthisup.nl, Uber Eats, Deliveroo.nl, Bun.run, Saddl.nl *

- I have already used crowdshipping
- I have already heard about crowdshipping, but I have never used it
- I have already heard about crowdshipping, but I didn't know it was called like this
- I have never heard about crowdshipping

9. If you were asked to be a courier for a bicycle crowdshipping platform, how important would you consider the crowdshipping job attributes below?
From low to high: 1: Not Important, 5: Very Important. The more important the attribute is, the more significantly it affects your willingness to work as a courier.

Additional distance (detour) to be traveled for performing crowdshipping job

	1	2	3	4	5	
Not Important	○	○	○	○	○	**Very Important**

Weight of the package to be delivered

	1	2	3	4	5	
Not Important	○	○	○	○	○	**Very Important**

Amount of monetary compensation for performing crowdshipping job

	1	2	3	4	5	
Not Important	○	○	○	○	○	**Very Important**

Amount of CO2 emissions saved by performing crowdshipping job

	1	2	3	4	5	
Not Important	○	○	○	○	○	**Very Important**

Imagine that you are about to make a commuting trip by bicycle on a **weekday morning**. This commute trip includes travel to work/school. It may also include trips to attend a meeting or trips you make for the work itself (if the work involves traveling like a door-to-door salesman).

Suppose you have opted to join a crowdshipping platform as an occasional courier. Before the departure of your trip, a notification appears in your crowdshipping app indicating available delivery jobs to be made. The job requires you to pick up a package in one of the parcel pickup points in your city (e.g., UPS/DHL/PostNL service point, supermarkets, drugstores), and deliver it to customers' homes. You are asked to decide whether to take any of the available jobs.

Below are job attributes to be considered before you make the decision:

1. **Additional Travel Time**, resulting from additional distance traveled.
2. **Package Weight**
3. **Profit**
4. **CO2 emission savings.** As your reference, 1 km of delivery van trip emits 0.2 kg CO2.

Additional travel time adds to the original travel time. Assume that your original commuting travel time is 15 minutes.

10. From the delivery jobs presented below, select the one that best represents your preference.

	Delivery Options	
Job Attributes	Option 1	Option 2
Additional Travel Time	20 minutes	6 minutes
Package Weight	3 kilograms	5 kilograms
Profit	6 euro	6 euro
CO2 emissions saved	1.3 kilograms	1.7 kilograms

Which job option would you choose? *

- Option 1
- Option 2
- I prefer none of the jobs

In case that you have to choose between the available jobs, which one do you prefer the most? *

- Option 1
- Option 2

11. From the delivery jobs presented below, select the one that best represents your preference.

Delivery Options

Job Attributes	Option 1	Option 2
Additional Travel Time	6 minutes	20 minutes
Package Weight	1 kilograms	5 kilograms
Profit	2 euro	8 euro
CO2 emissions saved	2.1 kilograms	0.9 kilograms

Which job option would you choose? *

- Option 1
- Option 2
- I prefer none of the jobs

In case that you have to choose between the available jobs, which one do you prefer the most? *

- Option 1
- Option 2

12. From the delivery jobs presented below, select the one that best represents your preference.

Delivery Options

Job Attributes	Option 1	Option 2
Additional Travel Time	6 minutes	20 minutes
Package Weight	5 kilograms	3 kilograms
Profit	6 euro	4 euro
CO2 emissions saved	1.3 kilograms	1.7 kilograms

Which job option would you choose? *

- Option 1
- Option 2
- I prefer none of the jobs

In case that you have to choose between the available jobs, which one do you prefer the most? *

- Option 1
- Option 2

13. From the delivery jobs presented below, select the one that best represents your preference.

Delivery Options

Job Attributes	Option 1	Option 2
Additional Travel Time	20 minutes	6 minutes
Package Weight	7 kilograms	1 kilograms
Profit	8 euro	2 euro
CO2 emissions saved	2.1 kilograms	0.9 kilograms

Which job option would you choose? *

- Option 1
- Option 2
- I prefer none of the jobs

In case that you have to choose between the available jobs, which one do you prefer the most? *

- Option 1
- Option 2

14. From the delivery jobs presented below, select the one that best represents your preference.

Delivery Options

Job Attributes	Option 1	Option 2
Additional Travel Time	14 minutes	14 minutes
Package Weight	1 kilograms	7 kilograms
Profit	4 euro	8 euro
CO2 emissions saved	0.9 kilograms	2.1 kilograms

Which job option would you choose? *

- Option 1
- Option 2
- I prefer none of the jobs

In case that you have to choose between the available jobs, which one do you prefer the most? *

- Option 1
- Option 2

15. From the delivery jobs presented below, select the one that best represents your preference.

Delivery Options

Job Attributes	Option 1	Option 2
Additional Travel Time	10 minutes	14 minutes
Package Weight	5 kilograms	3 kilograms
Profit	2 euro	2 euro
CO2 emissions saved	1.7 kilograms	1.3 kilograms

Which job option would you choose? *

- Option 1
- Option 2
- I prefer none of the jobs

In case that you have to choose between the available jobs, which one do you prefer the most? *

- Option 1
- Option 2

16. From the delivery jobs presented below, select the one that best represents your preference.

Delivery Options

Job Attributes	Option 1	Option 2
Additional Travel Time	10 minutes	14 minutes
Package Weight	7 kilograms	1 kilograms
Profit	8 euro	2 euro
CO2 emissions saved	0.9 kilograms	2.1 kilograms

Which job option would you choose? *

- Option 1
- Option 2
- I prefer none of the jobs

In case that you have to choose between the available jobs, which one do you prefer the most? *

- Option 1
- Option 2

17. From the delivery jobs presented below, select the one that best represents your preference.

Job Attributes	Delivery Options Option 1	Option 2
Additional Travel Time	14 minutes	10 minutes
Package Weight	3 kilograms	7 kilograms
Profit	4 euro	8 euro
CO2 emissions saved	1.7 kilograms	1.3 kilograms

Which job option would you choose? *

- Option 1
- Option 2
- I prefer none of the jobs

In case that you have to choose between the available jobs, which one do you prefer the most? *

- Option 1
- Option 2

Personal Characteristics

26. What is your gender? *

- Male
- Female

27. What is your age? *

- <18
- 18 - 24
- 25 - 34
- 35 - 44
- 45 - 54
- 55 - 64
- > 64

28. What is your average monthly gross income (in Euro)? *

- <500
- 501 - 1000
- 1001 - 1500
- 1501 - 2000
- 2001 - 2500
- 2501 - 3000
- > 3000
- I prefer not to answer

29. What is your occupation? Multiple choice is possible *

- Student at a school/university (PhD is not considered as student)
- Part-time employee
- Full-time employee
- Entrepreneur/Self-employed
- Unemployed, looking for a job
- Unemployed, not looking for a job
- Retired

30. What is your type of household? *

- Living alone (this includes living in a shared house/student house)
- Two person household without children
- Family with one or more children
- Other

31. What is your highest completed education? *

- Primary School
- VMBO/MAVO
- HAVO
- VWO
- MBO
- Bachelor
- Master
- PhD
- Other (write down)

32. Would you like to participate in the bol.com voucher lucky draw? If yes, fill in your email address below (preferably not university email). If you are selected, the digital voucher will be sent to your email.
Note: this information will be stored separately and will be deleted after the lucky draw

Your response has been recorded!

Thank you for taking the survey.
If you have any interest in knowing the result of this research, you can contact me through satriowicak.1992@gmail.com.

Best,
Satrio Wicaksono

Appendix 7 Dutch ecommerce transactions for products (service excluded)

Category	#tra	EUR/tra	% Transaction
Sports and Recreation	3,581,267	73.19	1.8%
Consumer Electronics	3,856,749	115.02	1.9%
Toys	4,683,196	60.28	2.3%
Household Electronics	7,438,017	94.88	3.7%
Telecom	7,713,499	198.66	3.9%
Home and Garden	10,743,802	84.45	5.4%
Health and Beauty	13,774,105	13.17	6.9%
Shoes and Lifestyle	14,325,069	64.75	7.2%
Information Technology	15,702,479	93.74	7.9%
Food/nearfood	26,721,763	34.71	13.4%
Clothing	33,333,333	55.04	16.7%
Media and Entertainment	58,126,722	13.53	29.1%

*Number of transaction is 200 million (Climate-KIC, 2018)
**Value of transaction is EUR 20,163 billion (Z. Wang et al., 2017)

Appendix 8 BIOGEME Input code (demand survey)

```
[ModelDescription]
This model intends to estimate online shopper preference on bicycle
crowdshipping

[Choice]
Choice

[Beta]
BETA_Cost          -0.131     -10000        10000       0
BETA_SpeedCS       -0.108     -10000        10000       0
BETA_DelivTW       0.395      -10000        10000       0
BETA_Rating        0.495      -10000        10000       0
BETA_CO2           1.22       -10000        10000       0
BETA_SpeedTrad     -0.108     -10000        10000       0
BETA_CS            0          -10000        10000       1
BETA_Trad          0.917      -10000        10000       0
BETA_OptOut        0.451      -10000        10000       0

[Utilities]
1   CS1     av1     $NONE
2   CS2     av2     $NONE
3   Trad    av3     $NONE
4   OptOut av4      $NONE

[GeneralizedUtilities]
1 C_CS1   * BETA_Cost + S_CS1   * BETA_SpeedCS   + DTW_CS1   *
BETA_DelivTW + R_CS1 * BETA_Rating + CO2_CS1 * BETA_CO2
2 C_CS2   * BETA_Cost + S_CS2   * BETA_SpeedCS   + DTW_CS2   *
BETA_DelivTW + R_CS2 * BETA_Rating + CO2_CS2 * BETA_CO2 + One * BETA_CS
3 C_Trad * BETA_Cost + S_Trad * BETA_SpeedTrad + DTW_Trad *
BETA_DelivTW + One * BETA_Trad
4 One * BETA_OptOut

[Expressions]
One = 1
av1 = 1
av2 = 1
av3 = 1
av4 = 1

[Model]
// Currently, only $MNL (multinomial logit), $NL (nested logit), $CNL
// (cross-nested logit) and $NGEV (Network GEV model) are valid
keywords
//
$MNL
```

Appendix 9 BIOGEME input code (supply survey)

```
[ModelDescription]
Supply Model

[Choice]
Choice

[Beta]
BETA_TOD    -0.114     -10000         10000        0
BETA_TT           -0.114     -10000         10000       0
BETA_Weight -0.78      -10000         10000        0
BETA_Profit 0.885      -10000         10000        0
BETA_CO2    0.92       -10000         10000        0
BETA_CS2    0.103      -10000         10000        0
BETA_OptOut -0.197         -10000         10000       0
//BETA_Exp  0.100      -10000         10000        0


[Utilities]
1   CS1    av1     $NONE
2   CS2    av2     $NONE
3   OptOut av3     $NONE

[GeneralizedUtilities]
1 TT_CS1 * TOD  * BETA_TOD  + TT_CS1  * BETA_TT   + WE_CS1  *
BETA_Weight + Pro_CS1 * BETA_Profit + CO2_CS1 * BETA_CO2
2 TT_CS2 * TOD  * BETA_TOD  + TT_CS2  * BETA_TT   + WE_CS2  *
BETA_Weight + Pro_CS2 * BETA_Profit + CO2_CS2 * BETA_CO2 + One *
BETA_CS2
3 One  * BETA_OptOut

[Expressions]
One = 1
av1 = 1
av2 = 1
av3 = 1

[Model]
// Currently, only $MNL (multinomial logit), $NL (nested logit), $CNL
// (cross-nested logit) and $NGEV (Network GEV model) are valid
keywords
//
$MNL
```

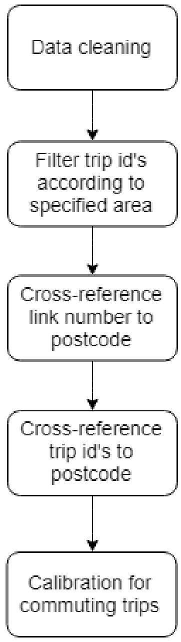
Appendix 10 Demand attributes' initial parameter estimates

```
                         Model: Multinomial Logit
Number of estimated parameters: 9
        Number of observations: 2560
         Number of individuals: 2560
           Null log-likelihood: -3548.914
            Cte log-likelihood: -3317.520
           Init log-likelihood: -3164.577
          Final log-likelihood: -2367.150
         Likelihood ratio test: 2363.527
                    Rho-square: 0.333
           Adjusted rho-square: 0.330
           Final gradient norm: +1.591e-002
                    Diagnostic: Convergence reached...
                    Iterations: 11
                      Run time: 00:02
           Variance-covariance: from finite difference hessian
                   Sample file: DataInput rev1.dat

Utility parameters
******************
Name           Value   Std err t-test p-val    Rob. std err Rob. t-test Rob. p-val
----           -----   ------- ------ -----    ------------ ----------- ----------
BETA_CO2       0.504   0.0955  5.28   0.00     0.0950       5.30        0.00
BETA_CS        -0.0481 0.0614  -0.78  0.43   * 0.0606       -0.79       0.43
BETA_Cost      -0.506  0.0166  -30.48 0.00     0.0169       -29.90      0.00
BETA_DelivTW   1.15    0.0664  17.38  0.00     0.0660       17.50       0.00
BETA_OptOut    -2.59   0.205   -12.67 0.00     0.204        -12.70      0.00
BETA_Rating    0.133   0.0703  1.89   0.06   * 0.0682       1.95        0.05
BETA_SpeedCS   -0.124  0.0138  -8.98  0.00     0.0140       -8.89       0.00
BETA_SpeedTrad -0.0347 0.0156  -2.22  0.03     0.0149       -2.32       0.02
BETA_Trad      -0.923  0.350   -2.64  0.01     0.337        -2.74       0.01
```

Appendix 11 Supply attributes' initial parameter estimates

```
                         Model: Multinomial Logit
Number of estimated parameters: 7
        Number of observations: 840
         Number of individuals: 840
           Null log-likelihood: -922.834
            Cte log-likelihood: -849.579
           Init log-likelihood: -1157.468
          Final log-likelihood: -793.752
         Likelihood ratio test: 258.165
                    Rho-square: 0.140
           Adjusted rho-square: 0.132
           Final gradient norm: +6.928e-003
                    Diagnostic: Convergence reached...
                    Iterations: 11
                      Run time: 00:01
           Variance-covariance: from finite difference hessian
                   Sample file: DataInput_Clean.dat

Utility parameters
******************
Name         Value   Std err t-test p-val    Rob. std err Rob. t-test Rob. p-val
----         -----   ------- ------ -----    ------------ ----------- ----------
BETA_CO2     -0.190  0.102   -1.86  0.06   * 0.0992       -1.91       0.06
BETA_CS2     0.0701  0.0804  0.87   0.38   * 0.0790       0.89        0.37
BETA_OptOut  -2.11   0.226   -9.32  0.00     0.215        -9.79       0.00
BETA_Profit  0.169   0.0474  3.57   0.00     0.0448       3.78        0.00
BETA_TOD     0.0102  0.00591 1.72   0.09   * 0.00586      1.73        0.08
BETA_TT      -0.0822 0.00924 -8.89  0.00     0.00861      -9.55       0.00
BETA_Weight  -0.180  0.0433  -4.15  0.00     0.0405       -4.43       0.00
```

Appendix 12 Derivation of cyclist OD matrix (Jafino, 2018)

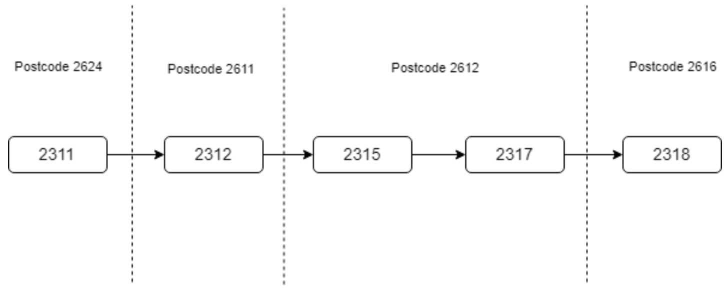


Four datasets were used to derive cyclist OD matrix, majority of them are GIS files. These include:

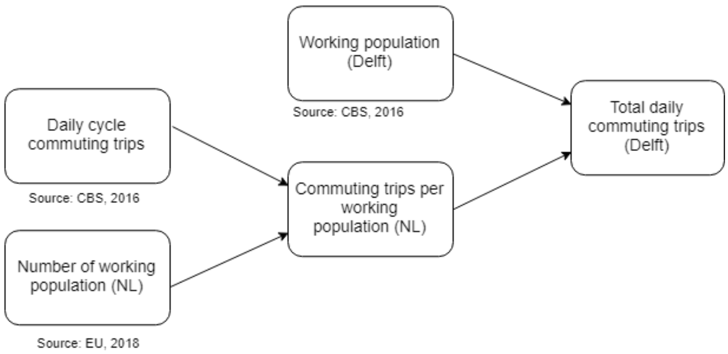
a) shapefile of municipalities in the Netherlands
b) shapefile of postcodes in the Netherlands
c) shapefile of Fietstelweek network consisting of cycle path link numbers
d) database of Fietstelweek trips consisting of trip id's and the corresponding link number. This data contains 16 million entries or 280K cycling trips. A trip id is comprised of sequence of links travelled by a cyclist within a trip

The last two datasets were sourced from Fietstelweek survey (Fietstelweek, 2016), an annual national bicycle travel survey conducted through a smartphone apps. Fietstelweek were aimed to gain insight on people's behaviour when using bicycles and to identify busy hours and links within the cycle network to improve the convenience of cycling in the Netherlands (fietstelweek.nl).

Referring to the flowchart above, the process is started with data cleaning. In this step data from (a) to (c) were cleaned by removing any information outside the scope (City of Delft). This also includes rectifying geographical data mismatch between sources (a) and (b) (such as area border). Afterwards, trip id's where the trip is started and ended in Delft is filtered. The logic behind the OD derivation is that we only need to take the first and the last link within the trip sequence to determine the trip origin and destination. As an instance, in figure below we have a cyclist traversing through 5 links within his trip (link number is inside the box). We are interested to know the postcode of the link at which the trip is started and the postcode of the link at which the trip is ended, both consequently be the origin and destination of the trip. To do so, the next step is to cross-reference link number to postcode, so that we know which link number belongs to which postcode, and lastly, to cross-reference the trip id to postcode. Completing these four steps allows us to infer the number of trips per OD-pair.



Now that we have the OD-matrix based on Fietstelweek data for the scope of Delft, the next step is to calibrate the number of trips such that it represents commuting trips of Delft population. To perform calibration, firstly we derive the total daily commuting trips in Delft according to the steps in the figure below. Next, we obtain the growth factor by calculating the ratio between total daily commuting trips (Delft) and Fietstelweek trips. By multiplying this growth factor to each OD-pair in Fietstelweek trips, we obtain the final OD-matrix of cyclist commuters in Delft. Note that Fietstelweek data does not differ trip purpose in its dataset, hence we assume that the trips in Fietstelweek data represents the magnitude of commuting trips between postcodes.



Appendix 13 Market share spreadsheet model

Demand Parameters

Attributes	Parameter Value
Cost	-0.506
Delivery Speed_Crowdshipping	-0.124
Delivery Time Window	1.16
Performance Rating	0.137
CO2 emission reduction	0.507
Delivery Speed_Traditional	-0.035
ASC Trad	-0.888
ASC OptOut	-4.87

Decision var

Crowdshipping	Traditional
8.62	4
8	
0	0
0	
1	
	30

Constants

μ	1.5
γ	0.09
θ	15%
α	1.5%

	2611	2612	2613	2614	2622	2623	2624	2625	2628
Potential Demand (parcels)	469	344	469	375	291	218	491	483	411
Cost	7.0	5.2	6.3	6.0	6.6	5.1	5.5	7.3	6.2
Utility Crowdshipping	-4.03	-3.13	-3.70	-3.51	-3.84	-3.07	-3.27	-4.17	-3.63
Utility Traditional	-3.96	-3.96	-3.96	-3.96	-3.96	-3.96	-3.96	-3.96	-3.96
Utility OptOut	-4.87	-4.87	-4.87	-4.87	-4.87	-4.87	-4.87	-4.87	-4.87
Share Crowdshipping	40.0%	62.0%	48.2%	52.8%	44.7%	63.6%	58.8%	36.7%	49.9%
Share Traditional	42.7%	27.1%	36.9%	33.6%	39.4%	26.0%	29.3%	45.1%	35.7%
Share OptOut	17.2%	10.9%	14.9%	13.6%	15.9%	10.5%	11.8%	18.2%	14.4%

Supply Parameters

Attributes	Parameter Value
Additional Travel Time	-0.0852
Profit	0.215
Package Weight	-0.217
ASC OptOut	-1.88

Decision var

Crowdshipping	No
7.33	
3	

C55:O67 S55:AE67

	2611	2612	2613	2614	2622	2623	2624	2625	2628
Profit	6.0	4.4	5.4	5.1	5.6	4.3	4.7	6.2	5.3
Share Delivery	0	62.5%	66.2%	58.2%	38.1%	40.6%	56.5%	52.0%	60.2%
Share OptOut	100.0%	37.5%	33.8%	41.8%	61.9%	59.4%	43.5%	48.0%	39.8%
Estimation									
Delivery capacity available	-	320	339	297	195	207	289	266	308
Total cycle trips	22,722	22,722	22,722	22,722	22,722	22,722	22,722	22,722	22,722
CS Demand (parcels)	188	213	226	198	130	138	289	177	205
SLACK (parcel)	188	-107	-113	-99	-65	-69	-0	-89	-103
MS	40.0%	62.0%	48.2%	52.8%	44.7%	63.6%	58.8%	36.7%	49.9%

Notes:

- Figures in column “Decision var” and “Constants” can be adjusted according to scenario wished to be tested
- The spreadsheet uses Goal-seek function to determine the equilibrium state. The principle is to continually change the value in cell “cost” (here shaded in yellow) such that the “SLACK” cell, representing the difference between supply and demand, approaches zero
- Note that the SLACK would never reach exactly zero (only approximating zero) because the profit, which serves as input to calculate supply share, is always a fraction of price (cost)
- The resulting market share can be referred to cell “share crowdshippping”
- The excel file can be downloaded via the link below:

  https://www.dropbox.com/s/gyk9vlik1b8jdsz/od_delft_all_OD_rev1.xlsm?dl=0

Appendix 14 Market share calibration (Train, 2009)

$$\alpha_j^1 = \alpha_j^0 + \ln(S_j/\hat{S}_j^0)$$

Equation above depicts the methodology to calibrate the ASC value. An iterative process is used for this purpose. Let α_j^0 be the estimated alternative-specific constant for alternative j. The superscript 0 is used to indicate that these are the starting values in the iterative process. S_j denote the share of decision makers in the forecast area that choose alternative j in the reference year (usually, the latest year for which such data are available.) Using the discrete choice model with its original values of $\alpha_j^0 \forall j$, predict the share of decision makers in the forecast area who will choose the alternative. Label these predictions $\hat{S}_j^0 \forall j$. Compare the predicted shares with the actual shares. If the actual share for an alternative exceeds the predicted share, raise the constant for that alternative. Lower the constant if the actual share is below the predicted. With the new constant α_j^1, predict the share again, then adjust the constant. The process is repeatedly performed until the actual share equals to the predicted.

Appendix 15 List of benchmarked companies

						Traditional			Delivery Conditions			Quality Assurance					Other features
Name	Spatial Scale	Category	Delivery Modes	Value Propositions	Shipment Type	Cost	Speed	Size/weight	Track & Trace	Pickup Time	Delivery Time	Rating	Experience	Expertise	Vetting	Insurance	
Zipments	Local	Crowdshipping	Bicycle, Car	- Door-to-door delivery (C2C) - Store-to-door delivery (B2C); omnichannel, ecommerce - Corporate services for local delivery - Marketplace delivery (bidding mechanism)	All packages	Fixed base rate, with incremental charge ($9 for same day)	- 60 minutes - 3 hours - sameday delivery	Modes adapt to shipment size	Available	Adjustable (9am - 9pm)	Customer's choice	star-rating based on; speed, package care, overall	# of delivery	Occassional	Yes	Yes, up to USD 250	- Mode preference**
Deliv	Local, Last-mile	Crowdshipping	Bicycle, Car	- Door-to-door delivery (C2C) - Store-to-door delivery (B2C); omnichannel, ecommerce - Corporate services for local delivery - Marketplace delivery (bidding mechanism)	All packages	Fixed base rate, with incremental charge	- 3 hours - sameday delivery	Package up to 50 lbs	Available	Adjustable (9am - 9pm)	Customer's choice	star-rating based on; speed, package care, overall	# of delivery	95% dedicated 5% occassional	Yes	Yes, up to USD 100,000	-
Trunkrs.nl	Last-mile	Crowdshipping	Car, Van	Store to door delivery (B2C). Main haul delivery is handled by professional couriers	All packages	Not fixed. Depends on shipment volume	- Same day - next day - scheduled	No information	No information	Driver choose	Customer's choice (depends on service type)	No information	No information	Dedicated and occassional	Yes	No information	- Delivery to people (future)***
Amazon Flex	Local, Last-mile	Crowdshipping	Bicycle, Car, Van	Store to door delivery (B2C). Main haul delivery is handled by professional couriers	All packages	Varies by item size and weight. Integrated with Amazon webshop	- one hour delivery - 2 hour delivery - same day - next day	Modes adapt to shipment size (up to 50 lbs)	Available	Driver choose	Customer's choice	Ontime delivery and reliability rating	Not applicable*	Occassional	Yes	No information	-
Saddl.nl	Local	Crowdshipping	Bicycle, cargo bike	C2C delivery (personal shopper)	All packages	Fixed base rate (EUR 5), with incremental charge	- 1 hour delivery	No information	Available	Driver choose	Customer's choice	No information	No information	Occassional	No information	Yes	-
Postmates	Local	Crowdshipping	Any means of travel	B2C delivery (personal shopper)	All packages	Fixed base rate ($6), with incremental charge/service fee	- 30 minutes - 60 minutes	No information	Available	Driver choose	Customer's choice	Yes	No information	Occassional	Yes	Yes	-
Fietskoeriers.nl	Last-mile and local	Bike/eco-courier	Bike, cargo bike	Store-to-door delivery (B2C); omnichannel, ecommerce	All packages	Not fixed. Depends on shipment volume 20-27 EUR - 60 min 17-25 EUR 4 hr 12-20 EUR same day	- Same day - 1 to 2 hours delivery	No information	Available	Driver choose	Customer's choice	No information	No information	Dedicated	Yes	Yes	- Emergency delivery
Piggybaggy	Local	Crowdshipping	Car, bicycle, PT	C2C delivery (courier service) B2C (webshop, retailer)	All packages	Negotiable	Not guaranteed	Max 2 tons	Available	Customer's choice	Customer's choice	No information	No information	Occassional	No information	Yes	-
PonyZero	Local, Last-mile	Eco-courier	Car, bicycle, e-scooter	C2C delivery (courier service) B2C (webshop, retailer)	All packages	Not fixed. Depends on shipment volume and delivery type	- Same day - next day - 1 hour (food)	100cm per side, 50 kg in weight	Available	Customer's choice	Customer's choice	No information	No information	Dedicated	Yes	Yes	- CO2 saving calculation
Doordash	Local	Crowdshipping	car, motorcycles, scooters, bikes, walk	B2C (webshop, retailer)	Food	Not fixed. Depends on shipment volume and delivery type	1 hour	No information	Available	Driver choose	Customer's choice	Yes	No information	Occassional	Yes	Yes	-
Favor	Local	Crowdshipping	Bicycle, car	B2C (webshop, retailer)	All packages	Fixed % of value of items delivered, min. tip	1 hour	No information	Available	Driver choose	Customer's choice	Yes	Yes	Occassional/dedicated	Yes	Yes	-
Deliveroo	Local	Crowdshipping	Bicycle	B2C (webshop, retailer)	Food	Fixed	1 hour	No information	Available	Driver choose	Customer's choice	Yes	No information	Occassional	Yes	Yes	-