Investigation of travel behaviour on a multimodal Mobility-as-a-Service hub within a closed-user area

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Preface

This master thesis has been conducted on behalf of Hely and was the final part of the Master of Science in Complex Systems Engineering and Management at the Delft University of Technology. The thesis consists of this report and a scientific article, of which the latter can be found in Appendix A. Both delve into the first 120-day operational period of the multimodal Mobility-as-a-Service hubs created by Hely. The aim of the research was to assess people's mobility behaviour by the usage of Hely Hubs in a closed user area. These Hubs provided multiple mobility vehicles that were accessible through an application. Before delving into the research, I would like to take a moment to thank those that helped me during this process.

I would like to start by thanking my committee members Prof.dr.ir Caspar Chorus, Dr.ir. Sander van Cranenburgh and Dr.ir. Mark de Reuver for their guidance of this research. Thank you for your time, input and lessons throughout this process.

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Last, I would like to thank my family and close friends. Not only for this particular research period, but for the all the support during my time at the University of Delft. Without you I would not have been capable of achieving this result, as I am only the sum-total of everyone I have ever met.

Kjell Ian Knippenberg,
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Executive summary

Hely has developed Mobility-as-a-Service (MaaS) through so-called Hely Hubs. These Hubs include a group of different modalities, being (e-)bikes, cargo bikes and (e-)cars, which are offered in designated residential areas and are made accessible through the Hely application. This study aims to assess people's mobility behaviour by the usage of Hely in a closed user group, as at this point there is no insight in the Hely community and travel behaviour that is engaged in on the Hely Hub.

The results were derived from the first 120-day operational period from December 2018 to March 2019, using two Hubs in Amsterdam and Delft. The users and usage of the Hubs were both investigated independently and pooled together, to optimize the dataset and maximize reliability of the results. The data was measured through three methods:

1. A user survey, which established the characteristics of the users, their prior travel behaviour, intention and motives to use the service, and prior attitude towards the modalities;
2. Investigation of Hely's database, which enabled to describe the number of trips, modal split, multimodality and accessibility of the Hub and the trip characteristics, such as weather condition, rental time and duration.
3. A non-user survey that defined the motivations for users to not use the service.

The survey gained 80 responses on persons that are subscribed for either the Delft or Amsterdam Hub. There were 112 user-accounts in de Hely-application, of which 45 were considered active. Active accounts are defined by users that made one or more trip using a Hely vehicle. 45 clients engaged in a total of 189 trips; Hub Delft and Hub Amsterdam account for 113 and 105 trips respectively. 16 non-users responded on the non-user survey.

The Hely community is characterized mainly by progressive metropolites, who are innovative bike- and public transport-using young professionals that seek a flexible and convenient service. The Hely community accesses the Hub either by foot or by bike, engaging in 3-hours trips on average. The main reason for not using the Hub was because of the costs.

The Hubs reveal travel behaviour with the shared (e-)car in its centre; covering 79% of the total trips that were engaged in. The small car has the highest use intensity. The remaining modalities are much less used, even less than initially intended. Subsequently, the motivation to use Hubs for its multimodality is currently not widely supported by the community. Moreover, mode choice is independent from weather conditions and type of day. Therefore, it can be concluded that currently a Hely Hub mainly eases accessibility of cars for individuals that do not use one.

Overall, the social impact of a MaaS-hub is beneficial to its environment, as the use of Hely always steers towards sharing products instead of owning one, which on the long-term increases resource efficiency as a whole. Moreover, multiple vehicle types are available to all social groups within a designated area. This enables clients to tailor its mobility to specific needs and providing a low threshold to try-out new modalities. Currently however, the results emphasize the dominant mindset of travelling by car, while other MaaS pilots proved to reduce private car ownership significantly. For this particular research possibly the geographical Hub location, specific modal split known for the Netherlands, and the absence of public transportation ensure that the cars are a dominant factor on a multimodal MaaS-hub.

It is proposed that the social and sustainable impacts on the neighbourhood are investigated more accurately in the future, by means of an after-survey. This will measure changing behaviour by the intervention of a Hely Hub, and should focus on the following four characteristics:

1. Total number of trips that are made by adding Hely to one's travel options.
2. Defining what non-Hely transportation mode is substituted per specific Hely-vehicle.
3. Confirm the modal split of the Hub for multiple seasonal weather conditions.
4. Measure and compare the attitude towards different modalities after a certain period upon the prior attitude, but also attitude towards electric vehicles, shared mobility and private car ownership.

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1 Introduction

This research explores the travel behaviour that is engaged in on a multimodal MaaS-hub. In this section, the subject will be introduced, and the scientific relevance is addressed. This builds to the problem statement, from which a main research question is derived. To answer this main research question accordingly, a research approach and resulting sub-questions are indicated. Lastly, the relation to the Complex Systems Engineering and Management-master is provided, and the report structure elaborated.

City-populations are growing at a high rate, therefore there's a higher need to be efficient with city-space to enable peoples' mobility (Ministry of Transport, 2016; Rodrigue, Comtois, & Slack, 2013; Lee & Sener, 2016). By providing Mobility-as-a-Service, various forms of transport are integrated into a user-tailored service, and accessible by individuals on demand (MaaS Alliance, n.d.). MaaS intends to free people from needing to own vehicles, hence reducing the existent fleet and maximising the utilisation of the remaining fleet. It therefore relies on the trends of digitalization, the sharing economy and the declining view on the car as status symbol (Pakusch, Bossauer, Shakoor, & Stevens, 2016). Public decision makers and researchers are expecting that MaaS will establish a next paradigm shift in mobility. Ideally, it would one day even substitute the private ownership of cars as a whole (MaaS Alliance, n.d.). Various pilots supported the ability of MaaS to change travel behaviour away from the car (Karlsson, Sochor, Aapaoja, Eckhardt, & Konig, 2017). Private cars are deemed to be a resource inefficient and unsustainable mode of transportation, especially within cities. Additionally, Mulley (2017) emphasizes that the habitual behaviour of owning and using a private car is the largest obstacle to accomplish a critical mass for MaaS. The particular challenge to compete with private car ownership is a recurring theme in almost all literature on MaaS (Erich, 2018; Kennisinstituut voor Mobiliteitsbeleid, 2018).

Hely is a Dutch company that currently exploits Mobility-as-a-Service (MaaS) as their core concept. Hely is "a well-funded start-up that makes shared mobility easier, more accessible and more flexible. No hassle with different apps and shared mobility providers, Hely takes care of all your favourite modes of transportation in one simple app'' (Hely, n.d.). Hely enters the mobility market through so-called Hely Hubs. These Hubs provide a group of different modalities, being (e-)bikes, cargo bikes and (e-)cars, which are offered in designated residential areas and are made accessible through the Hely application. The enrolment of the first Hubs are established in Delft and Amsterdam in December 2018. In line with the literature, Hely strives to compete with private cars and provide cities with more efficient and sustainable mobility. By addressing this public problem Hely strengthens its business case towards possible partners such as municipalities and residential property owners, who can help introducing the Hubs within neighbourhoods more easily.

1.1 Scientific relevance & Problem statement

Karlsson et al. (2017) advise to provide more empirical evidence on behavioural change by MaaS. Specifically, it is shown that the sensitivity of traveller's behavioural change after introduction of MaaS is most probably unknown and to that extent, what behaviour will change particularly. Hely provides a specific case in which their multimodal MaaS-hubs are tested within the specific neighbourhoods for closed user groups. Moreover, Hely strives to be not only viable as a business, but also serve public values by particularly changing travel behaviour away from private car use. However, at this point there is no insight in the Hely community, its travel behaviour on the Hely Hub, let alone in what way travel behaviour changes using Hely's service. This study aims to assess people's mobility behaviour by the usage of Hely in a closed user group. These results are then a stepping stone towards an evaluation methodology that is able to (1) tailor the Hely-service better to their users and (2) validate the objective of reducing private car ownership by Hely more accurately.

The research will explore the system that Hely is currently designing in. An exploratory research helps define the problems more clearly that helps determine research designs better, rather than providing conclusive solutions so that desired outcomes and measures can be prioritized more accurately (Saunders, Lewis, & Thornhill, 2012). This study thus describes the travel behaviour on the Hubs of individuals on short term level, and provides an advise on how to better identify the impact of the Hub on its environment on the long-term.

1.2 Main research question

A first grasp on the problem, objective and subsequent aim of this research is established. The research is further shaped by a research question, which is defined as follows:

"What is the travel behaviour of a community that uses a closed-user multimodal MaaS-hub?".

To answer this question in a structured manner several sub-questions are designed. The way these questions are designed also depends on how the research is approached; the questions divide the research question into manageable pieces, that are answered per chapter. The sub-questions are based on two aspects, the indication of (1) the community and (2) the use on the MaaS-hubs by this community. The research uses the data from Hely's community and its subsequent Hely Hubs. The questions are the following:

1. What are currently known characteristics of MaaS, its users, and mobility behaviour in general?
2. What are the characteristics of the Hely Hubs and its subsequent service?
3. How can the survey be designed best to indicate the Hely community?
4. What variables in the database help establish the use of a Hely Hub?
5. What characterizes the Hely community?
6. How are the Hely Hubs and subsequent modalities used?

1.3 Relation to CoSEM

During the Complex Systems Engineering and Management (CoSEM) master at the TU Delft, the main objective is to learn to design in socio-technical systems. These designs can be interventions that are proposed within an institutional setting, which tackle complex interconnected issues and consist of strong technical and social components. Moreover, it adds value to both the public and private domain. Methods and tools that are used for these issues can vary from discrete simulation, to interviews and surveys. The intervention of Hely's new service in the mobility market, with the use of the MaaS concept, is a perfect example of designing in socio-technical systems. In this case, the technical component is the app and its connection to physical vehicles, that is placed in society by a private company to (1) reduce a social problem (urbanization) and (2) uses different social trends to be successful in the market. The problem that is addressed within this concept corresponds perfectly to the curriculum, as with travel behaviour of the user's group, a social component of a technical intervention within society will be explored. Courses that are specifically addressing these issues are for example Travel Behaviour Research and I and C Service Design.

1.4 Report structure

Chapter 2 will elaborate on the state-of-the-art on MaaS and the mobility landscape of the Netherlands in general. In Chapter 3 Hely's characteristics, Hubs and vision are elaborated upon. Chapter 4 involves the methodology, describing the data collection methods, design of the survey and exploration of the user-database. Chapter 6 defines the data preparation and subsequent univariate analysis. Then, Chapter 7 shows all findings. Chapter 8 concludes on the main research questions and provides recommendations. Chapter 9 discusses the conclusions and results in more context. All chapters begin with a short introduction that mention the parts to come within that section and result in a conclusion that includes answering one or more sub-questions. This report also consists a coherent scientific article, which can be found in Appendix A.

2 State-of-the-art

In this part, state-of-the-art literature is explored. First, background, MaaS and its characteristics are defined, followed by its increasing influence on the mobility market. Thereafter, an exploration of the current Dutch mobility choice behaviour, and its current developments is executed. This will conclude in answering the first sub question, as stated in the previous section.

2.1 Background

The past decades movement of people towards cities has accelerated quickly. Today, the urban population is growing by 60 million persons per years worldwide and is expected to continue growing (Das Gupta et al., 2014). This phenomenon challenges every city worldwide to protect equal access to goods, housing, and improving overall quality of life (Habitat U.N., 2016). In countries like the Netherlands, this urban flow results in cities becoming more and more densely populated, as space is limited (Planbureau voor de Leefomgeving, 2015). This also means that providing efficient transportation within these cities is becoming a major challenge, while efficient transportation is considered important for the economic productivity and general quality of life within a city (Ministry of Transport, 2016; Rodrigue et al., 2013; Lee & Sener, 2016)). Specific problems of urbanization include (air) pollution, unsafe infrastructure, congestion, and inefficient use of space (Rodrigue et al., 2013). The relationship of urbanisation and mobility is their occupation of the physical space. Within cities focus of innovating in transportation is therefore shifting from expanding the network to increasing the current accessibility (Rantasila, 2015). The main goal is to reduce private car ownership. To accomplish this, multiple cities around the world are already implementing legislation against car use within the city borders (Garfield, n.d.). Simultaneously, efficient transportation and accessibility of these cities should be protected. One of the innovations that proclaims to be a viable alternative of private car use, is the concept of Mobility-as-a-Service (MaaS). Sharing products is a development that is currently exploited on many different levels in society. With regard to vehicles, sharing means that a user is able to rent a vehicle for a short period of time, against a fee per hour/minute. Usually this entails trips from and to predefined locations. An alternative is the free-floating model, in which users can choose a location at will to start and end their trip. Sharing these modalities means that a third party owns the vehicles, which dismisses taking care and bearing responsibility for the users of the vehicles.

2.2 Mobility-as-a-Service

In the study of Jittrapirom et al., (2017) the different concepts and definitions that are used for Mobility-as-a-Service are explored. Mobility as a Service is defined as "a mobility distribution model that deliver users' transport need through a single interface of a service provider. It combines different transport modes to offer a tailored mobility package". MaaS has 9 core characteristics: integration of transport modes, tariff option, one platform, multiple actors, use of technologies, demand orientation, registration requirement, personalisation and customisation. With this in mind, two viewpoints on MaaS are discussed next, an operator- and user-focused viewpoint.

2.2.1 Operator-focused design of MaaS

MaaS can be designed in three different ways: market-driven, public-controlled or public-private. (Smith, Sochor, & Karlsson, 2018) opt that designing in a public-private context is preferred. This means that the market is free for innovation, but the public interest should be a leading factor in development. Rantasila (2015) argues that public involvement is important, as MaaS could interfere on operational planning of land-use, and even on macro policy making. Currently, management of land-use already shifts from construction and maintenance of infrastructure to managing effective functioning of travel. Jittrapirom, Marchau, van der Heijden, & Meurs (2018) propose that collaboration between stakeholders should be incentivised, as this adds significant value to a MaaS initiative. Kamargianni, Li, Matyas, & Schafer (2016) advise that suppliers of MaaS should take a specific interest on how to combine different operators and to provide one service, which aligns with Hely's long-term strategy to become a stage manager. This is also indicated as important aspect by Jittrapirom et al., (2017) and Giesecke, Surakka, & Hakonen (2016). An upcoming challenge to establish this involves the actual implementation of a multi-sided platform and consequently reaching critical mass of users (Jittrapirom et al., 2017).

2.2.2 User-focused design of MaaS

Two known and scripted pilots have tested MaaS, the UbiGo-pilot in Gothenburg and the Smile-pilot in Vienna. These pilots proved feasibility of MaaS, as none of the households stopped using the service and most wanted to continue the use after the period ended (UbiGo, n.d.; Smile, n.d.). UbiGo found to have the potential to reduce car use, and in particular ownership of secondary cars. The study reports a decrease in private car use by 44 percent. Positive attitudes towards car- and bike sharing grew during the trial period. A side benefit of the service was that users found that expenditures were easily to track, as all was in one app. The SMILE-app found that 48 per cent of the users changed their mobility behaviour due to the app and that the modal split shifted away from the private car (Karlsson et al., 2017). These pilots support the theory that MaaS introduces behavioural change and thus provides value towards a more sustainable mobility market (Sochor, Karlsson, & Strömberg, 2016). The literature indicated four specific values for travellers when using MaaS, being; costs, convenience, choice freedom and customization. Several attributes were indicated that contributed to this particular change, being for example simplicity of service, improved access and improved flexibility. (Sochor et al., 2016) argue that MaaS sets a low threshold for travellers to try new modalities. However, habit persistence is seen as an important factor against behavioural change, as people seem to reject the modes that they are not yet familiar with (Matyas & Kamargianni, 2018). Moreover, Ho, Hensher, Mulley, & Wong (2018) stress the importance to raise awareness and increase the user-experience with MaaS initiatives and create the possibility to tailor the attributes of MaaS to specific wishes of users. To accomplish tailored services, a clear segmentation of the market is deemed important. This research, along with Ratilainen (2017), the first to try and indicate a willingness to pay for subscription packages. Lastly, car-loving participants saw the price as important obstacle to shift to MaaS (Frei, Hyland, & Mahmassani, 2017).

2.2.3 MaaS characteristics

MaaS is characterized through its level of integration. This characterization exists of five different levels, including a null-integration. Examples of known MaaS-initiatives and their level of integration are provided in Appendix B.

0 – No integration (single and separate services)

1 – Integration of information
The added value of this integration is to support finding the best trip. It is characterized by users, rather than customers. Service providers contribute by supplying open and standardized data for free. The market knows both global players, to attract advertisers, as local operated planners. Data also helps to manage traffic and infrastructure. This is mainly where players collect their revenue.

2 – Integration of booking & payment
This level focuses on single trips and is an extension of a travel planner. It offers easier access to users, as they can find, book, pay with the same app. This service is mainly for established multi-modal travellers, and does not yet provide an overarching service that can compete with the private car. This integration does not take responsibility towards the actual transport service. Therefore, it is difficult to make a level 2 integration run as a separate business, as it provides not enough added value.

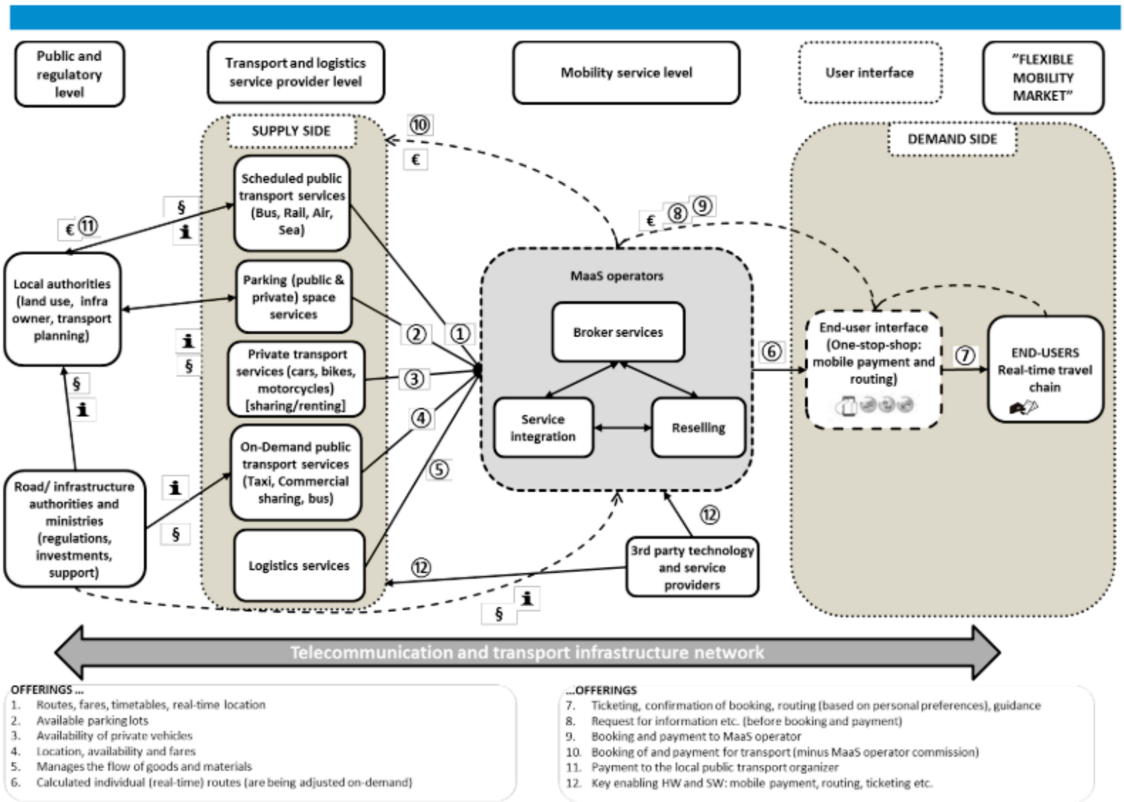
3 – Integration of the service offer
This level focusses on providing the complete customer's mobility needs. This is considered to be the viable alternative to car ownership. This MaaS service serves a household's full needs, not only single trips. The operator takes responsibility towards its customers and its suppliers to offer viable all-inclusive business and services. This level also requires an ICT-platform to run the business.

4 – Integration of societal goals
This level integrates societal goals. The main added value is to reduce car ownership and create more accessible and liveable cities. Incentives are implemented in the service. Public entities may influence the impact of the mobility service, by setting conditions for operators to create desired behaviour. This public involvement in commercial services can pose different challenges, mainly due to the fact that operators should offer a flexible

service and public entities are rather inflexible in their ways. This level is mainly on how changing a policy framework will affect MaaS and its users.

The MaaS ecosystem, with all its parties and relations, is depicted in Figure 1. Herein, the MaaS-operator is shown to be pivotal in connecting the supply and demand side of mobility, connecting all different supply transport to the end-user, using an all-inclusive service. Furthermore, the possible influence of public regulatory entities is shown.

Figure 1. MaaS ecosystem (copyright Karlsson et al, (2017),



2.2.4 Conditions and added value of MaaS

The Dutch Kennisinstituut voor Mobiliteitsbeleid (2018) indicates four main conditions for individuals to use MaaS, autonomy and flexibility, reliability, geographical accessibility, timely accessibility.

1 – Autonomy and flexibility
The UbiGo pilot reveals these two definitions to be important when using MaaS. Flexibility is defined as the possibility to adjust travel behaviour to personal circumstances, independent of time and location. Autonomy is defined as the independence of others' when taking a decision that involves mobility. People would like to always have access to vehicles, just in case. Furthermore, people prefer the car when engaging in trips that involve multiple stops. More specifically to use MaaS, people seem to fear the dependency on a system and the probable scheduling of their travel behaviour.

2 – Reliability
Sharing mobility leads to the challenge of assuring reliability of mobility, which is threefold. First, studies show that people are willing to pay extra for last-minute availability of modes. Second, the reliability of technology is deemed important, as your phone will become your mobility-lifeline. Lastly, reassurance of compensation or something alike should be in place, for when user-problems arise during a rental.

3 – Geographical accessibility
People think that this will be mainly of added value in cities, and less in rural environments. More specifically to the Netherlands, this means that MaaS will only have added value in de Randstad.

4 – Timely accessibility
Respondents are sceptical about the accessibility of modalities and think it would be difficult to provide a sufficient number of modalities to assure 100 per cent availability.

Mobility-as-a-Service has four distinct characteristics that can add value to one's mobility behaviour. These are known as the four C's.

1 – Costs
MaaS has the potential to be more cost efficient than owning a private car or public transport subscription. However, it is difficult to compare because private car costs are not transparent for its users. Also, sharing creates a suggestion that it should be cheaper than owning a car, which degrades the product value of MaaS.

2 – Convenience
Comfort and convenience are an added value of MaaS. During the UbiGo pilot, users got a feeling of all-inclusiveness. The fact that through MaaS all aspects of mobility, from planning to payment, is within one app was considered to be very convenient. This feeling was fuelled by the fact that problems were resolved fairly quickly through customer service.

3 – Choice freedom
The third additive is the inclusiveness of all modalities within one service. Furthermore, different options of type of cars were appreciated. Respondents argued that the possibility to combine these modalities could reduce the dependency on private cars. Also, this feature may support more use of public transport as the last-mile becomes more accessible through MaaS.

4 – Customization
The possibility to change mobility behaviour is higher when the service is tailored towards its users. MaaS can adjust subscription packages for different user groups. Users of the UbiGo service also proclaimed that these packages stimulated to evaluate their travel behaviour. Through the IT-aspect, MaaS has an exclusive possibility to monitor and thus tailor their service towards their customers. Three aspects are important to tailor a MaaS-service: (1) insight in mobility patterns; (2) social-economic status of users; (3) insight into attitudes and perceptions on mobility.

In addition, Sochor, Strömberg, & Karlsson, (2014) indicate that curiosity and environmental concerns are part of the motivations to try-out MaaS initiatives.

2.2.5 MaaS and private car ownership

In the Netherlands there are 7,2 million private cars, which means ,93 car on average per household. Within cities the ownership of cars is lowest, around ,5 per household, and in rural areas highest, around 1,4 car per household. Moreover, the density of cars is highest in cities, due to the consequent high density of inhabitants of these cities. The past years car ownership has increased with one percent (CROW, n.d.). As stated earlier, providing a viable alternative for private car use is an important driving force behind the development of MaaS initiatives. The UbiGo and SMILE pilots proved that MaaS has the ability to be such an alternative, as almost half and one-fifth of the population of these respective areas used their car less after the pilots. Moreover, studies differentiating the ownership and use of a private car also indicate that many would like to have access to a car, but not necessarily would want to own one. In particular, we see that the younger generation shows a changing attitude towards the car (Catapult, 2016). A nuance that experts introduce, is that most likely MaaS will first be a viable alternative towards owning a second car. Interviewees were quite sceptical when asked whether MaaS will substitute car ownership (Kennisinstituut voor Mobiliteitsbeleid, 2018). Furthermore, MaaS provides an opportunity to steer the public towards using electric vehicles more. Electric cars are considered still to be quite expensive and have several downsides with respect to conventional cars, such as a small range. However, for daily use and small distances electric cars could be a good substitute for gas-driven cars and are therefore interesting for a MaaS-initiative.

2.2.6 Maas and public transportation-use

All Dutch residents have easy access to public transport, using so-called ov-chipcards. These cards can be connected to bank accounts, check-in/check-out and show ride-history online. In 2017, there are 14 million chipcards circulating (Translink, 2017). Different studies (Kennisinstituut voor Mobiliteitsbeleid, 2018; Lehmuskoski, Hietanen, & Heikkilä, 2014; Ratilainen, 2017) argue that public transport is a central element when providing a shared mobility service. Moreover, public transport-users are seen as possible early adopters. For the Netherlands however, Hely queried the need to include public transport in their proposition and established that public transport is already well-reachable through the OV-chip card. This resulted that the inclusion of public transport in Hely is shunted for now.

2.2.7 Maas and private bike

Bikes are a central focus in the proposition of MaaS. However, the Netherlands is a well-known bikers' country. Almost a quarter of all trips are made by bike and a total of almost 15 trillion kms is covered per year. With 22,8 million bikes in the Netherlands what means every Dutch citizen owns 1,3 bike which is unique in the world. Hence, sharing regular bikes is probably not interesting for a Dutch client. However, sharing electric bikes can possibly be interesting, as e-bikes are quite expensive to buy but allows to reach a larger area and are easy to use. Also, sale of e-bike is firmly on the rise, increasing with 36% in 2017. Also, shared e-bikes are available, for example through Urbee. Dependent on for example the weather and baggage, it can be seen as substitute for nearby car tips.
Furthermore, there is a trend noticeable in which cars are replaced by cargo bikes, especially within cities. Traditionally, having carry-ons indicate that people use the car more often. (Frei et al., 2017). Riggs (2016) argues that the cargo biker can capture trips that would otherwise have been made by car. The cargo bike is mainly used within cities for trips with children but is also advised for grocery shopping and transporting relatively big objects (Cargoroo, n.d.). A known limitation of the cargo bike is the purchase cost, which is quite high. However, initiatives like Cargoroo (a partner of Hely) that offer a shared-cargo bike to particular neighbourhoods may remove this limitation. Thus, following Riggs' (2016) conclusion, urban sustainability potentially benefits from the advantages of the cargo bike. Apart from private use, (delivery)-businesses also begin to adopt cargo bikes as replacement of inner-city deliveries ("DHL vervangt busjes door bezorgfietsen", 2017; "Ook PostNL gaat op de bakfiets", 2017; "Supermarkt test bakfietsen voor bezorgen boodschappen", 2018).

2.2.8 MaaS and its users

The identification of the different users of the mobility market is considered to be quite difficult, because travel persists of strong habits and is influenced strongly by household variables (Hinkeldein, Schoenduwe, Graff, & Hoffmann, 2015). Following earlier work by Ratilainen (2017), the framework of Wockatz & Schartau (2015) is used to explore the current mobility market. Additionally, studies on the adopters of car sharing and MaaS-pilots are explored.

Traditionally, market segmentation is done through dividing socio-demographic characteristics of the user group. However, Wockatz & Schartau (2015) add different mobility lifestyles of the users to the research, such as travel frequency, main travel type, and motives. This leads to five different mobility groups, which are indicated in Table 1.

Table 1. Classic mobility groups

Group	Demographics	Frequency	Travel type	Mode	Income	Adopters	Motives
Progressive metropolites	Young professionals	Heavy	Work Leisure	PT[1] Car	High income	Early adopters	Sustainable Flexible Sharable Personalized
Urban riders	Students, Retirees, Unemployed	Infrequent	Work	PT Walking	Low income	Flexible in choice	Local Low costs
Default motorists	Suburban households	Frequent	Work Leisure	Car	Middle	No switchers	Flexibility Door-to-door convenience
Local drivers	Suburban elderlies	Infrequent	Work Leisure	Car	Non-working	No switchers	Convenient Comfortable
Dependent passengers	Kids, Elders, Impairments	Frequent	Leisure	Car Bus Walking	Low	No choice	Independence Accessible

In a European study on the adoption of car sharing by Erich (2018), several factors of high potential adoption are indicated. People who do not own a car, have public transport as main travel, and/or live in metropolitan areas are increasingly interested in car sharing services. Moreover, young adults with lower incomes are potential adopters of car sharing.

This shows that the adopters of car sharing are broadly in line with the groups shown above, having described the young metropolitan professionals as early adopters and the lower incomes as flexible choosers. Consequently, the number of children within a household has an influence on the interest towards MaaS-adoption, depending on the fleet offered. Lastly, Kennisinstituut voor Mobiliteitsbeleid (2018) argues that the digital skills of an individual and environmentalism also influences the potential interest in MaaS initiatives, as also defined by Attard & Shiftan (2015) seen in Table 2.

The segmentation of MaaS-users is addressed in different studies. Spatial, socio-demographic and household variables maintain to be the most important indicators to categorize users (Hinkeldein et al., 2015; Ratilainen, 2017). Sochor et al. (2016) categorized their groups based on car- or public transportation-preferences of users. They indicate car shedders, keepers, sharers and accessors. This distinction stresses that there are not only individuals that intending to abandon car ownership; there are also people that search access to cars. Contrarily to the above literature, Ho et al. (2018) argue in their recent study that a public transport-user would be less interested in the adoption of MaaS. These contrasts support the infancy of the studies on MaaS and its potential users and addresses the importance to consider all alternatives.

Table 2. User groups of integrated services (Copyright Attard & Shiftan, 2015)

Name	*Mode*	*Environmentalists*	*Innovators*	*Techs*	*Neighbourhood*	*Service*
Traditional car lovers	Car	No	No	Medium	Rural	No
Flexible car lovers	Car Mixed	Low	Low	Medium	Rural	No
Urban oriented PT-lovers	PT	No	No	No	Urban	No
Conventional bike lovers	Bike PT	High	Medium	No	Inner city	Yes
Ecological PT and bike lovers	Bike & PT	High	Low	No	Inner city	Yes
Innovative technology multioptionals	Mixed	High	High	High	City	Yes

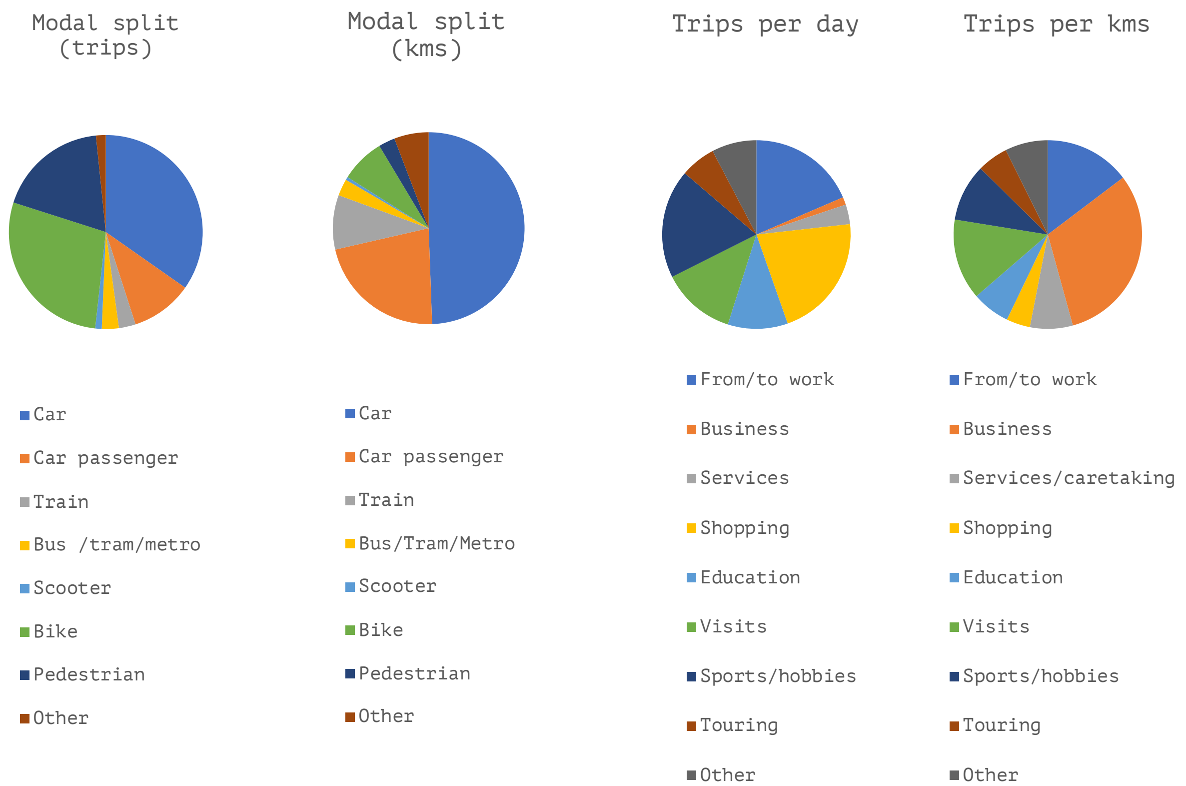
[1] PT = public transportation

2.3 Travel behaviour in the Netherlands

Every year The Dutch Centraal Bureau voor Statistiek (CBS) collects data on mobility behaviour of Dutch residents. This research queries individuals on their travel behaviour. The respondents group cover 0,2% of the Dutch population. Their travel behaviour of one particular day is questioned. The most up-to-date numbers stem from 2017 and are described next (Centraal Bureau voor de Statistiek, 2018a).

The total amount of distance travelled in the Netherlands in 2017 was 194 billion kms. Over the years the amount of kms in total and per modality and per trip motif are relatively steady. However, the number of trips has decreased to 832 on 1000 persons per day, which fits the trend of the last few years. More specifically, the number of people that travels by train increased.
In the Netherlands on average a trip is 11 kms long. The modal split is depicted in figure 2. Car-use covers the majority of the trips and travelled kms. Also, the Dutch travel a lot of kms by train and bike. In terms of motives, CBS indicates 9 categories. Business trips are a small portion of the pie that cover a lot of kms. Furthermore, work, shopping and hobbies are daily made transports, followed by education and visits. Work, business and visits tend to have the longest distance.

Figure 2. Travel behaviour Dutch population



2.3.1 Mobility characteristics

CBS uses different characteristics to indicate mobility behaviour of the respondents, such as trips, trip duration, trip distance, trip origin and destination, motif, modality, and travel party. Furthermore, the study specifically describes that weather has an effect on travel behaviour, something which is also acknowledged in the study of (Frei et al., 2017). Dutch weather can be fairly rainy and by times snowy, having a temperate maritime climate. The research firstly concludes that the influence on the number of kms is limited, as it is only noticeable by the number of recreational trips that are made. Furthermore, weather does have an influence on mode choice behaviour. This basically entails that bad weather means bicycles are used less.
Lanken, Aarts & van Knippenberg (1994) emphasize the importance of repetitive behaviour by individuals when determining travel behaviour. As individuals have experience with all sorts of journeys and all kinds of modes in all circumstances, familiar trips can be chosen in a more or less habitual manner. This theory explains *mode choice*

as more a matter of habit rather than conscious action. However, it is found that even in routine social behaviour is always regulated at some level of cognitive effort. On a higher scope, Ajzen, Schmidt & Bamberg (2003) conclude that when offered a new or changed *service,* past behaviour is not that indicative for future behaviour. More specifically they discovered that a changing situational context makes individuals very receptive to new information and other behavioural decisions. Therefore, public that moves to a new place, job or other situational context are likely to consider and try new services or products, provided that these are of well-enough quality.

2.3.2 MaaS in the Netherlands

In the Netherlands, there are currently around 41.000 shared cars that are used by 40.000 people. There's a firm rise of shared cars noticeable, especially within cities. Furthermore, the fleet of shared cars seem to be more environmentally friendly than private cars, with 6,5 % of the fleet being electric (CROW, 2018). Also, the shared bike business has exploded in for example in Amsterdam, even leading to a ban on dockless (free-floating) shared bike services (BikeBiz, 2019). A second development is the demand dependent mobility services. These are new services that drive on both collective as individual demand. These rides are from door-to-door or stop-to-stop. Usually an application structures the supply/demand dynamics in this market. Well-known examples are ViaVan, Uber and Lyft (Kennisinstituut voor Mobiliteitsbeleid, 2018).

2.4 Conclusion

This section described the current Dutch mobility market and the corresponding travel behaviour. Moreover, it explored MaaS, its characteristics, and possible users and impact. The sub-question: '*What are currently known characteristics of MaaS, its users, and mobility behaviour in general?'* will be answered by summing the characteristics in Table 3, and a description of the Dutch mobility landscape below.

Table 3. Characteristics of travel behaviour and MaaS

Current travel behaviour	*Mobility-as-a-Service*
Travel behaviour in the Netherlands o Number of kms are steady over the years o Number of trips have decreased o Mainly car users, that also account for the most kms covered. o Bike has many trips. o Significant increase of train use o 9 motifs to travel, from which work, shopping, sports & hobbies are the most engaged in o Business and commuter trip make the most kms	Paradigm shift towards MaaS due to the following trends: o Association of mobility and negative experiences o Increased use of smartphones o Trends to share services MaaS is consists of three central elements o To offer a service in which the customer needs are the main focus; o To offer mobility rather than transport; o To offer integration of services; It is therefore classified by the level of integration, that consists of five levels. The MaaS-operator plays a central role in connecting supply and demand within the system, using an all-inclusive service. Integration of full mobility service through an application.
- Characteristics to describe travel behaviour: o Trips o Trip duration o Distance covered o Origin and destination o Motif o Modality o Travel party o Weather o Business/recreational	Conditions to properly consider a MaaS initiative are the following: o Autonomy and flexibility o Reliability o Geographical accessibility o Timely accessibility Characteristics of MaaS that add value for customers o Costs ▪ Transparency ▪ Cost-efficient o Convenience ▪ Customer service ▪ All-inclusiveness o Choice Freedom ▪ Different modalities ▪ Different sizes, types per modality

	o Customization ▪ Per user group ▪ Per attitudes/belief ▪ Per mobility behaviour o Changing behaviour ▪ Curiosity ▪ Environmental concerns
	MaaS and private vehicles - Car o On average, almost all households own a car o Car ownership is on the rise o MaaS showed that it can be an alternative for car ownership o Dutch interviewees were sceptical on substituting their car for MaaS o Electric cars can be pushed through MaaS-initiatives - Public transport o PT has a central role within current MaaS-initiatives o However, easily accessible in the Netherlands and not included in current Hely-proposition - Bike o The Netherlands is a well-known bike country o E-bike and cargo bike are on the rise, private as well as shared.
- User categorization o Spatial; o Socio-demographic; o Household variables, and o Mode preferences	- User categorization o PT as main travel o Live in urban areas o Young adults o Have children o Known digital skills

The Dutch mobility landscape has a few characteristics that are important to be recognized for MaaS initiatives like Hely. Firstly, with a trip being 11 kms on average gives Hely has a logical claim to, apart from pushing owning a car towards sharing a car, strive to substitute car use for (cargo) bike use. However, the Dutch have quite a multimodal split already, which is different than other MaaS-pilots. We know that all individuals already own a bike and have quite easy access to PT. It would therefore be interesting to establish whether the multimodal approach of Hely will be seen as an asset to specifically the Dutch residents. Furthermore, we already see different shared mobility initiatives rise in the Dutch mobility landscape, mainly of car-sharing services, but also by (cargo) bike services. Thus, the MaaS-market is slowly beginning establishing itself within the mobility market, hence Hely could have a favourable timing to establish itself as a MaaS-operator, as they are working from a level 3 integration and seek partnerships with other MaaS-providers. The focus to start within the urban areas is supported by the literature, as it can be expected that especially young metropolitans are the early adopters of the Hely-service, and especially the ones having a technological and sustainable mindset.

3 Hely

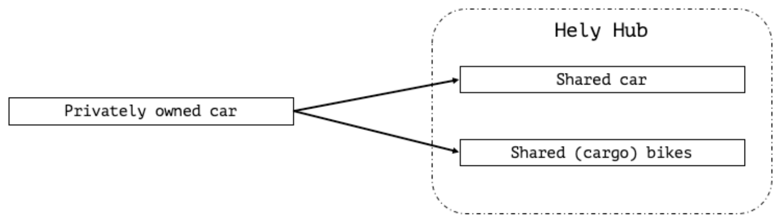
In this chapter Hely is elaborated upon. The company, ambition, Hely Hubs and application are handled. Also, the Hely Hubs are explained, with the corresponding pricing model. The specific characteristics that are important to take into account for the remaining research are concluded. Information is retrieved from multiple documents within Hely that are not available online.

Hely is a Mobility-as-a-Service provider that started establishing its sharing platform early 2018 and has a mission to realise sustainable mobility. Hely currently consists of 15 employees, including its own development team. Nationale Spoorwegen is the only shareholder of the start-up. Hely has the ambition to become stage manager of the mobility market and be a catalyser for the change towards shared door-to-door mobility. It believes that shared mobility contributes to a better quality of living and traffic control, and that shared mobility is both smarter and more fun for the user. Furthermore, they strive to be accessible, easy and complete in their service. Hely stimulates people to own less rarely used vehicles and to engage in a more conscious vehicle choice per distinct trip. To realise this, they offer a complete service using many different modalities. Hely works in close cooperation with municipalities, project developers and all kinds of mobility providers. This approach of working together with other parties can create an ecosystem in which sharing is the norm. Using the framework of Figure 1, Hely can be indicated as a level 3 integration. In the near future Hely focuses on scaling, and including a business proposition, public transport and start a free-floating model. These goals help supporting the long-term goal of becoming a platform and be a central player within the mobility market. But first, the market is penetrated by establishing Hely Hubs within neighbourhoods. The trips that are engaged in the Hubs are two-way trips; always beginning and ending on the Hub.

3.1 The Hely Hub

Hely provides multi-modal MaaS-hubs as alternative for the private car (Figure 3). This is interesting for municipalities and property owners specifically in areas with congestion and low parking quota's as sharing increases efficiency of use. Hely Hubs are for closed user groups, that are assigned to a specific neighbourhood. This way, Hely can also provide new mobility as an integral part of the newly established neighbourhoods and therefore closely cooperates with residential property owners. Hely strives to get people not only from private cars to shared cars, but from car to (e-)bikes and cargo bikes. These modalities can serve as alternative for trips under 20 kms. Using a Hub, people will be more flexible and contribute towards a better environment and quality of life. In December, the first two multimodal Hely Hubs were launched. The following Hubs are planned in the first quarter of 2019 in The Hague, Utrecht and Haarlem. In 2019, Hely strives to launch a total of 20 Hubs. At the moment, Hely offers (e-)cars, (e-)bikes and an e-cargo bike per Hub. These modes are provided through partnerships with Mywheels, Urbee and Cargoroo. The coming months other modalities will be added to Hely's proposition, for example scooters, public transport and taxi services. Moreover, Hely strives to have more than one partnership per modality. Hence, Hely will in-time become a brand-independent platform. Furthermore, in 2019 Hely-users can also use the vehicles of its partners outside the Hubs. This means that through the Hely-application the user has access to shared mobility in all four big cities in the Netherlands.

Figure 3. Desired changed behaviour through Hely Hubs



3.2 Effectuating a Hely Hub

Hely takes several steps for activating a Hub within the area. After a tender is won, it can build a Hub within 8-10 weeks, depending on the presence of charging stations and other operational requirements on location. Four phases of Hub phases can be indicated. First, the intentions and goals of the local partners and stakeholders are obtained, through meetings and surveys. These requirements shape the operational process of the Hub, for example what permits should be obtained and whether charging stations should be included in the design. Secondly, the users and mobility needs are identified to design the marketing process accordingly. This information will also be used to identify the desired vehicle fleet for the particular Hub. In the third phase the operational procedures and online marketing are started, which ends with testing the Hub-vehicles on location and launching the new Hub in the application. Usually a Hub takes 5 parking spaces, depending on the precise fleet that is introduced. During the fourth phase the Hely Hub is launched. This means that the residents that signed up in the previous weeks are onboarded and an offline marketing campaign in launched in the neighbourhood. Furthermore, the use of the Hub will be monitored and the (use of the) Hub will be optimized during a period.

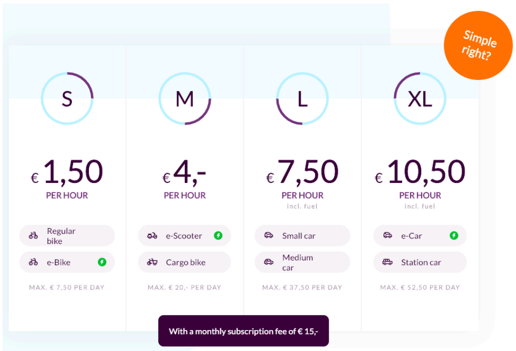
3.3 The Hely-application

Through the Hely-app an end-user is able to use all these modalities through one simple application, by integrating all service providers on one platform. This provides a transparent service, in which pricing, billing, reserving, paying insurance are all handled within one app, for all mobility services. Moreover, electric mobility is made accessible to all and several financial advantages arise, for example no vehicle costs on taxes, parking tickets or sudden costs on repairs and maintenance. The Hely application is available for both Android as iOS. An individual can apply through Hely.com. When the Hub is ready, they receive a mail which contains the link to finish the application. In this process, one is obliged to connect his/her driver's license and bank account. Once the application is completed, one can immediately use the vehicles in the Hub or reserve a vehicle for later use. Cars can directly be opened/locked, for bikes one receives a six-digit code to use on the lock. All information about use, tariffs etcetera is provided in the app, so no other external information is needed. Lastly, in the app the client can check ride-history and her planned invoice. All cars and bike stands have infographics. Moreover, cars have their own charging cards for fuel, phone chargers, children's seats and navigation systems. Customer service is one click away to answer remaining questions or handle problems. For now, people are bound to one specific Hub and thus cannot (yet) use Hubs on different locations.

3.4 Pricing model

Hely uses four buckets to indicate different prices. These prices are different for different modalities. The buckets are described as small, medium, large and the extra-large bucket. As shown in figure 4 the price differentiates from 1,50 to 10 euro per hour and different modalities are priced in the same bucket. The total price per day is maximized; the moment one uses a vehicle over 5 hours, the total price will not increase any further. Next to the pay-per-use buckets, a monthly subscription fee of 15-euro is added. Hely does not use an additional km-price, all is included in the hourly price. For every new Hub, there is a first-use bonus that entails that clients have the first three months free of monthly subscription and a 50-euro free-to-spent on every account.

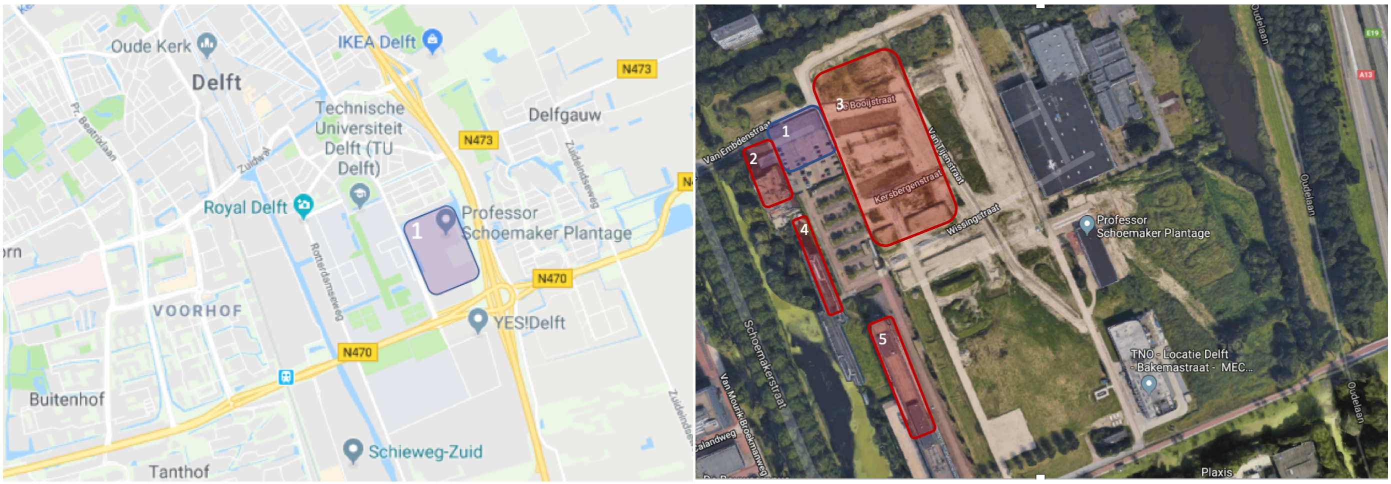
Figure 4. Pricing model



3.5 Hely Hubs in this research

(1) In the Schoemakers Plantage Delft, BAM and AMvastgoed are developing a new residential area (Figure 5). These property owners partnered with Hely to establish a Hely Hub for the neighbourhood. In October 2018, Hely launched its second Hub in Delft. HD is the first residential area with a charged service. In the area, 4 e-bikes, 2 bikes, 1 cargo bike, 2 conventional and 2 electric cars are placed at the Hub. The Hub is provided with 4 dedicated Hely parking lots, of which two have electric charging possibilities. The development project was divided in different phases, from which the first is completed. These first phase are terraced houses (area 3). Furthermore, there are three established flats in the area, one for student housing (area 4), two conventional flats (area 2&5). The parking norm in this area is quite high, as 1,7 parking spots are provided per household. It is therefore not expected that the Hely Hub will be used from pure necessity, but more from interest in the new technology.
At this moment, 500 residents can potentially use a Hely Hub, which could be extended towards 1500 residents in the future. There is a wide diversity of social-demographics present in this area, as the Hub can be used by students, young professionals and families. This also entails diverse incomes are present in this area. Residents are not known to have a specific sustainable mind-set. The user-rate on 1 January is 48 users and is likely to rise further over the coming month.

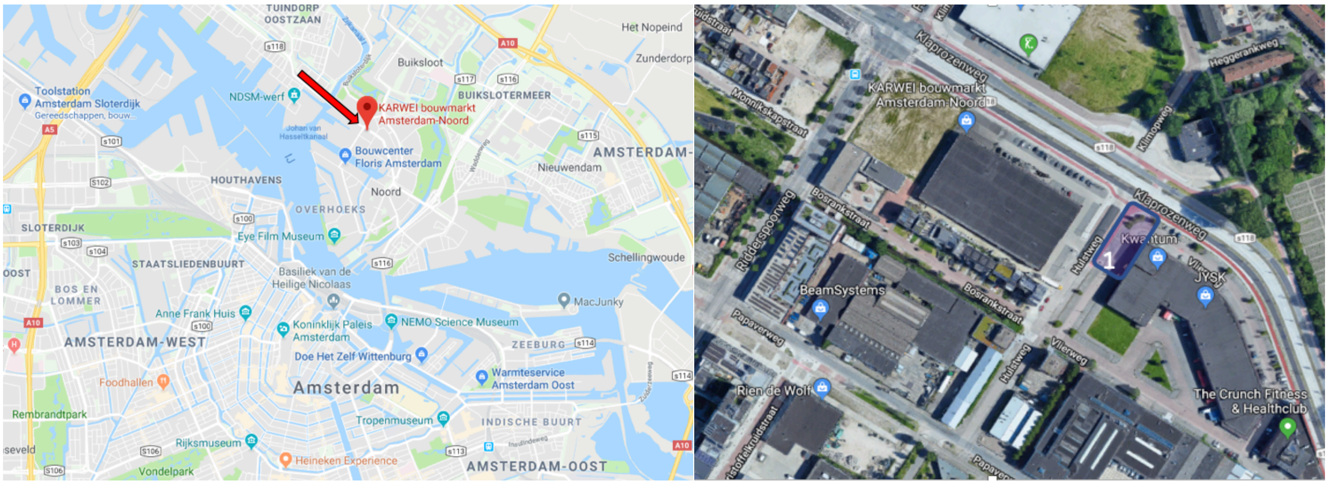
Figure 5. Hely Hub in Delft



(2) January 2019, the Amsterdam Hub is launched in Buiksloterham (Figure 6). The area Buiksloterham is dedicated by the municipality Amsterdam as a circular neighbourhood. This means, goal is to be fully sustainable and circular. These ambitions are grounded in a manifest by the municipality (Municipality of Amsterdam, 2019). Hely partners with the municipality, to provide its shared mobility. However, as there is a public cooperation the Hub itself is placed on a private terrain. The Hub is placed on the Kwantum-parking lot, as can be seen in figure 6, area 1. This Hub is provided with 4 e-bikes, 2 bikes, 2 electric cars and a cargo-bike. There are two exclusive Hely parking areas provided with an electric charging possibility. Buiksloterham has a total surface of 66 hectares. The area currently homesteads about 615 residents. The municipality prospects that the coming years 3500 houses and 200.000 m^2 working spaces will be added to the neighbourhood. The parking norm in Amsterdam is low, with 0,225 parking spaces per house. This creates a window of opportunity for new residents to consider the Hely Hub as a replacement for certain purpose trips, as private car ownership is thus not cost efficient in Amsterdam.

The majority of the residents in BSH are 25-45 years old and are unmarried. The residents are mainly young professionals and is typified by one person per household. The ethnic diversity is 50/50 autochthonous and migrants. The neighbourhood is known for having a sustainable mind-set. In the beginning of January, HB has 55 users.

Figure 6. Hely Hub in Amsterdam



3.6 Conclusion

In this chapter the following question is addressed: '*What are the characteristics of the Hely Hubs and of its subsequent service?*'.

Hely provides an all-inclusive service, using different modalities combined to offer an alternative for private car use. Their long-term goal is to become an independent mobility platform with all shared mobility initiatives included. To build their critical mass, they now penetrate the market with Hely Hubs, in which (e-)cars, (e-)bikes and e-cargo bikes are offered to its clients. PT is not yet included in Hely's proposition. The trips that are engaged in are two-way trips; always beginning and ending on the Hub. Hubs are centred around new residential projects, and according to the theory in section 2.2.2 the people should be open to try-out new mobility for their changing travel behaviour. To establish this, they cooperate closely with both municipalities and property owners. This strengthens the window of opportunity for Hely to recruit clients.

The Hubs are currently only available for residents of that specific neighbourhood. The pricing is made as easy as possible, and therefore uses 4 buckets for different modalities, in which all costs are combined into one hourly rate. Currently, new users are offered 50 euro off their first invoice and the first month free from subscription costs. Due to this discount, this research cannot establish a viable analysis on this aspect and so cost is excluded from further investigation.

This research targets two Hubs, in Delft and Amsterdam. Both Hubs are used only a few months by the very first Hely clients and provides a total of 1135 possible clients. Both locations are quite different in terms of social-demographics and residential characteristics. As Hely provides on individual subscriptions and no household-based subscriptions, this research focuses solely on individual travel behaviour and not on households. As we study within the Hely community we can assume that they have a positive attitude towards a MaaS-initiative and it is assumed that they are influenced less by their surroundings, being innovators and early adopters of the service.

4 Methodology

In this section the methodology is explained. First the data collection methods are discussed, based on the 120-day test period. Then, the design and analysis of the pilot survey are elaborated, which defines the definitive survey. Next, the variables within database of Hely are revealed and the non-user survey is elaborated upon. Lastly the methods of univariate analysis that will be used in the next section are defined.

4.1 Data collection methods

For choosing the data collection method it is important to recognize that the problem definition steers the process, not the other way around. The lack of insight on the Hely community and its subsequent use drive the data collection towards using two different methods, of which the surveys are structured through two different kinds of user groups. This results in three distinct moments of data collection.

1. A user survey is incorporated that describes the social-demographic characteristics, prior travel behaviour, expectations and motivations of MaaS by the Hely community. These aspects are derived from the concluded literature in Section 2.4. Moreover, due to the uncertainty of possible use of the Hubs during the coming months, the intention to use the Hely service is incorporated into the survey. These intentions are tested on the characteristics of the community by univariate analyses. Also, it is possible to compare the intention to use and actual use of the Hely Hubs on their similarity. Intention precedes actual use and is considered to directly and solely influence, and thus be a good indicator for, actual use (Appendix D).
2. Investigation of the Hely database after a use-period of 120 days, focusing on the two Hubs that are established from December 2019. This reveals the modal split and different trip characteristics of both Hubs and Hely in total, which will further be specified in section 4.3. Moreover, external sources are incorporated to address possible influence of weather on mode choices, as described to be important in Section 2.4). Database exploration is done through Microsoft Excel. Dependencies are indicated by univariate analyses through SPSS.
3. A non-user survey is designed for users that did not try the service after the given research period. Addressing these users will provide a complete oversight on the userbase within this period. Additionally, it helps Hely validate the quality of their service.

It should be noted that depth of all analysis stated above is fully dependent on the success of Hely during its starting period, which directly affects reliability of the data. Moreover, to ensure results are usable to answer the research question it is crucial to consider the stages that have yet to come. Therefore, the survey is tested on a pilot sample. Piloting will almost always increase validity and efficiency of research design. Also, the feasibility of the research and response rate can be estimated through a pilot (Johanson & Brooks, 2010).

4.1.1 Data type

Hely provides the opportunity to model revealed preference (RP) data through two Hubs: Delft and Amsterdam. This means the data that is collected is based on choices that are actually made by respondents. For the survey this entails that the analyst asks questions as to what has occurred in a certain situation. Moreover, also the logged data represents actual behaviour on the Hely Hub. This can reveal mode shares and can thus identify the modal split and actual characteristics on the use of the Hely Hub. This data can also be incorporated as revealed preference data for statistical analysis. Analysis will be executed using different types of univariate techniques, which is further defined in section 4.5. A downside is that, by using RP data, choices mostly remain a black-box and identification of choice-processes are difficult to indicate.

Next, intention to use the service is queried within the survey, which entails stating hypothetical questions. This is done by asking what a respondent would do or choose, given a certain situation. As described in Appendix D, this intention precedes actual behaviour, and is deemed a valid substitute to measure possible behaviour. Hypothetical data is also possible to test through statistical analysis.

4.1.2 Survey questions

A survey delivery method should be appropriate to the questions asked. Similarly, questions should correspond to the type of data that is required. Furthermore, wording the questions should be done very carefully and several pitfalls should be considered. (1) Is the question appropriate for this study and is the question absolutely necessary? Be sure to ask, “need to know” and not “nice to know” questions. (2) Another important issue is whether the respondent understands the question. Therefore, the right trade-off between simplicity and pretentiousness should be found. Also, ambiguity should be avoided, and the culture should be acknowledged. Lastly, avoid double-barrelled questions (Hensher, Rose, & Greene, 2005).

4.1.3 Respondent group

The research addresses users of two different Hubs, both with distinct different social-demographic characteristics. This offers different methodologic possibilities, for example to compare both Hubs or pool them together. Each Hub has a rather heterogeneous pool of residents, with families, students, and young professionals. As the main focus is to explore the Hely community it is interesting to investigate the community as a whole, indicating the different social-demographics. Moreover, it is interesting to also indicate the differences between both Hubs, comparing Delft, in which the Hub is mainly pushed by the property owner, and Amsterdam, in which the sustainable-minded community had an important say in the arrival of the Hely Hub.
This exploratory research has no aim to provide a representative sample of the population, but rather to indicate the specific characteristics of this community. To determine whether the Hely community has different characteristics than the population, a comparison will be made using the insights in Dutch travel behaviour provided in Figure 2.

4.2 Before-survey design

The survey reveals the values of the variables that are tested prior to the changed situation (Table 4). The survey is structured by five main interests: social-demographic and mobility characteristics, travel behaviour, attitude towards Hely, electric vehicles, and private car.
First, the standard social-demographic characteristics of the respondent are questioned. Secondly, characteristics of mobility behaviour are asked by stating the number of cars within the household and whether the respondents care about sustainability. Next, travel behaviour prior to the introduction of the Hely Hub is questioned. This is done through stating the respondents preferred choice of modality and specifically asking the number of kms the respondent drives in a car. Also, the intention to use Hely is queried per modality and for what trip purpose (Section 2.4). Furthermore, the survey includes the motifs on why respondents subscribed for Hely, derived from Section 2.4. Lastly, the intention to sell the private car is measured. The full survey and its categories (Appendix F) also included some variables that were in particular interest to Hely, however not for this research.
the Likert-scale is used to measure the statements. Likert (1932) provides a scale on which attitude can be quantified. The variables are transcribed to statements, which the respondent will value from 1 (not agree) to for example 5 (totally agree). The used range of these options varies and depends on the level that people have fine-grained opinions on the matter. A range too small dismisses certain knowledge that can be obtained, while a range too large may add randomness into the variable. For this pilot, a scale from 1 to 5 is chosen, to increase statistical power for the possible limited sample size. The survey states only need to know question and therefore the following questions were not included. First, the type of neighbourhood (rural/city/urban) is set by the destination of the Hely Hub. Hub Amsterdam is within a city area, Hub Delft within an urban area. Secondly, people that subscribe to Hely are assumed to be both service-minded as innovators, as they are the first-ever users of a multimodal Hub service. Moreover, as stated earlier, all Dutch residents are expected to own, or have access to, a bike within the household and have easy access through their ov-chipcards. This way, possible respondent’s fatigue is recognized and thus completion rate is maximized. This is also tested in the pilot survey.

Table 4. Elements of the pilot before-survey

Before survey		
Demographic characteristics		
		Gender
		Age
		Household type
		Income
		Education level
Mobility characteristics		
		Car ownership
		Care for sustainable travel
Travel behaviour		
		Preferred modality
		Distance per private car
Attitude towards Hely		
	Motifs to use Hely	
		Costs
		Convenience
		Choice freedom
		Customization
	Intentional trip purpose	
	Intentional mode choice	
Attitude towards private car		

4.2.1 Pilot survey

Hely uses a specific tool for its surveys, namely Typeform. On request of Hely this tool will be used during research, mainly to ensure recognisability of Hely towards its clientele. The pilot is 26 questions long, and a possibility to leave feedback is included in the last section.
Apart from testing variables and categories, the response rate and thus the efficiency of addressing respondents through the chosen medium and text is tested. Following Johanson & Brooks, (2010), a group of around 30 respondents is recommended to test as preliminary survey. Piloting on a sample of the targeted audience gives the best representative results but decreases number of respondents of the real survey. As the target audience for this research is considered to be quite small, the pilot is tested on Hely subscribers living outside of Delft and Amsterdam. These are people that have subscribed for the Hely-newsletter and arguably reaches the same type of people, without meddling with the target audience. Through Hely's database 232 individuals were reached online, inviting them to participate in a survey on their current travel behaviour.

4.2.2 Analysis

The pilot survey was first checked by Hely on its representativeness and clarity before emailing it to its clients. No changes were proposed. The survey was sent to respondents on a Friday 0900am and the results were imported four days later. In total 20 individuals responded, what resulted in a response rate of 9%. This is considered a somewhat small response rate, even for external surveys. In total 41 people visited the survey, which gives a completion rate of 49%. Moreover, the completion time was higher than expected, which could be improved. This may also positively influence the completion rates.

All variables are tested through SPSS on their categorization and whether the units will be suited to explain the desired results. The social-demographic characteristics of the pilot, as well as an overview of the variables are shown in Appendix F. Results imply that several changes will increase the quality of the results of the survey:

1. Some variables of the social-demographic characteristics should be extended or changed to be more inclusive and simpler. Income and age will be recoded into larger categories, to ensure large enough groups per category will result. Next, employment status is extended, to divide "unemployed; but not looking for work" and "currently unemployed and looking for work". This differentiates homemakers and jobseekers, as these arguably have a different travel pattern. Lastly, household type is extended with two more options to be more inclusive for respondents.

2. For this research it is of particular interest whether the respondent has exclusive access to a private car. Therefore, it is decided to add a yes/no question on whether the respondent is the main user of a car, adopted from (Centraal Bureau voor de Statistiek, 2018b).
3. The pilot does not reveal one's current travel behaviour specifically and objectively enough. Following the (Centraal Bureau voor de Statistiek, 2018b; Richardson, Seethaler, & Harbutt, 2003) the definitive survey will ask for the number of trips per week for car, bike and public transportation. The variable will not specify the option of travelling by foot, as Hely has no intention to compete on behaviour of such short distance and which is free of charge.
4. Motifs to use Hely are extended with "business trip" and "to university" option, following (Centraal Bureau voor de Statistiek, 2018b).

4.2.3 Resulting design and approach

The survey consists of 29 questions in total, including some questions that were not intended for this research (*italic* in Table 5). All included variables are shown in Table 5 and the full survey is included in Appendix J. The pilot survey concluded that an external mail does not yield the desired response- and completion rate. Moreover, new clients subscribe for the service on a continuous basis, and therefore potential respondents should be continuously recruited. To increase the response rate and optimize recruitment, the survey is included in an automatic confirmation-email that is send to every person that applies on Hely.com. It is expected that the willingness to participate in the survey is highest when just finishing the subscribing to the service. In this email it is asked whether they would like to note their preferred vehicles for their respective Hub. It is expected that creating active participating through this approach will increase the willingness to participate. Through this method there is a recruitment period starting from 20 November 2018. On 15 March 2019 the surveys were included for analysis.

Table 5. Definitive before-survey

Variables	Categorization	Categories
Gender	Nominal	Man Woman
Age	Ratio	0 to 24 25 to 34 35 to 44 45 to 54 55 to 64 65 +
Zip code	Nominal	Open
Employment status	Interval	Employed full-time (40+ hours per week) Employed part time (up to 39 hours per week) Unemployed; looking for work Unemployed; not looking for work Student Retired Unable to work
Education	Ordinal	No education Primary education Secondary school University
Household type	Ordinal	I live alone I live together with my partner I live together with my family I live alone, with my kids I share a house with others I live with my parents

Household income	Ratio	To 19999 20000 to 39999 40000 to 59999 60000 to 79999 80000 to 99999 100000 or more unknown/don't want to tell
Household car ownership	Interval	No cars 1 car more cars lease car shared car with family/friends/neighbours shared car subscription sometimes car rent No car ownership of rental
Main car user	Nominal	No Yes
Frequency of bike/car/public transport use	Ratio	Open (trips/week)
Mobility satisfaction in neighbourhood	*Interval*	*Likert-scale (1-to-7 scale)*
Car sharing experience	*Nominal*	*Sometimes from family/friends* *Sometimes at a rental company* *Shared car within a closed group* *Shared car on an open platform* *No experience*
Bike sharing experience	*Nominal*	*No* *Yes*
Trip purpose for Hely-service	Interval	Work Business trip Groceries and shopping Sports and hobbies Social occasion Day away
Intention to use car/e-car/e-bike/bike/cargo bike	Interval	(Almost) never Monthly Weekly Several times a week Daily
Motifs to use Hely	Interval	Likert-scale (1-to-5 scale)
Intention to leave private car	Nominal	Yes, I'm prepared to waive my second car. Yes, I'm prepared to waive my only car. Yes, I will not buy a new car what I was planning to do. I'm still in doubt. No, I'm not prepared to waive my second car. No, I'm not prepared to waive my first car. This question does not apply to me.

4.3 Hely's database

Hely's gathers data on all Hub activity through their application. It tracks all the rentals and users, and for example shows the total trips that were made over a certain period of time and per user. Also, the modal split of a Hely Hub, the number of trips per modality and per bucket can be defined. These two are different as three different type of cars are included in Hely's fleet, that are divided in two buckets. Namely, the XL-bucket consists of either an e-car or an MPV and a large bucket consists only of a small car. As research is also interested specifically in e-car use, both categories are explored in the results. Moreover, the dataset can reveal regular and occasional users. Lastly, it shows gender, date and time per rental.
Additionally, weather conditions are included from an external source (KNMI, n.d.) and connected to the logged data. This process is explained in more detail in Appendix H. The tool that is used for analysis is Excel. With this set of variables, the components that are indicated in Table 7 can be identified and tested through SPSS.

Table 7. Variables in database

Variables	Unit	Scale
Rentals	# trips	Ratio
Users	# users	Ratio
Trip time	minutes	Ratio
Modality	(e-)bike/cargo bike/small car/e-car/mpv	Nominal
Bucket	small/medium/large/extra-large	Ordinal
Date	day/month/year	Interval
Rainy day	yes/no	Dichotomous
Gender	male/female	Dichotomous
Hub	Zip code	Nominal

Table 6. Objectives

Goal	Components	Unit
Hely Hub use	Total	# trips
	Use intensity	# trips / user
	Modal split	# trips / modality
	Bucket split	# trips / bucket
	First/Last mile	yes/no
Characteristics	Weather	rain / modality
	Gender	gender / modality
	Trip duration	minute / modality
	Week	day type / modality

4.4 Non-user survey

Investigation of the user database indicated that there are 67 accounts that were redeemed, which means that a client downloaded the app and finished the application but did not yet engage in a trip from the Hely Hub. This is a substantial percentage: 60% of all the users in Hely's database. It is important to explore what barriers these individuals experience before using a Hely-vehicle. Therefore, a single-question survey is designed to get a first grasp of this group. The survey exists of one in-mail multiple-choice question to reduce the probability of not-participating in the survey. This is deemed important for this particular survey because (1) there are only 67 would-be respondents and (2) individuals that are not actively participating in the service are expected to be less triggered to participate in a lengthy survey.
Six options are identified as choices. These options are adapted from the criteria that are used for evaluating MaaS initiatives (defined in Section 2.4); costs, geographical access, reliability, and diversity of modes (Table 8). Moreover, an "other"-option was included to allow new arguments and an option "no reason, I want to use Hely" is included, for people that simply did not yet have the time to try-out the service. As piloting non-use is not possible, the alternatives were feedbacked by Hely personnel.

Table 8. Non-user survey

What is your most important reason for not participating in a trip on the Hely Hub?
The Hely Hub is too far away
The app is inconvenient
It is too expensive
The vehicles on the Hub are not satisfactory
Nothing, I intent to use the Hely Hub
Other

4.5 Data analysis

Data is fundamental to model and analyse behaviour in the real world. This study uses quantitative data, which is data that is measurable in a certain numerical unit. Quantitative data can be either continuous or discrete and have different scales of measurement. In this research we identify discrete values that take on only a relative few different distinct values. More specifically, we focus mainly on statistical analysis of these values. To perform statistical analysis the variables should be categorized, for which we know four different scales. These scales depend on the observed variable and are known as nominal, ordinal, interval and ratio intervals. Nominal variables provide certain classification or categorization, however, do not apply a certain order. Ordinal scaled data is data that provides an indication of order, for example ranking a product. Distances between objects cannot be determined. Interval scaled data has an equal distance between different values, for example temperature. Lastly, ratio data introduces a zero point in the scale, which shows an absence of the object that is considered. Furthermore, to define underlying structures the variables should be defined as either dependent or independent. However, identifying these are not always simple. If a variable is either the cause, the grouping factor or the static variable, it can be defined as the independent variable. The scales and (in)dependency of variables define the type of analysis that should be executed to study the variables and their correlation and is therefore considered a crucial aspect of the analysis (Hensher et al., 2005).

4.5.1 Hypothesis testing

Statistical testing is done to determine whether results that are established in a sample can be generalized to the population in general. To do this, hypotheses are tested, which can either be accepted or rejected. Deciding whether a hypothesis is true or false is done using a statistic, which depends on the values given by the sample and a predefined value limit. If the statistic is lower than this limit the null-hypothesis is accepted, otherwise it is rejected. The null-hypothesis always states that there exists no relation between the variables that are tested. If the hypothesis is rejected, the alternative hypothesis is accepted. This hypothesis does define a relation of some sort between the variables. The alternative hypothesis can be defined either two-sided or one-sided. If background theory predicts a direction of the relation, for example positive or negative, then the alternative hypothesis can be tested one-sided. A lacking theoretical background entails that testing two-sided is required.

4.5.2 Sample distribution

The sample distribution defines the probability that certain values of the statistic appear. This statistic is bound to specific analysis techniques, such as the chi-square, t-value or F-value. Based on the value of this statistic we measure whether the relation between two variables is statistically significant or not. The sample distribution determines the probability that a statistic value is found, assuming the null-hypothesis is true. This is based on many draws of a sample from a known population, from which in every draw the statistic is calculated. These values can be shown in a histogram. Dependent on the confidence interval that is chosen, we can determine whether the null-hypothesis should be rejected or not. This confidence interval describes the chance that we might conclude wrongly, as with statistical analysis we never draw a conclusion with 100 per cent certainty.

The level of significance defines the risk that one might conclude wrongly. Regarding the decision of rejecting/accepting the null-hypothesis there are two types of mistakes: (I) the null-hypothesis wrongly is rejected (II) the null-hypothesis is wrongly accepted (Table 9). The probability that the type I error occurs, the researcher can determine himself through defining the significance level. The value is called the p-value and in most researches 5% and thus a 95% confidence interval. Furthermore, the type II error cannot be chosen, and largely depends on the number of respondents of the research. The errors are related; if type I is chosen to be smaller, the probability of occurrence of type II rises.

As stated earlier, the alternative hypothesis can be defined either one- or two-sided. Hypothesizing two-sided means that on both sides of the interval there exists a 2,5% critical interval field in which the null-hypothesis can be rejected. If the alternative hypothesis is one-sided there is a one-sided 5% interval field. A one-sided hypothesis lowers the possibility that the null-hypothesis is wrongly accepted.

Table 9. Types of mistakes

	In reality	
Decision	**Null hypothesis is true**	**Alt hypothesis is true**
Null hypothesis is not rejected	OK	Type II mistake
Null hypothesis is rejected	Type I mistake	OK

4.5.3 Chi-square test

A chi-square test is used to research whether two variables of nominal scale are independent of each other. To determine what hypothesis is accepted, the chi-square value and p-value are calculated. The chi-square value is based on the difference in the expected frequency and actual frequency of the distinct groups. The expected values can be calculated by following the distribution of the sample as a whole. Formula 1.1 identifies the chi-square value. Herein, the o_i are the observed counts and e_i are the expected counts.

$$X^2 = \sum_{i=1}^{k} \frac{(o_i - e_i)^2}{e_i} \tag{1.1}$$

The chi-square value follows a chi-square distribution, which is dependent on the number of degrees of freedom (Appendix E). The chi-square test has two prerequisites: (1) All category frequencies should at least be equal to 1; (2) a maximum of 20% of all expected frequencies may lie between 1 and 5. The chi-square value is more sensitive to cells with a low expected frequency, which is now accounted for.

4.5.4 Independent samples t-test

An independent samples t-test is executed to test an interval/ratio scale on a dichotomous independent variable. This t-test compares the means of the two different groups. The assumption is that both groups are independent of each other. The t-test uses a t-value, which is calculated as shown in 1.3. In this equation X_a and X_b represent the means of group A and B respectively and n_a and n_b represent the sized of group A and B respectively.

$$t = \frac{X_a - X_b}{\sqrt{\frac{S^2}{n_a} + \frac{S^2}{n_b}}} \tag{1.3}$$

Furthermore, S^2 is the estimator of the common variance of both groups, and is calculated as in 1.4:

$$S^2 = \sum \frac{(X - m_a)^2 - (X - m_b)^2}{n_a + n_b - 2} \tag{1.4}$$

The t-value is thus dependent on the differences in the means of both groups. If the two means have high differences this entails the t-value increases. As the t-value increases, the chance that the null hypothesis is rejected also increases. The limit value that is chosen to decide whether the hypothesis is upheld depends on the number of respondents. Appendix E provides the information to choose this value. There is one requirement that should be upheld by the data, in order to execute a t-test properly: the variable is either normally distributed, or the both groups have N>30.

4.5.5 ANOVA

A variance (ANOVA) test is used to compare the means of three or more groups and is thus used for variables with an independent ordinal level and dependent ratio level. The test is based on the variance of the different groups. As one of the assumptions is that the variances in all groups is the same, two estimators can be used for the variance, being (1) within group variance and (2) between group variance. The first estimator is based on the variance within each group. The variance of each distinct group is established and then weighted by the number of cases. The second estimator is based on the variance of the grouping average around the total average. If the grouping averages are equal, then each of the groups can be considered a distinct but comparable sample of the same population. The test explores whether the grouping averages are equal to one another. An increasing variance of the between group variance compared to the within variance decreases the probability that all grouping averages are equal. The test statistic, also known as the F-value, is defined as defined in 1.5.

$$F = \frac{between\ group\ variance}{within\ group\ variance} \tag{1.5}$$

This formula entails if the F-value increases the probability that the grouping averages are significantly different to each other. The value follows an F-distribution and is dependent on the number of groups that are compared within the sample. The test has three conditions that should be adhered to: (1) the samples are independently and randomly drawn, (2) Each group has a normal distribution, (3) The variances of all groups are equal. The last condition is tested through the ANOVA-test.

4.5.6 Correlation analysis

A correlation expresses the direction and strength from a linear dependency of two variables. These two variables are of interval scale at minimum. A correlation analysis does not identify (in)dependency between the two variables, thus there is no causality indicated. The strength of the correlation is indicated between -1 and +1. If the value goes towards 1 the direction is said to be stronger. An assumption is that there is a linear correlation between both variables. This can be explored through a scatterplot, in which the cases should be similar to a straight line.

4.6 Conclusion

The users and usage are measured through three different methods:

1. A user-survey, which established the characteristics of the users, their prior travel behaviour, intention and motives to use the service, and attitude towards modalities;
2. Investigation of Hely's database, which enabled to describe the number of trips, modal split of the Hub, multimodality and accessibility of the service and trip characteristics. Through comparing prior travel behaviour and the modal split in the Hub, the modal shift is defined.
3. After-survey, which defines motivations of the non-users.

The first sub-question that is addressed is: *"How can the survey be designed best to reveal the Hely community?"*. The before-survey contains five different categories (Table 4) and is tested upon their (in)dependence through various univariate analysis in SPSS. It is chosen to collect surveys continuously over a time span of 120 days, by adding them to the subscription-confirmation mail of new clients. This will optimize response rates.

The second sub-question that is addressed is: *"What variables in the database help establish the use of a Hely Hub?"*. The data is provided in Table 6. Besides description of the results, various univariate analyses will be done to establish (in)dependency and specific characteristics of the Hely Hub and its users to better understand the characteristics of the Hub usage.

The test period persisted of 120 days, in which the Hely Hubs were used by its first clients. Both the survey and database enabled using both revealed and hypothetical preference data through two Hubs in Delft and Amsterdam. The users and usage of the Hubs are both pooled together, to maximize the dataset and optimize reliability of the results and analysed independently. The survey queried actual users of the Hub and the logged data represented actual behaviour on the Hely Hub, which revealed mode shares and thus the modal split. In sum, the following components are tested upon each other in the next section (Table 10). The first analysis consists of the categories derived from the before-survey. Analysis II and III stem from the database. The scope level indicates whether the community as a whole, Hub community; and total modalities or Hub-modalities will be tested. Furthermore, the prior modal split, intended modal split and actual modal split will be compared. But first, the data is prepared.

Table 10. Analyses to conduct

Analysis	*Component A*	*Component B*	*Scope level*
I	(Travel) characteristics user	Intention to use Hely	Modalities
	(Travel) characteristics user	Motifs to use Hely	Community and Hub
	(Travel) characteristics user	Intention to leave private car	Community and Hub
II	Characteristics user	Actual use	All
III	Trip characteristics	Actual use	Hub and Modalities

6 Data analysis

The data is now collected, however not yet usable. Therefore, the data should be prepared first. All datasets are cleared from missing or unusable data and inspected whether or not it reveals reliable and desired results. This is firstly done for the before-survey, after which the database and after-survey are handled. Then, the univariate analyses are stated.

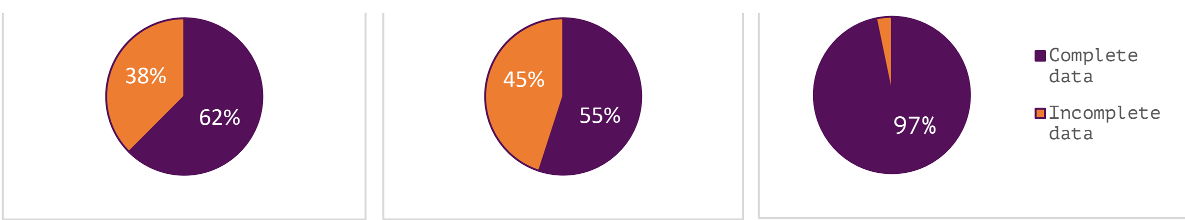
6.1 Before-survey

The survey gained 80 responses on persons that are subscribed for either the Delft or Amsterdam Hub. These The dataset is checked and cleaned of undesired data-entries. Firstly, the data is filtered by zip code only selecting those areas close to the respective areas. The area codes between 1024 – 1412 and 2611 – 2645 are used, covering for Amsterdam and Delft respectively. Furthermore, duplicated surveys were identified and cleared from the set, comparing the Network ID's on similarity that were provided by Typeform.

6.1.1 Missing data

Next, missing data is investigated and shown in Figure 7. 7 variables have a small number of missing data that will not impede results (Appendix G). For bike and public transport use there is significant missing data, missing 40% of the cases. However, it can still be used for analysis using the Multiple Imputation method.

Figure 7. Summary of missing values



Variables *Cases* *Values*

The Multiple Imputation (MI) method is generally accepted as one of the most sophisticated methods for dealing with missing data and also deemed the most convenient for this research (which is explained in-depth in Appendix G). The missing values within the data is interpolated six times, which results in six additional datasets: five with randomly drawn values for the missing data cases and one is the so-called pooled dataset. In the pooled dataset the data of the other five drawn datasets is analysed and parameter estimates are averaged. The pooled dataset is used for analysis in the next section, as it is compared and defined to be the best in line with the original variable parameters. The original dataset and imputed sets will be used as control groups during analysis. Lastly, the pooled dataset is checked on outliers. As the questions are almost all closed-form, no outliers were identified in the sample.

6.1.2 Recoding variables

The variables in the dataset have different categories. Those categories help define the statistics and thus the results. It is possible that these categories are too small, especially in smaller datasets like this. This means variable-information is defined too specific, which results in these categories having a disproportionate influence on the test statistics. Therefore, categories are preferred to be at least N>5 and/or have a systemic distribution. The descriptive results show that several variables should be recoded into new categories, so they have more statistical power:

1. Employment categories 'retired', 'not working', and 'student' are recoded into one variable 'not working'. This group explains individuals that do not travel for work, which is seen as the main travel motif, and thus engage in a different kind of travel behaviour.
2. Household variable contained the category "I live alone, with my kids", to be all-inclusive in terms of options. Results show only one respondent in this situation. Therefore, it is decided to recode and include in the category "I live with my family".
3. The age category of 65+ underrepresented (N=2) and can therefore not reveal reliable results.

4. Intention to sell car has seven categories. These categories are quite insightful, however contain too small categories for further univariate analysis. Therefore, a new variable is designed for that specific part. This variable condenses the options to: “Yes, I consider selling my car” and “No, I will not sell my car”.
5. The trips purposes with Hely vehicles has two categories that did not receive any response, being ‘business trip’ and ‘university trip’. These categories were excluded from further investigation.
6. Lastly, the multiple-choice question of possible purposes of Hely trips is recoded into 5 dichotomous variables to enable investigating these individually.

6.2 Logged data

Hely collects data on both their rentals as their user activity. There are 112 user-accounts in de Hely-application, of which 45 are considered active. Active accounts are defined by users that made one or more trip using a Hely vehicle. 45 clients engaged in a total of 189 trips over 120 days. Hub Delft and Hub Amsterdam account for 113 and 105 trips respectively. To use this dataset it should first be cleaned from noise and unusable data. Four aspects were considered. First, the user list was filtered of accounts dedicated to Hely-employees and partner-accounts. These accounts use the application and vehicles mainly for example for maintenance purposes and application testing, what will impede results for this research. Deleting these accounts consequently means that there remain rentals that are not owned by an account. These rentals are test-trips that were never engaged in and are thus filtered from the data. Furthermore, also clients sometimes rent a vehicle through the app and for various reasons never engage in a trip. These trips should not be included in analysis. Hence, it is assumed that trips that are shorter than 5 minutes are never engaged in and are excluded from the dataset. Outliers can also impede realistic results and are therefore deleted. For example, one rental was 72 hours, which can be explained by a client with car trouble and ended up having to tow the car. This information is important to acknowledge as rental, however, should be excluded for analyses that focus on the trip duration. Hence, when investigating trip duration, the rentals are checked and all above 14 hours were excluded, as all these clients experienced some sort of problem during their rental. A total of 14 trips were excluded for the analysis on trip duration. Lastly, trip duration is recoded from hours to minutes for better inquiry in SPSS.

6.2.1 Use intensity

The logged data provides the number of trips. To get a better grasp on the use intensity per user the data is recoded so that is corresponds to the before-survey. The rationale behind the categorization of the actual use is as follows: “daily use” means a use of at least four out of five working days per week. Next, “several times per week” is stated on at least 2 times per week and “weekly” defined as at least one time per week. Lastly, “monthly” is up to 1 time a week and “almost never” is stated as 0 to 1 trip per month. Moreover, we should account for the duration that a client is subscribed to Hely, as we focus on the use *per month.* Formula 1.5 is defined as follows:

$$\text{mode-use frequency per client} = \text{\# trips per mode} / \text{months subscribed} \quad (1.5)$$

Secondly, the modalities used and the use intensity in the logged data and the before survey are recoded, as provided in Table 11 and 12.

Table 12. Comparing modalities

Modalities in before survey	Modalities in logged data
Conventional car	Small car + MPV
Electric car	Electric car
Cargo bike	Cargo bike
E-scooter	Not included
Bike	(E-)bike
E-bike	(E-)bike

Table 11. Recoding actual use

Intention to use Hely	Actual use per month
(Almost) never	0-1 trips
Monthly	1-3 trips
Weekly	3-7 trips
Several times per week	8-15 trips
Daily	15 or more trips

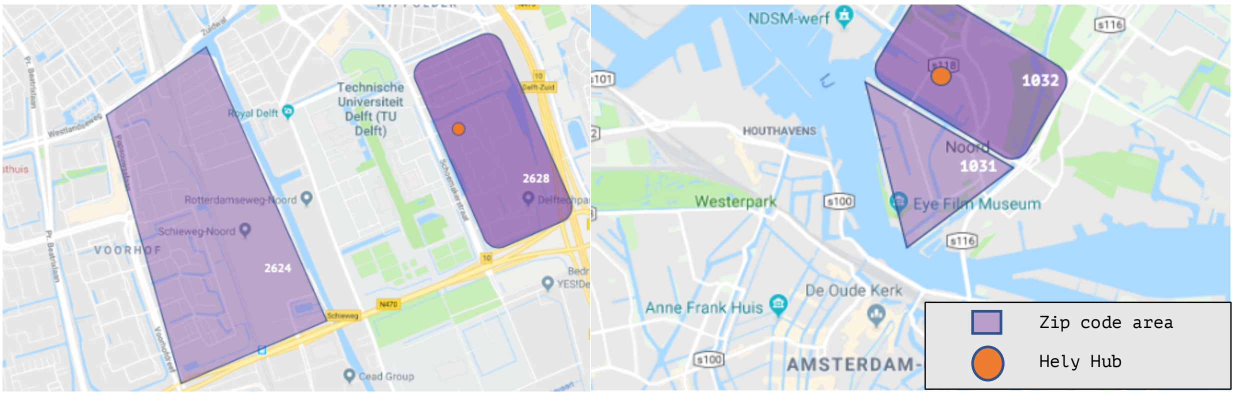
6.2.2 Distance to the Hub

Through the zip codes of the accounts it was investigated what distances users cover to arrive at the Hub. To do this, it is assumed that people who have similar zip code to the Hub live within walking distance of the Hub. Moreover, as Hub BSH is on the edge of two zip codes, for BSH two zip codes are assumed within walking distance, being 1031 and 1032 for BSH, and 2628 for Delft. This resulted in 115 trips that were made by 25 users within walking distance. Zip code 2624 counted 34 trips, which is striking as it is at least a 10-minute bike ride to the Hub. Table 13 shows that 2 frequent users live within that neighbourhood. Overall, 19 users were prepared to engage in a first and last mile to reach the Hub, what accounted for 39% of all trips. Figure 8 defines the most important areas.

Table 13. Distribution user and trips per zip code

Zip code	*Trips*	*Users*
2628	52	11
2624	33	2
1031	16	4
1032	47	11
Other	41	17
Total	189	45

Figure 8. User areas for both Hubs: Delft on the left; Amsterdam on the right.



6.3 Non-user survey

67 accounts received the survey, from which 25 people clicked and 16 completed the survey. This gives a completion rate of 64%, response rate of 24% and a completion time of 26 seconds. None of the respondent found that the diversity of modes was lacking, so this option is excluded from the results. Lastly, none of the non-users did participate in the before-survey after subscribing to Hely. Therefore, it was not possible to indicate more in-depth information on the characteristics of these users.

6.4 Analysis I| Before-survey

The first univariate analyses are conducted on the variables from the before-survey. The relevant analyses are described in this part. All other variables were either independent or did not have the statistical power to provide reliable conclusions (Appendix I).

6.4.1 Household and car ownership

An ANOVA is used to investigate possible dependence between household type and car ownership (Table 14). The results show that statistically significant correlation, which means both factors are not independent from each other and that there is a difference in car ownership for different types of households for this sample. More specifically, more members in the household means more cars are in the household. A 1-person household only owns a car half of the time. Families tend to own more than one vehicle on average.

	Distribution			Bonferroni	
Household	*Mean*	*Std. deviation*	*N*	*Partner*	*Family*
Alone	0,50	0,62	16	0,39	0,005
Partner	0,84	0,76	32		0,11
Family	1,25	0,74	28		
F=5,602; p=0,005					

Table 14. Household and Car ownership

6.4.2 Main car user on sustainability

The independent t-test is used to indicate that being a main car user has an effect on having sustainability as motif for engaging in MaaS (Table 15). Having a private car indicates that Hely is appealing because of its sustainable aspect, as these people score sustainability .7 point more important than their opposites on average. This is based on a 95% confidence interval. N shows that normality is no issue in this analysis, as N>30 for both categories.

Main car user	*Mean*	*Std. Dev*	*N*
NO	3,7	1,3	39
YES	4,4	0,9	44
	Difference	*T*	*P (1-sided)*
t-test	-0,7	-2,6	0,01

Table 15. Main car user and Sustainability motif

6.4.3 Flexibility and convenience

There is a significant correlation (B=0,42) between both variables (Table 16). There is no clear causality between both, however the correlation is significant, based on the 95% confidence interval. Thus, one that appreciates flexibility of the Hely service also wants the service to be convenient.

	Coefficient	P-value
Constant	2,55	0,00
Convenience	0,43	0,00
R-square	0,17	

Table 16. Flexibility and convenience

6.4.4 Main car user on intention to use bike

The independent samples t-test investigates whether being a main car user shows and the intention to use a bike are dependent variables. Table 17 shows that there is a difference for the intention to use a bike for people that have exclusive access to a car. These people have the intention to use a Hely-bike more often than their opposites, based on the 95% confidence interval. N shows that normality is no issue in this analysis, as N>30 for both categories.

Main car user	*Mean*	*Std. Dev*	*N*
NO	1,56	0,82	39
YES	2,10	1,30	41
	Difference	*T*	*P (2-sided)*
t-test	-0,53	-2,206	0,031

Table 17. Main car user and intention to use bike

6.4.5 Car ownership and day away trips

This chi-square statistic shows a significant value on the number of cars in the household and whether or not the respondent intents to use Hely for a day trip (Table 18). Clients that do not own a car would use Hely more for day-activities. Moreover, households that have multiple cars would not use Hely for their day-filling activities, based on the 95% confidence interval.

	Day trip		Sum
Household cars	NO	YES	= 100%
0	5	22	27
1	17	16	33
2	12	8	20
Total	56	24	80
Chi^2=9,958; df=2; p= 0,007			

Table 18. Car ownership and day-trip using Hely

6.4.6 Work-related trips and intention to use bike

The independent-samples test finds that respondents that would use Hely to work are more interested in using the Hely-bikes than others, as shown in Table 19.

Work-related trips	*Mean*	*Std. Dev*	*N*
NO	1,60	0,92	48
YES	2,19	1,31	32
	Difference	*T*	*P (2-sided)*
t-test	-0,583	-2,349	0,021

Table 19. Work-related trips and intention to use Hely-bike

6.4.7 Shopping-related trips and intention to use e-car

Table 20 shows that there is a significance between shopping-related trips and the intention to use the electric car in the Hub. More specifically, it shows that intent to use Hely for (grocery) shopping also intent to use the e-car more frequently than others. This is based on the 95% confidence interval.

Shopping-related trips	*Mean*	*Std. Dev*	*N*
NO	1,95	0,96	38
YES	2,53	1,06	40
	Difference	*T*	*P (2-sided)*
t-test	-0,578	-2,519	0,014

Table 20. Shopping-related trips and intention to use e-car

6.4.8 Shopping-related trips and intention to use bike

Table 21 shows that respondents also have the intention to choose the bike more often when they intent to use Hely for grocery shopping. However not officially significant following the 95% confidence interval, it is worth at least to mention the correlation.

Shopping-related trips	*Mean*	*Std. Dev*	*N*
NO	1,59	1,069	39
YES	2,07	1,13	41
	Difference	*T*	*P (2-sided)*
t-test	-0,483	-1,834	0,053

Table 21. Shopping-related trips and intention to use the Hely bike

6.4.9 Day activity-related trips and intention to use bike

Table 22 shows that the independent samples test resulted in a significant correlation between day activity and intention to use the bike. More specifically, clients that intent to use Hely for a day-activity plan to use the Hely bikes less than other respondents. This is based on the 95% confidence interval.

Day activity-related trips	*Mean*	*Std. Dev*	*N*
NO	2,24	1,21	34
YES	1,54	0,96	46
	Difference	*T*	*P (2-sided)*
t-test	0,692	2,855	0,006

Table 22. Day-activity-related trips and intention to use bike

6.4.10 Gender on intention to use cargo bike

The independent samples t-test investigates whether gender and the intention to use the cargo bike are dependent variables. Table 23 shows that women intent to use the cargo bike more often than men, based on the 95% confidence interval. N shows that normality is no issue in this analysis, as N>30 for both categories.

Gender	*Mean*	*Std. Dev*	*N*
Man	1,33	0,64	44
Woman	1,69	0,89	36
	Difference	*T*	*P (2-sided)*
t-test	-,37	-2,08	0,042

Table 23. Gender and intention to use cargo bike

6.4.11 Employment type and car-selling aspirations

This chi-square statistic shows a significant value on the type of employment and whether or not the respondent intents to sell their car. Table 24 shows that fulltime employees have the intention to sell their privately-owned car more frequently than part-timers, after subscribing to Hely. This is based on the 95% confidence interval. There should be noted that more than 20% of the categories has N<5. Therefore, the "not working"-category has a disproportionate contribution to the chi-square statistic. However, the table shows that fulltime and part-time employees do state a difference of almost 3/1 and 2/1 respectively. Therefore, the dependency of both variables is worth mentioning at least.

	Car selling-aspiration			Sum
Employment type	NO	YES	Other	= 100%
Fulltime	11	29	10	50
Parttime	5	10	5	20
Not working	7	2	1	10
Total	23	41	16	80
Chi^2=9,915; df=4; p= 0,042				

Table 24. Employment type and car-selling aspirations

6.5 Analysis of Dataset II| Logged data

The second univariate analyses are conducted on the variables from the database. All analyses are described in this part, as also independency provided usable intel on the behaviour of the Hely Hub.

6.5.1 Use intensity and mode choice on gender

The use intensity is tested on gender through an independent samples t-test. This result shows no dependence of use on gender, based on the 95% confidence interval (Table 25). However, the chi-square test, that results in Table 26, shows that modality choice and gender are not independent. It shows that women tend to travel more by non-car vehicles than men. This test adheres to the assumptions of the t-test.

	Mode choice					Sum
Gender	(e-)bike	Cargo bike	Small car	MPV	e-car	= 100%
Man	21	1	41	21	52	136
Woman	12	7	13	5	16	53
Total	32	8	54	26	68	189
Chi^2=17,256: df=4; p=0,002						

Table 25. Mode use per gender

Gender	*Mean*	*Std. Dev*	*N*
Man	1,52	0,51	29
Woman	1,56	0,51	16
	Difference	*T*	*P (2-sided)*
t-test	0,045	0,28	0,77

Table 26. Use intensity on gender

6.6 Analysis of Dataset III| Logged data

The third univariate analyses are conducted on the variables from the database. All analyses are described in this part, as also independency provided usable intel on the behaviour of the Hely Hub.

6.6.1 Mode choice and weather condition

The chi-square test results in Table 27. It shows that in this sample the mode choice does not depend on the weather, based on the 95% confidence interval. As the definition of a rainy day is an assumption, this could meddle with the results. Therefore, we tested different levels of assumptions, with a rainy day being established on 5 mm/day, 10 mm/day and 15 mm/day. On all levels no significant test results were found. As the test adheres to the assumptions for a chi-square, it can be concluded that rain does not drive certain mode choices.

	Mode choice					Sum
Use	(e-)bike	Cargo bike	Small car	MPV	e-car	= 100%
Dry	18	4	27	16	36	101
Rain	15	4	27	10	32	88
Total	33	8	54	26	68	189
Chi^2=1,003: df=4; p=0,91						

Table 27. Mode use per weather condition

6.6.2 Mode choice on day type

First the overall Hub use on week and weekend days is investigated. During the testing period 34 weekend days and 86 weekdays are distinguished (29% weekend-days). The Hubs are used on 65 weekend- and 124 weekdays (34% weekend-days). More specifically for mode choices, the chi-square test results in Table 28. It shows that in this sample the mode choice does not depend on the day type being week or weekend, based on the 95% confidence interval. All tests adhere to the assumptions for chi-square, hence it can be concluded that day type does not drive certain mode choices.

	Mode choice					Sum
Use	(e-)bike	Cargo bike	Small car	MPV	e-car	= 100%
Week	25	3	37	14	45	124
Weekend	8	5	17	12	23	65
Total	33	8	54	26	68	189
Chi^2= 6,11; df=4; p=0,19						

Table 28. Mode use per day type

6.6.3 Starting time and day type

The independent samples t-test results in Table 29. It shows for week and weekends different starting hours of rentals. We see that for weekdays rentals usually take place during the day and on weekends in the morning. Moreover, rentals during the weekdays are more spread during the day, whereas in weekends the rentals are more condensed towards the morning hours. This is based on the 95% confidence interval and assumes that variances are not equal based on Levene's test (p=0,010). Moreover, we assume a normal distribution of both week and weekend distributions.

Day type	*Mean*	*Std. Dev*	*N*
Week	12,79	4,56	123
Weekend	11,52	3,49	65
	Difference	*T*	*P (2-sided)*
t-test	1,27	2,12	0,035

Table 29. Starting time and day type

6.6.4 Starting time and vehicle type

An ANOVA is used to investigate possible dependence between vehicles and the starting time (Table 30). The results show that statistically significant correlation, which means both factors are not independent from each other and that there is a difference in starting times of rentals for different modalities for this sample. More specifically, e-cars and the MPV peak at different hours. This is based on the 95% confidence interval. Moreover, the assumption of variance and normality are not strictly held, however N of the important categories is deemed high enough to conclude on significance of the ANOVA.

	Distribution			Bonferroni
Vehicle type	*Mean*	*Std. deviation*	*N*	*E-car*
E-bike	12,24	3,22	34	
Cargo bike	10,62	2,61	8	
Small car	13,11	5,04	54	
E-car	14,34	5,12	26	
MPV	11,23	3,37	68	0,008
F=3,557; p=0,01				

Table 30. Vehicle type and starting time

6.6.5 Rental duration and day type

The independent samples t-test shows no dependency of rental duration on day type, based on the 95% confidence interval (Table 31).

Day type	*Mean*	*Std. Dev*	*N*
Week	161,6	201,5	123
Weekend	169,6	194,1	65
	Difference	*T*	*P (2-sided)*
t-test	-7,945	-0,26	0,79

Table 31. Day type and rental duration

6.6.6 Mode choice and rental duration

The ANOVA tests the dependency of modalities of the average rental time. Results show, as can be seen in Table 32, that rental times do not depend of the modality that is chosen, having an average rental time of 3:04h. It should be recognized that the minimum for almost all vehicles was 5 minutes because this was an assumption to divide real and test rentals. Moreover, for this particular inquiry rental times above 14 hours were deleted. These rentals were rentals done by clients, however are rentals that reported problems and through that had extended rental times. These rentals distort this particular investigation and are thus excluded from the ANOVA. The analysis adheres to the normal distribution and uses a 95% confidence interval.

Bucket	*Vehicle*	*Average rent time (hour)*	*Maximum*	*Minimum*
Bucket S	E-bike	3:00h	22:36h	0:05h
Bucket M	Cargo bike	2:16h	6:02h	0:14h
Bucket L	Small car	2:58h	13:52h	0:05h
Bucket XL		3:13h		
	E-car	3:32h	13:45h	0:05h
	MPV	2:20h	13:48h	0:15h
Totals		3:04h	22:36h	0:05h
F=1,069; p=0,34 for modalities				

Table 32. Average rental time per bucket and vehicle

6.7 Conclusion

After the data preparation, the analysis through SPSS derived 17 dependencies of the Hely community and its Hub usage (Table 33). This helps define the behaviour more carefully and are connected to the descriptive results in the next Chapter.

Method	Variable A	Variable B
Before-survey	Household	Car ownership
	Main car user	Sustainability
	Flexibility	Convenience
	Main car user	Intention to use bike
	Car ownership	Day away motif
	Work trips	Intention to use bike
	Shopping trips	Intention to use e-car
	Shopping trips	Intention to use bike
	Day away trips	Intention to use bike
	Employment type	Car-selling aspirations
Database	Gender	Use intensity
	Gender	Mode choice
	Weather condition	Mode choice
	Day type	Mode choice
	Day type	Starting time
	Vehicle type	Starting time
	Day type	Rental duration
	Modality	Rental duration

Table 33. Resulting dependencies from the dataset

7 Findings

In this section the descriptive results and corresponding dependencies of Chapter 6 are elaborated in more detail. Moreover, the users are compared to the Dutch population. First, the Hely community and its travel behaviour is indicated. Then, the use of the Hely Hub is elaborated upon, after which intention of private car use and non-users are indicated.

7.1 The Hely community

The survey gained 80 responses on persons that are subscribed for either the Delft or Amsterdam Hub. These Hely subscribers are mainly between 25 and 34 years old and live in either a two-person household or with kids (Figure 9; Figure 11). The largest part of Hely's clientele works fulltime and a quarter works part-time (Figure 10). Lastly, slightly more males than females subscribe for the Hely service. However, per age category, man and women are distributed equally. Compared to the Dutch population, men are overrepresented in this community and the users are younger on average, with a mean of 34 and 41 years respectively (Centraal Bureau voor de Statistiek, 2018a; Centraal Bureau voor de Statistiek, 2018b).

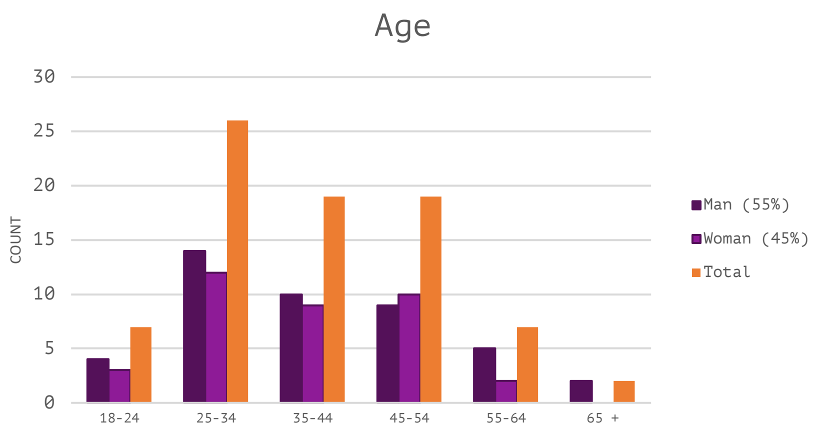


Figure 9. Age distribution of Hely community

Figure 12 shows the income of the respondents. Overall, the results are similar to the Dutch population (Centraal Bureau voor de Statistiek, 2019). The households in this sample are mainly represented by partners or by families. Some users live alone, and some share a house with others. The households are not representing the Dutch population, as these contain more one-person households relative to this sample (Centraal Bureau voor de Statistiek, 2018c). The Hely users within these households are mainly working fulltime and are highly educated; 72% finished a study. Moreover, a fair part works part-time, and a small part does not work at all. This means they are either retired, not able to work, in between jobs or a student. This result is opposite compared to the population, that note more part-time employees than fulltime employees (Centraal Bureau voor de Statistiek, 2019b). It should be noted that these numbers are not up-to-date as these are dating from 2011, however it cannot be logically expected that this has changed significantly over the past years.

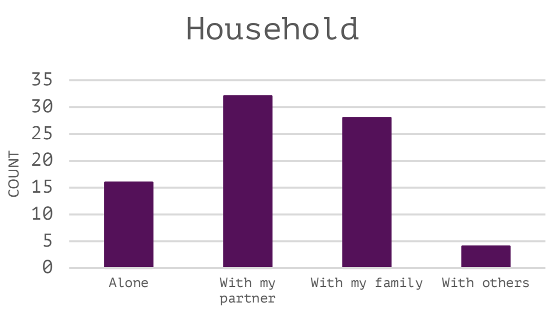


Figure 11. Household type of community

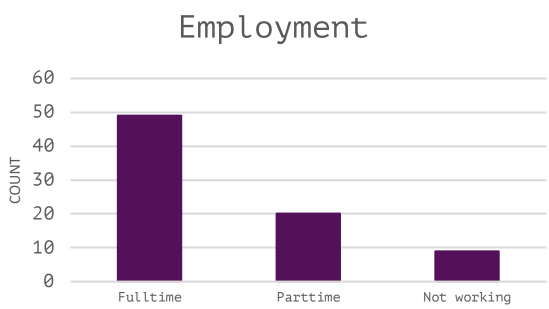


Figure 10. Employment type of community

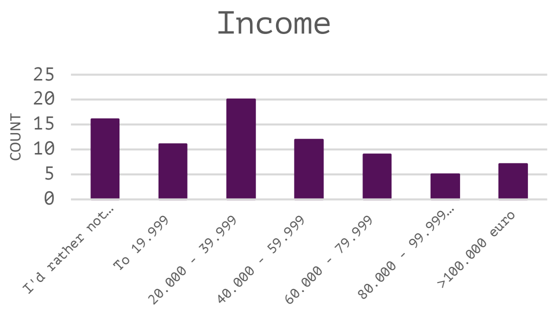


Figure 12. Income of sample of community

7.2 Travel behaviour

In this section the travel behaviour of the community is explored, first by defining vehicle ownership. 66% of the Hely users owned one or more cars on the time of subscription (Figure 13). More members in a household increases the number of cars that are possessed, hence most of the single households do not own a car, for two-person households it depends, and a family usually owns multiple cars (Table 14; p=0,005). Within this sample, households with two or more persons possess less cars relative to the population (Centraal Bureau voor de Statistiek, 2017).

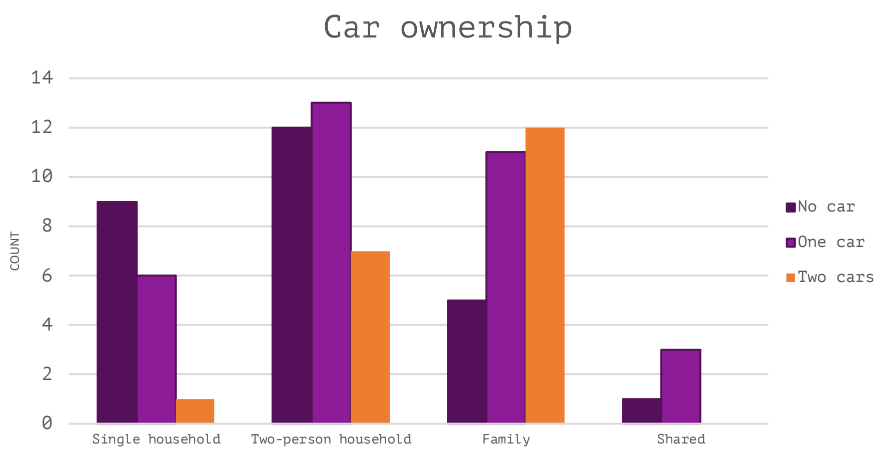
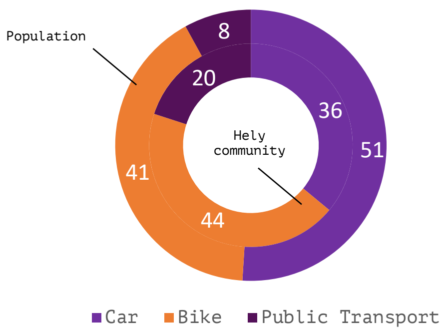
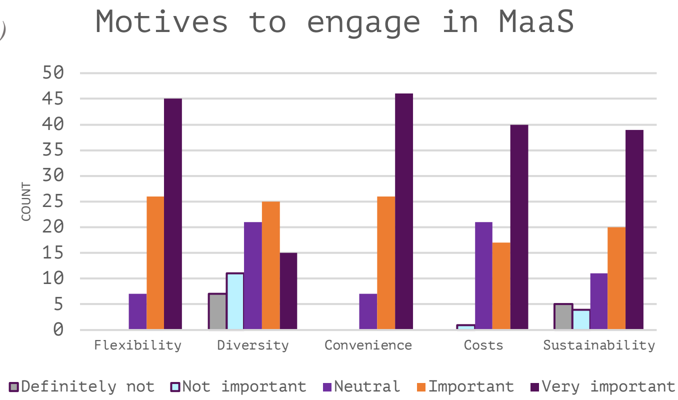


Figure 13. Car ownership per household type (N=80)

In terms of vehicle choice prior to the Hely service, the community mainly uses the bike, on average 12 times a week. The car is used 9 and public transport 5 times per week on average. This is a different modal split than the Dutch population has, as shown in Figure 14. The Hely community is less car-minded and prefers either bike or public transport as transportation. Zooming in on the specific neighbourhoods shows that Hub Delft knows mainly car owners, whereas the Amsterdam group knows more non-car owners. Moreover, in line with the neighbourhood characteristics that were described in section 3, Hub Delft has more families and Hub Amsterdam more 1-person households.

Figure 14. Modal split of Dutch population & Hely (%)





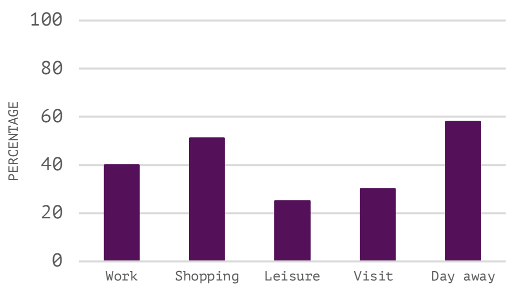
Flexibility: I do not want to commit, however use the service whenever I want to.
Diversity: I would like a large variation of modes to choose from.
Convenience: I want to easily plan, book, use and pay my journey.
Costs: I do not want to pay more on mobility than I currently do.
Sustainability: I would like to choose sustainable vehicles.

Figure 15. Motives for subscription

7.2.1 Addition of a Hely Hub

The Hely community mainly prefers a convenient service that is all-inclusive, from planning their journey to receiving their monthly invoice. Other than that, they prefer a flexible service that does not ask much commitment (Figure 15). Users that choose flexibility also like the service to be convenient, as these motives are correlated (Table 16; R^2=0,17). Also costs and sustainability are drivers to choose for MaaS, albeit in somewhat smaller proportions. Especially car users tend to choose Hely for sustainable motives (Table 15; p=0,01). Choosing between multiple modalities is less a motif to choose MaaS.
Users expect to use Hely for one or more specific trip purposes, such as work, shopping or leisure activities. Figure 16 shows that almost 60% of the clients see Hely as a possibility for day-activities. Non-car owners, and thus people that tended to use cars over bikes in the Hely Hub, chose this motif (Table 20 & Table 25). Furthermore, half of the users plan to use Hely for grocery shopping. Shoppers intent to use the e-car and bike more often (Table 20 & Table 21). Bikes were also preferred by users who tend to use Hely from and to work (Table 19; p=0,021). Lastly, women intend to use the cargo bike more often (Table 23; p=0,042). Visiting- and hobby-related trips are less a reason to visit a Hely Hub.

Figure 16. Trip purposes for using a Hely Hub

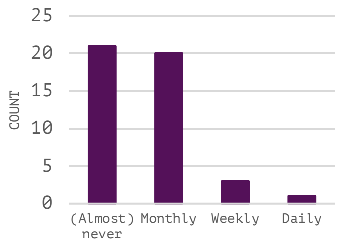


7.3 Use of the Hely Hub

There are 112 user-accounts in de Hely-application, of which 45 are considered active. Active accounts are defined by users that made one or more trip using a Hely vehicle. Of these accounts 65% are men and 35% women; 25 live in Delft and 20 in Amsterdam. Users live on different distances from the Hub. In total, 25 users live within walking distance of the Hub and 19 users are prepared to engage in a first/last mile to reach the Hely Hub.

45 clients engaged in a total of 189 trips over 120 days. Hub Delft and Hub Amsterdam account for 113 and 105 trips respectively. The use per user differentiates in two categories; first-timers and more frequent users. First-timers are clients that only tried-out the service one or two times. In total there were 24 users that have engaged in 3 trips or more during the test period. This covers 52% of the total trips made. Overall, we see that 40 users used Hely 1-3 times a month, and only a handful one to more times per week (Figure 17).

Figure 17. Use intensity of the users



Trips can be distinguished by the different buckets and modalities that are chosen. As can be seen in both Figure 19 and 20, cars are the preferred modality, covering 79% of the total trips that were engaged in. Of the cars the e-car is most popular, followed by the small car and the MPV. However, when accounting for the fact that 4 e-cars are provided, as opposed to 1 small car and 1 MPV, the small car has the highest use intensity, followed by the MPV and lastly the e-car (Figure 18). Furthermore, the non-car modes represent 21% of the total use, of which the cargo bike is chosen 4% of the times a person arrives at a Hely Hub. This entails in terms of bucket distribution that the XL bucket is the most popular, and the M bucket is least popular. It should be noted however that the cargo bike had some technical hitches during the test period and was not available fulltime. Interestingly, the modal split for first-timers is different than for more frequent users. First users preferred the e-bike over all other modalities. Overall, first-timers chose the non-car modalities 65% of the time when entering a Hely Hub. Also, females account for more non-car use, and specifically account for all cargo bike rentals (Table 25; p=0,002).

Figure 18. Use intensity per car type

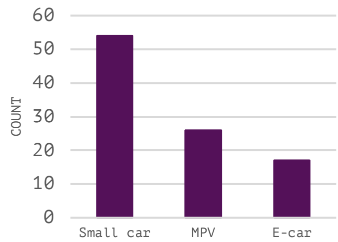


Figure 20. Modal split of a Hely Hub

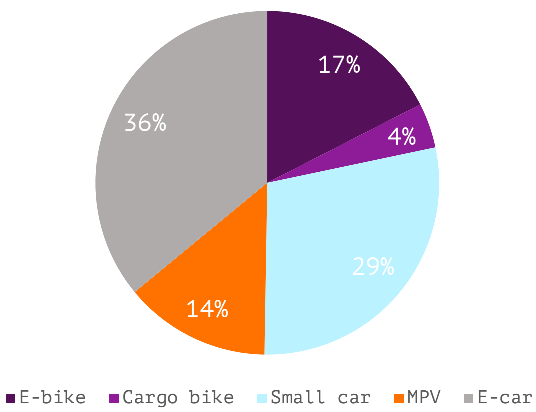
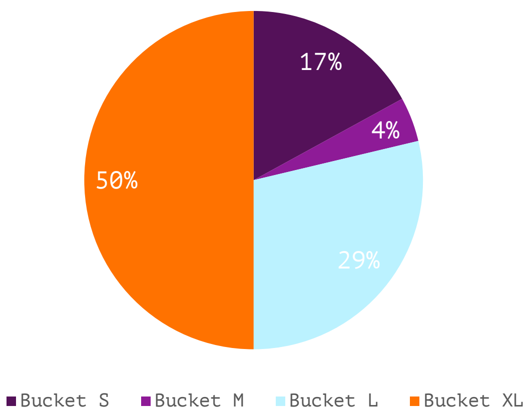


Figure 19. Bucket split of a Hely Hub



7.3.1 From intention to actual use

Users subscribed to Hely with a certain intention to use the service, either for a specific modality, trip purpose or just to try-out. These intentions were queried and resulted in Figure 21. Overall, we see comparisons between the intention and the actual use of the Hely Hub, with the e-car as most popular vehicle followed by the conventional car. Moreover, based on intention it was expected that the e-bikes were intended to be used more frequently. Especially people who have a car exclusive to themselves intended to use Hely-bikes more frequently (Table 17; p=0,031).

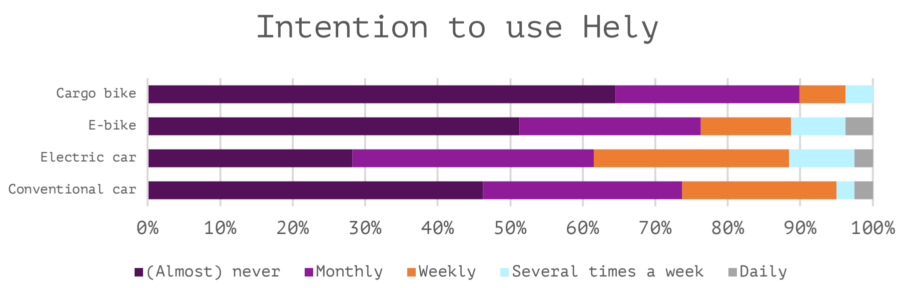
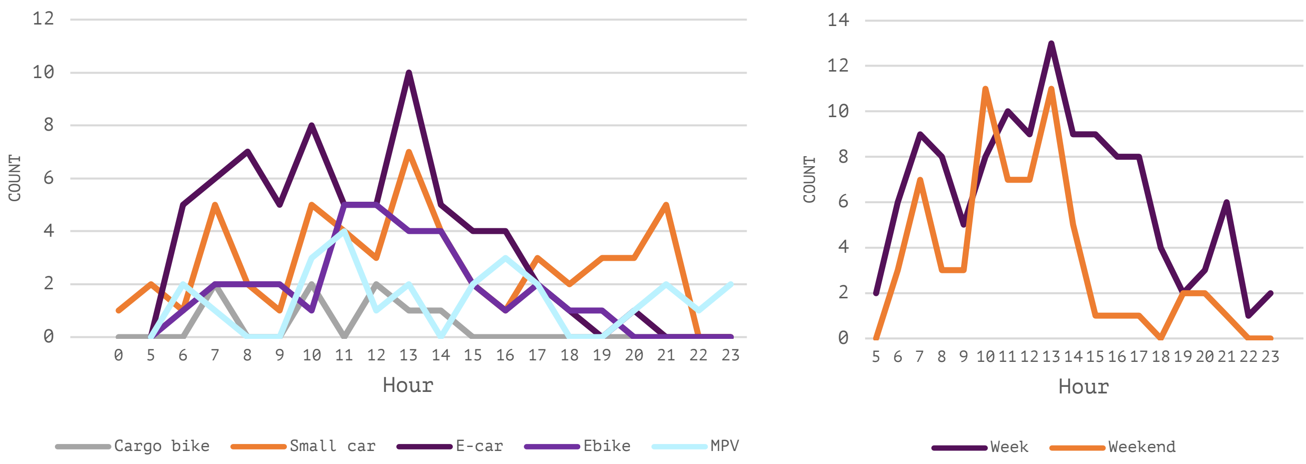


Figure 21. Intention to use the different modalities of the Hely Hub

7.3.2 Trip characteristics

The trips were investigated by weather condition, week type and trip time, of which the last one is differentiated in starting time and trip duration. A Hely Hub is used in both dry and wet weather; 59/41 percent of the times respectively. More specifically; rainy conditions do not imply specific modes being used more or less frequently (Table 27; p=0,91).

Figure 22. Starting hour rental per vehicle per day type

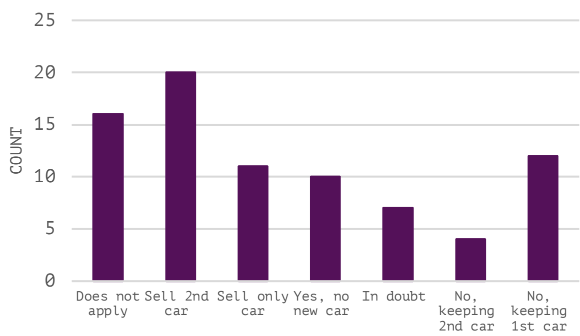


A second rental characteristic is that of the type of day. Travel behaviour is different during the week and weekends on the Hely Hub, namely as the starting times of the rentals are found to be significantly different (Table 28 & Table 29; p=0,035). During the week the rentals were more spread out during the day, having rentals from 0500h until 2300h. Weekend rentals were more condensed to the morning hours, peaking between 1000h and 1300h and having almost no rents after 1500h (Figure 22). Revisiting the possible motifs to use Hely, it can be hypothesized that these weekend trips correspond with "day away"-motif and leisure motif. However, it is not possible to conclude on this correlation of trip motifs and day type within this research. Moreover, there is no dependence of vehicle choice on day type for this sample. There is however a correlation of vehicle choice on the starting hour of a rental (Table 30; p=0,01). More specifically, the start of rentals on the MPV and the e-car differ. Furthermore, it is observed that after 2000h no rentals were started for Hub Amsterdam (as these only offer e-cars and bikes). It can be hypothesized people did not prefer to enter that Hub after sundown, as it is in a remote area without supervision. E-bikes are not rented at all after 2000h. For Delft we see a steadier rental rate during the day; especially the small car keeps a steady rental count. Lastly the rent duration per mode and bucket is indicated. All modalities, and thus the buckets note equal average duration times for all day types (around 3 hours on average; Table 32).

7.4 Private car intentions

Hely envisions to compete against the ownership of private cars, and specifically against ownership of the second car within a household. As stated earlier 20 households of Hely own two cars, 33 own one car and 27 do not own a car. The respondents were asked whether or not they consider selling their car upon subscribing to Hely. The results are depicted in Figure 23. Overall, most users state that they consider having less cars in their households, whereas 25 percent states that they will hold on to their private cars. Hely is seen mainly as a replacement for the households' 2nd car. Lastly, the type of employment relates to the intention to reduce the number of privately-owned cars; people that work fulltime are more inclined to sell their cars than part-time employees (Table 24; 0,042).

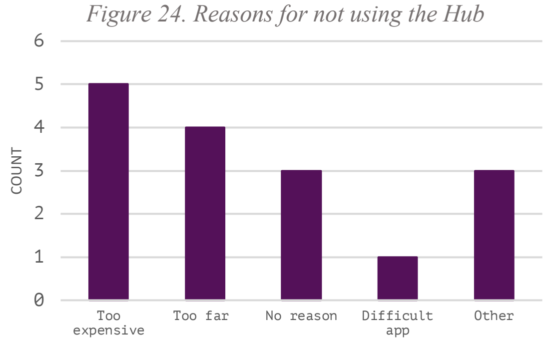
Figure 23. User's opinion of private car upon subscribing to Hely



7.5 Non-users

Non-users are the individuals that registered to Hely, downloaded the App and made an account, but did not engage in a trip thus far (Figure 24). The database showed a total of 67 of such accounts that were within the area of either Hub Delft or Amsterdam. A total of 16 people answered to the survey, that stated why they had not yet made a trip using Hely. The results are shown below. Mainly, people find it too expensive at this point or find the Hub too far away. 3 people intent to use Hely, however did not have a reason to. Only 1 found that the app is too difficult to use. Moreover, on respondent stated that he did not use Hely yet as he just bought a new car.

Figure 24. Reasons for not using the Hub



7.6 Conclusion

This chapter elaborates on the results of the analysis of the survey and the logged data. Two sub-questions were answered in this part.

What characterizes the Hely community?
There is a balanced group of man and women, mainly between the age of 25 and 35 that subscribed for the service. Moreover, users tend to be fulltime employees who are living in shared households with their partner or family. In terms of prior travel behaviour, the community owns and uses cars less than their respective Dutch residents. The Hely service should mainly provide convenience and flexibility, followed by costs and sustainability. Diversity is not deemed important compared to the other factors. Almost 60% of the client's intent to use Hely for day-activities and half of the users plan to use Hely for grocery shopping. Most users state that they consider having less cars in their households, whereas 25 percent state that they will hold on to their private cars. Hely is seen mainly as a replacement for the households' 2nd car.

How are the Hely Hubs and subsequent modalities used?
The modal split of the Hub reveals that cars are the preferred modality, covering 79% of the total trips that were engaged in. The small car has the highest use intensity followed by the MPV and lastly the e-car. Furthermore, the non-car modes represent 21% of the total use, of which the cargo bike is chosen 4% of the times a person arrives at a Hely Hub. This entails in terms of bucket distribution that the XL bucket is the most popular, and the M bucket is least popular. Interestingly, the modal split for first-timers is different than for more frequent users, showing a dominant use of the e-bikes. Overall, we see comparisons between the intention and the actual use of the Hely Hub, with the e-car as most popular vehicle followed by the conventional car. Moreover, based on intention it was expected that the e-bikes were intended to be used more frequently.
Trips that are made with Hely were investigated by weather condition, week type and trip time, of which the last one is differentiated in starting time and trip duration. Travel behaviour is different during the week and weekends on the Hely Hub, namely because the starting times are significantly different. All modalities, and thus the buckets note equal average duration times, around 3 hours on average.

8 Conclusion

Subscribers to Hely search an addition on their current travel behaviour that serves their travel needs more accurately, either for substituting other modes or engaging in more trips. The aim of this study is to provide first insight into the users and use behaviour of the first Hely Hubs. It answers the following research question:

"What is the travel behaviour of a community that uses a closed-user multimodal MaaS-hub?".

The Hely community is characterized by progressive metropolites, who are mainly innovative bike- and public transport-using young professionals that seek a flexible and convenient service. The Hely community accesses the Hub either by foot or by bike, engaging in 3-hours trips on average. Currently, the Hubs reveal travel behaviour with the shared (e-)car in its centre; covering 79% of the total trips that were engaged in. The small car has the highest use intensity followed by the MPV and lastly the e-car. The remaining modalities are much less used, even less than initially intended. Subsequently, the motivation to use Hely for its multimodality is currently not widely supported by the community. Moreover, mode choice is independent from weather conditions and type of day. It can therefore be concluded that at this point, a Hely Hub mainly eases accessibility of cars for individuals that do not use one.

The results are a stepping stone towards an effective evaluation methodology for Hely that is able to (1) tailor the Hely-service better to their users and (2) validate the objective of reducing private car ownership by Hely more accurately. This proposed evaluation methodology is elaborated upon in more detail in Section 8.2. First, the limitations of this research are described.

8.1 Limitations of the research

This study has several limitations, all origin from the fact that the test period covered the first 120 days of the Hely service. The users and usage at T0 were zero and the resulting sample size of users and consequent usage was less than expected, and thus statistical power of this research is lacking. Moreover, the initial concept of measuring *change* in travel behaviour through an additional after-survey did not yield enough respondents. This also resulted in insufficient data to establish social and environmental impact of the Hub. The research showed that tracking individuals during a test period will significantly reduce response when they are not actively and knowingly participating in an experiment, even if they are provided with a bonus for participating. Also, the test period was during the Dutch winter period. Although this study accounted for weather conditions, it could be that during summer the usage of a Hely Hub shifts towards a different modal split.
The described limitations were mainly time constraints and, as Hely's clientele and Hub development is gradually rising the coming months, it will be possible to conduct the initially research that was setup. This is elaborated in the next section.

8.2 Recommendations for future research

The recommendations are divided into those addressed to the scientific community and to Hely specifically. It should be noted that for Hely also the described recommendations in 8.2.1 are worthy to pursue.

8.2.1 Scientific community

The multimodal MaaS-hubs provide an interesting addition to the growing MaaS-literature and pilots. This study reveals a first grasp of the travel behaviour on these hubs. It is proposed that, following Karlsson et al., (2017), this is investigated more in-depth through an after-survey that measures changing behaviour by intervention of a multimodal MaaS-hub. Defining the change of travel behaviour by a hub can also evaluate the social, sustainable and business impact of these hubs. Following the KPIs from this framework, the panel after-survey should focus on the following four characteristics:

1. Total number of trips that are made by adding a multimodal MaaS-hub to one's travel options.
2. Defining what non-hub transportation mode is substituted per specific hub-vehicle.
3. Measure the modal split of the hub for different seasonal weather conditions.
4. Measure and compare the attitude towards different modalities after a certain period upon the prior attitude, but also attitude towards electric vehicles, shared mobility and private car ownership.

More specifically; conducting a before/after-survey enables the possibility to establish a panel-survey on individual level. This panel-survey should focus on weekly individual trips, which is most efficient for smaller sample sizes such as first-engaging MaaS-groups. Also, using more responses and covering a longer research period will help establish a more robust research. Additionally, and also done in previous pilots, including qualitative interviews enables to explain the results of these surveys with more context.

Also, a multimodal MaaS-hub is among the first that can test the choice process of an individual when provided with multiple modalities under different circumstances in real life. This can also include the willingness-to-pay, as this study shows costs are an important barrier to start using MaaS-modalities. Indicating choice processes helps forecasting the demand for modalities more accurately and subsequently helps tailoring MaaS-services better to its users and contexts. A proposed method to track these processes in real life is to execute a travel diary under frequent hub-users, who are ideally users of all modalities within this hub. Travel diaries are frequently used in MaaS-studies (Sochor et al ,2014).
A travel diary enables to track the number of trips per modality and the characteristics and contextual factors per trip. These variables address the question how modalities are used and for what kind of trips specifically. This method allows to record a large number of trips using a relatively small number of respondents. Travel diaries are often activity-focused, as activities are better recalled by respondents (Harvey, 2003). The characteristics of these trips can best be structured by limited options, as advised in Harvey (2003) and as done by for example Centraal Bureau voor de Statistiek (2018). This increases simplicity for the respondent and provide easier workable results for the researcher. Crucial in the process of collecting data of travel diaries is that, as it is more time consuming than standard surveys, people should be extra willing to cooperate. This means, the researcher is to make contact with the respondents more explicitly, in order to obtain a satisfactory response rate. This can have implications in time and costs for the researcher.

This research did not include any economical or cost aspects. The costs for customers are off course a crucial part of the service, as is also supported by the data of the non-user group. Apart from the willingness-to-pay for different modalities within the hub, future research should also focus on the changing total travel costs for multimodal hub clients and the subsequent sensitivity of these changes for different contexts and user characteristics.

8.2.2 Hely

Hely collects responses of the before-survey continuously. By designing an accompanying after-survey, a panel survey specifically for Hely can be established fairly quickly. A proposed after-survey and collection method that can be used by Hely is included in Appendix K. This way a more accurate evaluation methodology on the impact of Hely within different neighbourhoods can be established, and subsequently specific characteristics of different Hubs or neighbourhoods can be compared. Moreover, changes and additions of Hely's service and/or Hub proposition can be tracked carefully. An addition to the service is for example public transportation. Hely is planning to incorporate public transportation in the near future and it is advised to study the behaviour after this intervention in the Hely community closely, as literature states public transportation is an important element for establishing a MaaS service (Section 2.2.6).

Hely closely cooperates with property owners and municipalities and an important part of their business case is dependent on this cooperation. Ideally, Hely proposes its service as an integral part of a new residential area, in which new residents are offered the Hely service as supplement in their housing contract. For Hely to become an essential component for residential property owners, qualitatively interviewing these stakeholders is advised, so that specific expectations of these stakeholders and cooperation can be managed more accurately.

Karlsson et al., (2017) defined a third “business” impact, that is defined by six KPIs; number of customers, customer segments, revenues/turnover, data sharing, partnerships in the value chain, changes in responsibilities. For Hely it is interesting to address these KPIs in the future, especially to track their development for reaching critical mass in the market and subsequently becoming the stage manager of the Dutch mobility market, as also addressed by literature in section 2.2.1 and Hely’s vision in section 3.

Lastly, the results imply that social safety within the Hub is an aspect that possibly constraints use after 2000h. For Hely to become an always accessible and trustworthy service, it should be further explored whether this is a real motif. This could provide an extra constrain for choosing future Hub locations.

9 Discussion

The use of Hely always steers towards sharing products instead of owning one, which on the long-term increases resource efficiency as a whole. The Hely service is making different vehicle types available to all within a designated area. This enables for clients to tailor its mobility to specific needs and providing a low threshold to try-out new modalities (Sochor et al., 2016). The Hely community can best be described as progressive metropolites that seek a service that provides convenience and flexibility; diversity of modes is not deemed important compared to the other factors. The modal split of the Hub reveals that cars are the preferred modality, independent from all trip characteristics. Therefore, at this point a Hely Hub mainly eases accessibility of cars for individuals that do not use one frequently. This result is supported by, among others, Matyas & Kamargianni (2018) and Mulley (2018), who emphasize the dominant mindset of travelling by car. On the other hand, other MaaS pilots proved to reduce private car ownership significantly. Hence, the specific modal split of the multimodal MaaS-Hubs from Hely are further discussed. Secondly, first insights into the possible social and sustainable impact of the Hubs on its environment are discussed, using the assessment framework of Karlsson et al. (2017).

9.1 Explaining dominant car use

The dominant car use of the Hub can be discussed by two characteristics of the pilot that was executed; Hub location and bikes and public transportation in de Netherlands.

9.1.1 Hub location

Hely intends to substitute private car use by (cargo) e-bikes and shared cars. Bikes can theoretically only really compete to cars in inner-cities, as for all other area's cars are deemed the most efficient point-to-point transportation mode. The resulted modal split for Delft and Amsterdam proved this, as both are well-established urbanised neighbourhoods, however both Hubs did not trigger bike use. Therefore, an external driver and specific context seems important to trigger this specific modal shift. Neighbourhoods without parking spaces within inner-cities are considered to be the best areas for Hely to add public value, as these circumstances nudge people towards considering alternative mobility solutions. In the Netherlands however, there are few real inner-city densities (however increasing), which narrows the possibility to substitute cars by bikes significantly (Planbureau voor de Leefomgeving, 2015).

9.1.2 Bike riding and public transportation in the Netherlands

Different literature (Section 2.2.6) emphasizes the importance of public transport to establish a sustainable mobility system through MaaS. Adding public transportation to the multimodal Hubs will change the possibilities for which the Hub can be used by enabling multimodal trips. As the Hely-service strives to provide all mobility, planning and payment within the application and with the Dutch public transportation system being well established and accessible within urban areas, this could be a gamechanger for the proposition of Hely in terms of their public value. As an example, the successful MaaS-pilots of UbiGo and SMILE provided an efficient multimodal trip that could compete against the private car by having public transport as a backbone in their service. This could potentially help create a modal shift away from point-to-point car usage.
It should be noted however, that all Dutch residents have easy access to, or own, a bike. Bike riding is something that is deeply embedded into Dutch culture. It can therefore be questioned whether providing multimodality through extra bikes within the neighbourhood would actually impact any mode transportation choice for a Dutch resident. This also means that the first/last mile combining the bike and public transportation is already a well-established multimodal trip in the Netherlands (Kennisinstituut voor Mobiliteitsbeleid, 2014).

Thus, it is difficult for the multimodal Hubs to compete with private vehicles and public transportation in general in the Netherlands. To substitute these vehicles on the long-term requires clear economic benefits of the MaaS-hubs, and/or in terms of short-term public value a clear beneficial sustainable aspect of the service. This could be done by pursuing the all-electric Hubs more intensively. Moreover, Hely will possibly really start adding their public value when they are able to unlock their shared services for their users on all different locations, so that mobility is accessible in areas where the user does not have a private vehicle. This then enables the multimodal trip and unlocks the all-inclusive service that Hely has envisioned.

9.2 Social and Environmental impact

Karlsson et al. (2017) designed multiple Key Performance Indicators (KPIs) that help define the usage of MaaS-initiatives on a societal level, namely by indicating environmental and social impact (Appendix C). To define these impacts, it uses KPIs that are described using aspects of the individual travel behaviour of MaaS-services; (1) the total number of trips; (2) modal shift; (3) multimodal trips; (4) perceived accessibility; (5) attitudes towards mobilities. The description of the KPIs for the Hubs are defined in Table 34.

KPI	Impact of multimodal MaaS-hubs
Number of trips made	At this point it cannot be indicated whether Hely reduces, substitutes or adds trips to the total mobility system, as there is no information whether private vehicles were used less due to Hely.
Modal shift	In terms of modal shift, the Hubs seem to either extent the overall pie with car trips, substitute public transport- and bike-use by car trips or replace private cars by shared cars, of which only the last will add public value to the system.
Number of multimodal trips	The Hely community does engage in a first/last mile towards the Hub and thus in multimodal transportation. To use a Hely-vehicle towards for example the train is not yet cost-efficient, due to the fact that using a Hely-vehicle is a two-way trip which always ends at the Hub.
Attitudes towards modalities	The attitudes are measured towards all Hely modalities prior to use of the Hely Hub. All vehicles have some intention to being used, albeit in different frequencies. The attitude towards the (e-)car is best.
Accessibility to transport	Hely clearly enhances accessibility to transport. People are able to access multiple vehicles within their neighborhood 24/7, which increases to tailor transportation to the trip needs more accurately. Despite that Hey is currently only available for closed user groups within cities, the results show it is an accessible service used for various income- and age-groups.

Table 34. KPIs and impacts on individual level of Hely (adapted form Karlsson et al., 2017)

The impact on societal level is then defined by four KPIs, that are provided in Table 35. These KPIs are defined by the individual KPIs that are described above. This resulted in the following impact descriptions of the multimodal MaaS-Hub.

KPI	Impact
Emissions	Emissions are dependent on total number of trips, modal shift and level of electric fleet. The total number of trips that were made by an individual was not accurately established. There was a dominant use of cars on the Hub, mainly coming from bike and public transport users. On the other hand, Hubs account for 66% electric rides and a substantial part actively considers selling their private car due to Hely. Thus, no conclusive result on emissions can be provided.
Resource efficiency	The influence of MaaS on resource efficiency is a nuanced dynamic, depending on reduced private cars and total number of trips added/reduced by the Hub in total. There is an intention to sell the private car, however most users use Hely to have easy access to a car.
Modification of vehicle fleet	Hely drives a modification of the fleet, both towards different modalities and electric vehicles and sets a low threshold to try-out these vehicles. There was a dominant positive attitude and use of the e-car. Moreover, the e-bikes and cargo bike are tried, however somewhat less than intended.
Citizens accessibility to transport services	Hely enhances accessibility to transport. People are able to access multiple vehicles within their neighborhood 24/7, which increases to tailor transportation to the trip needs more accurately. Despite that Hey is currently only available for closed user groups within cities, we see an accessible service used by various income- and age-groups.

Table 35. KPIs and impacts on societal level of Hely (adapted form Karlsson et al., 2017)

The social impact of a MaaS-hub is beneficial to its environment, by making multimodal vehicles available to all social groups within a designated area. This also enables tailoring mobility to specific client needs and providing a low threshold to try-out modalities, which supports modification of the vehicle fleet. Establishing a beneficial social impact does however not mean simultaneously enhancing sustainability. From the results of this research it could not be discussed whether a multimodal Hub reduces emissions and resource efficiency, and thus sustainability within the social system as a whole, mainly due to the lack of insights on total number of trips made by clients. It is advised to further explore this in the previously mentioned recommendations section.

9.3 Concluding remarks

Hely as a start-up strives to contribute to more quality-of-life within cities, by reducing private car ownership. However it may contribute to some private cars being used less, the main contribution of their Hubs currently through the use of their shared cars. This way, it most likely contributes to the number of trips made by car in total or in the best scenario substitutes exactly equal number of trips made by private cars. At this point, Hely thus is a mobility solution that is comparable to that of the shared car service, and their claim to "relieve neighbourhoods of private car ownership" remains an unsupported one. Reducing private car use seems largely dependent on the individual specific values and contextual factors like parking quotas, and not so much on Hely's proposition.
On the short term, public value of Hely lies within their ability of making mobility more accessible in densely populated areas and providing the possibility to test new modalities for their users. Moreover, by providing an all-electric Hub, as done in Amsterdam, the claim of Hely to be a sustainable solution for mobility would currently be justified. In terms of transmitting added public values towards possible partners, these aspects are currently better-grounded claims than reducing private car use.

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Appendix A| Scientific Article

A study into the travel behaviour on a multimodal Mobility-as-a-Service hub within a closed-user area

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Abstract

Hely has developed Mobility as a Service (MaaS) through multimodal Hubs, which are offered within closed-user residential areas and made accessible through an application. This exploratory study aims to assess people's mobility behaviour by the usage of Hely in a closed user group. It focused on two aspects: the indication of (1) the community and (2) the use on the hubs by this community. The community is characterized by mainly innovative bike- and public transport-minded young professionals that seek a flexible and convenient service. The motivation to use Hubs for its multimodality is currently not widely supported by the community. Moreover, the Hubs reveal travel behaviour with the shared (e-)car in its centre, independent of all trip characteristics. Therefore, it can be concluded that currently a multimodal MaaS-Hub mainly eases accessibility of cars for individuals that do not use one often, which emphasizes the car as a lasting dominant factor within the current mobility market.

Keywords

Mobility-as-a-Service, MaaS, multimodal, mobility, hub, shared, travel service, travel behaviour

1 Introduction

City-populations are growing at a high rate and therefore there's a higher need to be efficient with city-space to enable peoples' mobility (Ministry of Transport, 2016; Rodrigue, Comtois, & Slack, 2013; Lee & Sener, 2016). By providing Mobility-as-a-Service, various forms of transport are integrated into a user-tailored service, and accessible by individuals on demand (MaaS Alliance, n.d.). MaaS intends to free people from needing to own vehicles, hence reducing the existent fleet and maximising the utilisation of the remaining fleet. It therefore relies on the trends of digitalization, the sharing economy and the declining view on the car as status symbol (Pakusch, Bossauer, Shakoor, & Stevens, 2016). Public decision makers and researchers are expecting that MaaS will establish a next paradigm shift in mobility. Ideally, it would one day even substitute the private ownership of cars as a whole (MaaS Alliance, n.d.). However, these optimistic statements still lack substantial scientific support, as much is still to be explored within the field of Mobility-as-a-Service (Giesecke, Surakka, & Hakonen, 2016). Karlsson, Sochor, Aapaoja, Eckhardt, & Konig (2017) advise to provide more empirical evidence of behavioural change by MaaS. Specifically, it is shown that the sensitivity of traveller's behavioural change after introduction of MaaS is most probably unknown and to that extent, what behaviour will change particularly.

Hely is a startup that has developed Mobility as a Service (MaaS) through so-called Hely Hubs. These hubs include a group of different modalities, being (e-)bikes, cargo bikes and (e-)cars, which are offered in designated

residential areas and are made accessible through the Hely application. Hely entered the mobility market in December 2018, by launching two Hubs in Delft and Amsterdam. At this point there is no insight in the Hely community, its travel behaviour on the Hely Hub, let alone in what way travel behaviour changes using Hely's service. Moreover, desired reduction of private car use by the service is thus not yet established for this particular MaaS-concept. This study aims to take the first step and assess people's mobility behaviour by the usage of Hely in a closed user group. The research is further shaped by the research question, which is defined as follows: *"What is the travel behaviour of a community that uses a closed-user multimodal MaaS-hub?"*. This research question is focused on two aspects; the indication of (1) the community and (2) the use on the hubs by this community. It uses the Hely's clientele and database for this investigation.
The research will be exploratory, which entails that it helps defining the context more accurately and possible problems more clearly, rather than providing conclusive solutions (Saunders, Lewis, & Thornhill, 2012). The study first elaborates on the specifications of Hely, after which the methodology is explained. The travel behaviour is revealed in the findings section. This will lead to a conclusion in which the main research question is answered. The conclusion is then discussed in a broader context using the known literature.

2 Hely

Hely is a Dutch company that currently exploits Mobility-as-a-Service (MaaS) as their core concept. Hely is "a well-funded start-up that makes shared mobility easier, more accessible and more flexible. No hassle with different apps and shared mobility providers, Hely takes care of all your favourite modes of transportation in one simple app'' (Hely, n.d.). Hely enters the mobility market through multimodal shared Hubs. These hubs provide a group of different modalities, being (e-)bikes, cargo bikes and (e-)cars, which are offered in designated residential areas and are made accessible through the Hely application. Public transport is not yet included in Hely's proposition. For pricing Hely uses 4 buckets that are defined by different hourly prices, in which the modalities are categorized. The enrolment of the first hubs are established in December 2018. For researching the Dutch mobility landscape, it should be noted that there exists a particular modal split, namely that the mobility in the Netherlands is particularly bike-minded. Moreover, the public transportation system is very well established and represented in the total modal split (Centraal Bureau voor de Statistiek, 2018).

3 Methodology

The results were derived from the first 120-day operational period from December 2018 to March 2019, using two Hubs in Amsterdam and Delft. The users and usage of the Hubs are investigated independently and pooled together, to maximize the dataset and optimize reliability of the results. The users and usage are measured through two methods:

1. A user-survey, which established the characteristics of the users, their prior travel behaviour, intention and motives to use the service, and attitude towards modalities;
2. Investigation of Hely's database, which enabled to describe the number of trips, modal split of the hub, multimodality and accessibility of the service and trip characteristics.

Database exploration is done through Microsoft Excel. Dependencies of all variables are indicated by univariate analyses through SPSS. The survey gained 80 responses on persons that are subscribed for either the Delft or Amsterdam Hub. There are 112 user-accounts in de Hely-application, of which 45 are considered active. Active accounts are defined by users that made one or more trip using a Hely vehicle. 45 clients engaged in a total of 189 trips over 120 days; Hub Delft and Hub Amsterdam account for 113 and 105 trips respectively.

4 Findings

The results are divided in two parts: (1) the Hely community is established and (2) the usage on the Hub is revealed.

Hely community

The Hely subscribers are mainly between 25 and 34 years old and live in either a two-person household or with kids. The largest part works fulltime and more males than females subscribe for the Hely service. However, per age category, man and women are distributed equally. Their income is similar to the Dutch population (Centraal Bureau voor de Statistiek, 2019). The households in this sample are mainly represented by two members or families. Some users live alone, and some share a house with others. The Hely users within these households are mainly working fulltime and are highly educated; 72% finished a study. Moreover, a fair part works part-time, and a small part does not work at all. This means they are either retired, not able to work, in between jobs or a student.

66% of the Hely users owned one or more cars on the time of subscription. Households with two or more persons possess less cars relative to the population (Centraal Bureau voor de Statistiek, 2018). Most users stated that they consider having less cars in their households after subscribing to Hely, whereas 25 percent states that they will hold on to their private cars. Hely is seen mainly as a replacement for a households' 2nd car.
Prior to Hely, the community mainly uses the bike, on average 12 times a week. Moreover, the car is used 9 and public transport 5 times on average per week. This is a different modal split than the Dutch population has for car, bike, and public transport, as can be seen in Figure 2. This shows that the Hely community is less car-minded and prefers either public transport or bike as means of transportation. Respondents mainly intent to use the e-car in the Hely Hub, followed by the conventional car. Moreover, e-bikes are considered to be use somewhat less in total, however more frequently per user. People showed that the multimodality of the Hub was not a motivation to join the Hub (Figure 1).

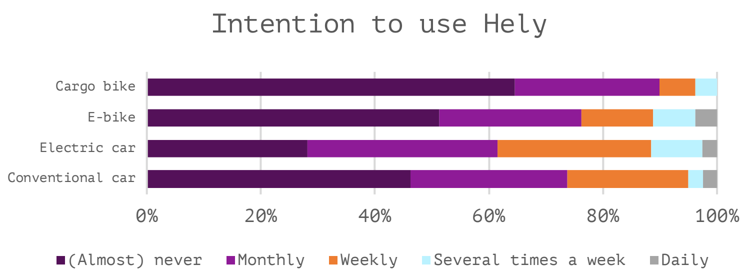


Figure 1. Intention towards Hely vehicles

Hely Hub use
45 clients engaged in a total of 189 trips over 120 test-days. Users lived on different distances from the Hub. In total, 25 users lived within walking distance of the Hub and 19 users were prepared to engage in a first/last mile to reach the Hely Hub. The use per user is differentiated in two categories; first-timers and more frequent users. First-timers were clients that only tried-out the service one or two times. In total there were 24 users that have engaged in 3 trips or more during the test period. This covers 52% of the total trips made. Overall, we see that 40 users used Hely 1-3 times a month, and only a handful one to more times per week.
Trips can be distinguished by the modal split. Cars are the preferred modality, covering 79% of the total trips that were engaged in (Figure 3). The e-car is most popular, followed by the small car and the MPV. However, when accounting for the fact that 4 e-cars are provided, as opposed to 1 small car and 1 MPV, the small car has the highest use intensity. Furthermore, the non-car modes represent 21% of the total use, of which the cargo bike is chosen 4% of the times a person arrives at a Hely Hub. Interestingly, first-timers chose the non-car modalities 65% of the time upon entering a Hely Hub. Also, females account for more non-car use, and specifically for all cargo bike rentals. Mode choice did not depend on the weather condition and day type.

Figure 2. Modal split of Hely and population

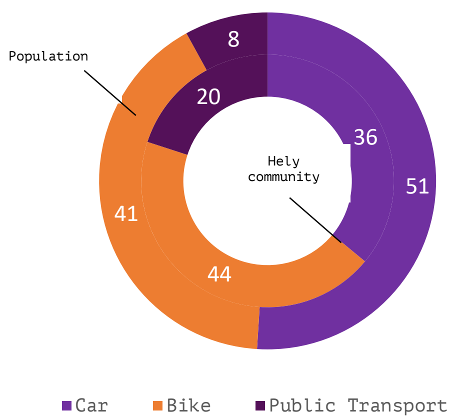
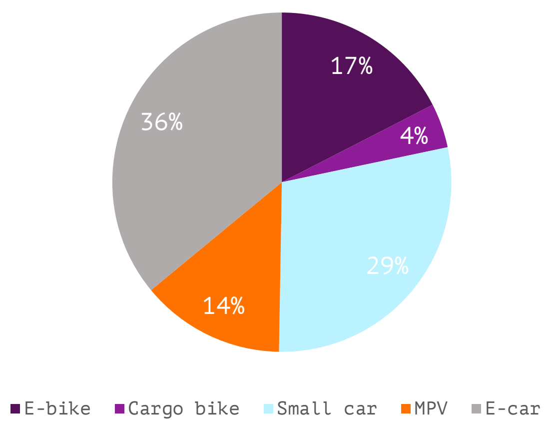


Figure 3. Modal split of a Hely Hub



4 Conclusion

The aim of this study is to provide first insight into the users and use behaviour of multimodal MaaS-Hubs. It answers the following research question: *"What is the travel behaviour of a community that uses a closed-user multimodal MaaS-hub?"*. The use of a MaaS-Hub always steers towards sharing products instead of owning one, which on the long-term increases resource efficiency as a whole. The service makes different vehicle types available to all within a designated area. This enables for clients to tailor its mobility to specific needs and provides a low threshold to try-out new modalities. The community is characterized by mainly innovative bike- and public transport-minded young professionals that seek a flexible and convenient service. The community accesses the Hub either by foot or by bike, engaging in 3-hours trips on average. The Hubs reveal travel behaviour with the shared (e-)car in its centre; covering 79% of the total trips that were engaged in. The small conventional car has the highest use intensity. The remaining modalities are much less used, even less than initially intended. Subsequently, the motivation to use Hely for its multimodality is currently not widely supported by the community. Moreover, mode choice is independent from weather conditions and type of day. Therefore, it can be concluded that, at this point, a Hely Hub mainly eases accessibility of cars for individuals that do not use one often.

Limitations of the study

This study has several limitations, all origin from the fact that the test period covered the first 120 days of the Hely service. The users and usage at T0 were zero and the resulting sample size of users and consequent usage was limited, and thus statistical power of this research is lacking. Moreover, the initial concept of measuring *change* in travel behaviour through an additional after-survey did not yield enough respondents. The research showed that tracking individuals during a test period will significantly reduce response if they are not actively and knowingly participating in an experiment, even if they are provided with a bonus for participating. Also, the test period was during the Dutch winter period. Although this study accounted for weather conditions, it could be that during summer the usage of a Hely Hub shifts towards a different modal split.
The described limitations were mainly time constraints and as Hely's clientele and Hub development is gradually rising the coming months. Therefore, the limitations of this research can be used as a setup for future research.

Recommendations for future research

The multimodal MaaS-hubs provide an interesting addition to the growing MaaS-literature and pilots. This study reveals a first grasp of the travel behaviour on these Hubs. It is proposed that, following Karlsson et al., (2017), this is investigated more in-depth through an after-survey that measures changing behaviour by intervention of a multimodal MaaS-hub. Defining the change of travel behaviour by a Hub can also evaluate the social, sustainable and business impact of these Hubs. Following the KPIs from this framework, the panel after-survey should focus on the following four characteristics:

5. Total number of trips that are made by adding a multimodal MaaS-hub to one's travel options.
6. Defining what non-Hub transportation mode is substituted per specific Hub-vehicle.
7. Measure the modal split of the Hub for different seasonal weather conditions.
8. Measure and compare the attitude towards different modalities after a certain period upon the prior attitude, but also attitude towards electric vehicles, shared mobility and private car ownership.

More specifically; conducting a before/after-survey enables the possibility to establish a panel-survey on individual level. This panel-survey should focus on weekly individual trips, which is most efficient for smaller sample sizes such as first-engaging MaaS-groups. Also, using more responses and covering a longer research period will help establish a more robust research. Additionally, and also done in previous pilots, including qualitative interviews enables to explain the results of these surveys more in-depth.

Also, a multimodal MaaS-hub is among the first that can test the choice process of an individual when provided with multiple modalities under different circumstances in real life. This can also include the willingness-to-pay, as this study shows costs are an important barrier to start using MaaS-modalities. Indicating choice processes helps forecasting the demand for modalities more accurately and subsequently helps tailoring MaaS-services better to its users and contexts. A proposed method to track these processes in real life is to execute a travel diary under frequent Hub-users, who are ideally users of all modalities within this Hub. Travel diaries are frequently used in MaaS-studies (Sochor et al., 2014).

This research did not include any economical or cost aspects. The costs for customers are off course a crucial part of the service, as is also supported by the data of the non-user group. Apart from the willingness-to-pay for different modalities within the Hub, future research should also focus on the changing total travel costs for multimodal Hub clients and the subsequent sensitivity of these changes for different contexts and user characteristics.

5 Discussion

The modal split of the Hub reveals that cars are the preferred modality, independent from all trip characteristics. Therefore, at this point a Hely Hub mainly eases accessibility of cars for individuals that do not use one frequently. This result is supported by (Matyas & Kamargianni, 2018; Mulley, 2018) that describe the dominant mindset of travelling by car. On the other hand, other MaaS pilots proved to reduce private car ownership significantly. Hence, the specific modal split of the multimodal MaaS-Hubs from Hely are further discussed.

Multimodal hubs intend to substitute private car use by (cargo) e-bikes and shared cars. Bikes can theoretically only really compete to cars in inner-cities, as for all other area's cars are deemed the most efficient point-to-point transportation mode. The resulted modal split for Delft and Amsterdam proved this, as both are well-established urbanised neighbourhoods, however both Hubs did not trigger bike use. Therefore, an external driver and specific context seems important to trigger this modal shift. Neighbourhoods without parking spaces within inner-cities are considered to be the best areas for Hely to add public value, as these circumstances could nudge people towards considering alternative mobility solutions.

Also, Karlsson et al., (2017) emphasize the importance of public transport to establish a sustainable mobility system through MaaS. Adding public transportation to the multimodal Hubs will change the possibilities for which the Hub can be used by enabling multimodal trips. As an example, the successful MaaS-pilots of UbiGo and SMILE provided an efficient multimodal trip that could compete against the private car by having public transport as a backbone in their service. It could potentially help create a modal shift away from point-to-point car usage.

Lastly, specifically for the Netherlands, it should be noted that all Dutch residents have easy access to, or own, a bike. Bike riding is something that is deeply embedded into Dutch culture. It can therefore be questioned whether providing multimodality through extra bikes within the neighbourhood would actually impact any mode transportation choice for a Dutch resident. Moreover, the first/last mile using the bike is already a well-established multimodal trip in the Netherlands (Kennisinstituut voor Mobiliteitsbeleid, 2014).

6 Literature

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Appendix B| Examples of MaaS

Naam	Locatie	Status	Vervoerswijzen	Niveau van integratie
moovel	Hamburg en Stuttgart, Duitsland	Operationeel (2015-)	Autodelen, taxi, stedelijk ov, regionaal ov.	Niveau 2 (gedeeltelijk, integratie van betalen).
myCicero	Italië	Operationeel (2015-)	Stedelijk ov, regionaal ov, internationaal ov, parkeren, toegang tot stedelijke 'congestion charging zones'.	Niveau 2 (gedeeltelijk, integratie van betalen).
NaviGoGo	Dundee en North East Fife regio, Schotland, VK	Operationeel (2017-)	Autodelen, taxi, stedelijk ov, regionaal ov.	Niveau 2 (gedeeltelijk, integratie van betalen).
iDPASS	Frankrijk	Operationeel (2017-)	Autohuur, taxi, valet parkeren.	Niveau 2 (gedeeltelijk, integratie van betalen).
Tuup	Turku regio, Finland	Operationeel (2016-)	Autodelen, fietsdelen, taxi, stedelijk ov, DRT.	Niveau 2 (gedeeltelijk, integratie van betalen), integratie van ticketing i.o..
Hannovermobil	Hannover, Duitsland	Operationeel (2014-)	Autodelen, taxi, stedelijk ov, regionaal ov.	Niveau 2.
EMMA (TaM)	Montpellier, Frankrijk	Operationeel (2014-)	Fietsdelen, autodelen, stedelijk ov, parkeren.	Niveau 2.
Business kaarten: NS Business Card, MobilityMixx, Radiuz Total Mobility, etc.	Nederland	Operationeel (nationaal bereik van deze kaarten sinds 2013)	(Autodelen, parkeren, brandstofkosten, e-auto laden, taxi, autohuur), fietsdelen, stedelijk ov, regionaal ov.	Niveau 2 (Business to Business), deels niveau 1.
Smile	Wenen, Oostenrijk	Pilot (2014-2015)	Fietsdelen, autodelen, taxi, stedelijk ov, regionaal ov, parkeren.	Niveau 2.
WienMobil Lab	Wenen, Oostenrijk	Operationeel (2017-)	Fietsdelen, autodelen, taxi, stedelijk ov, parkeren.	Niveau 2.
SHIFT	Las Vegas, VS	Gepland (2013-2015)	Fietsdelen, autodelen, taxi, DRT, valet parkeren.	Niveau 3.
UbiGo	Gothenburg, Zweden	Pilot (2013-2014), versie 2.0 in voorbereiding	Fietsdelen, autodelen, autohuren, taxi, stedelijk ov.	Niveau 3.
Whim	Helsinki, Finland	Operationeel (2016-)	Fietsdelen (autodelen i.o.), autohuren, taxi, stedelijk ov, regionaal ov.	Niveau 3.

Figure 25. Examples of MaaS providers

Appendix C| Overview of assessed impacts of MaaS

Level	KPI	Impacts		
		Environmental	Economic	Social
Individual /user level	Total number of trips made	x		x
	Modal shift (from car to PT, to sharing, to ...)	x		
	Number of multimodal trips (combining different modes of transport)	x		
	Attitudes towards PT, sharing, etc.	x		
	Perceived accessibility to transport			x
	Total travel cost per individual/household		x	x
Business/ organisational level	Number of customers		x	
	Customer segments (men/women, young/old, ...)		x	x
	Collaboration/partnerships in value chain		x	
	Revenues/turnover		x	
	Data sharing		x	
	Organisational changes, changes in responsibilities		x	
Societal level	Emissions	x		
	Resource efficiency (roads, vehicles, land use, ...)	x	x	
	Citizens accessibility to transport services			x
	Modification of vehicle fleet (electrification, automation, etc.)	x		
	Legal and policy modifications	x	x	x

Overall positive increase/decrease	
Both positive and negative increase/decrease	
Overall negative increase/decrease	
Not possible to assess	

Figure 26. Assessment of MaaS-pilots

Appendix D| Theory of Planned Behaviour

A widely recognized and empirically tested framework to explain individualistic behaviour is that of the Theory of Planned Behaviour (TPB) by (Ajzen, 1991). The Theory of Planned Behaviour centralizes around an individual's intention to perform a given behaviour, which then drives its actual behaviour. The intention is fuelled by three distinct factors:

(1) Attitude towards behaviour, that is defined as the user's evaluation of the desirability to use a certain system. A user bases this on the likely consequences of the behaviour. This produces a (un)favourable attitude toward the behaviour.
(2) Subjective norm, that is based on the normative expectations of others. This results in a perceived social pressure on the individual to engage in the given behaviour.
(3) Perceived behavioural control, which are the resources and opportunities that are accessible to a person. This should dictate the likelihood of behavioural achievement. Hereof, a perceived ease of use arises.

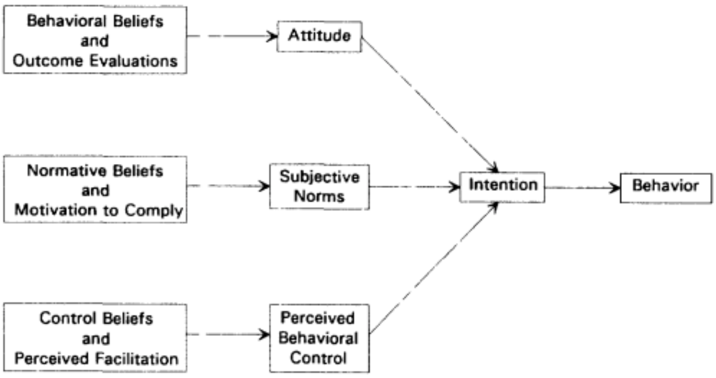

Figure 27. Theory of Planned Behaviour

The three aspects explain the intention to use a service or product. The attitude and subjective norms mean that one's motivation is favourable towards a certain behaviour. If persons have behavioural control they are expected to carry out their intentions under the rightly given circumstances. Then, intention directly drives behaviour, which this is only the case when individuals can be realistic about their perceived control.

Appendix E| Table for critical values

df	tweezijdig		df	tweezijdig		df	eenzijdig
1	12.706		10	2.228		10	1.812
2	4.303		15	2.131		15	1.753
3	3.182		20	2.086		20	1.725
4	2.776		25	2.060		25	1.708
5	2.571		30	2.042		30	1.697
6	2.447		40	2.021		40	1.684
7	2.365		60	2.000		60	1.671
8	2.306		120	1.980		120	1.658
9	2.262		oneindig	1.960		oneindig	1.645

Table 36. Critical values for t at different degrees of freedom, using a significance of ,05

Appendix F| Pilot before-survey

Table 18 shows all the variables, scales and categories as they were used in the pilot survey.

Variables	**Categorization**	**Categories**
Gender	Nominal	Man Woman
Age	Ratio	0 t/m 17; 18 t/m 24; 25 t/m 29; 30 t/m 34; 35 t/m 39; 40 t/m 44; 45 t/m 49; 50 t/m 54; 55 t/m 59 60 t/m 64; 65 years or older
Zip code	Nominal	Open
Employment status	Interval	Employed full-time (>=40 hours per week) Employed part time (<39 hours per week) Unemployed; looking for work Student Retired
Household type	Ordinal	I live alone I live together with my partner I live together with my family I share a house with others
Household income	Ratio	<10.000 euro 10.000 - 14.999 euro 15.000 - 19.999 euro 20.000 - 24.999 euro 25.000 - 29.999 euro 30.000 - 39.999 euro 40.000 - 49.999 euro 50.000 - 59.999 euro 60.000 - 79.999 euro 80.000 - 99.999 euro > 100.000 euro Dat deel ik liever niet
Education	Ordinal	No education Primary education Secondary school University
Main vehicle choice	Nominal	Own bike Shared bike E-bike Scooter Cargo bike Private car Shared car Rented car Tram, bus, metro Train Taxi
Household car ownership	Nominal	No car use 1 car More than one car Lease-car Shared car subscription Car rental
Car use	Ratio	Open (kms/day)
Mobility satisfaction in neighbourhood	*Interval*	*Likert-scale (1-to-5 scale)*
Car sharing experience	*Nominal*	*Sometimes from family/friends* *Sometimes at a rental company* *Shared car within a closed group* *Shared car on an open platform* *No experience*
Bike sharing experience	*Nominal*	*No* *Yes*
Trip purpose for Hely-service	Interval	Work Groceries and shopping

		Sports and hobbies Social occasion School/University Day away
Intention to use car/e-car/e-bike/bike/cargo bike	Interval	(Almost) never Monthly Weekly Several times a week Daily
Motifs to use Hely Flexibility Diversity Convenience Costs Sustainability	Interval	Likert-scale (1-to-5 scale)
Intention to leave private car	Nominal	Yes, I'm prepared to sell my second car. Yes, I'm prepared to sell my only car. Yes, I will not buy a new car what I was planning to do. I'm still in doubt. No, I'm not prepared to waive my second car. No, I'm not prepared to waive my first car. This question does not apply to me.

Table 37. Pilot survey variables

Descriptives of the before-survey

Number of respondents	20
Gender	70% male – 30 % female
Age	18 - 24; 10% 25 - 34; 35% 35 - 44; 30% 45 - 54; 15% 55 - 64; 10%
Household type	I live alone; 15% I live together with my family; 40% I live together with my partner; 30% I share a place with others; 15%
Occupation	I am a student; 10% I am looking for work: 5% I work fulltime: 60% I work part-time: 20% No answer: 5%
Income	<10.000 euro; 5% 10.000 - 14.999 euro; 5% 20.000 - 24.999 euro; 10% 25.000 - 29.999 euro; 20% 30.000 - 39.999 euro; 5% 40.000 - 49.999 euro; 15% 60.000 - 79.999 euro; 20% 80.000 - 99.999 euro; 10% >100.000 euro; 5% I'd rather not tell; 5%
Education	No education: 0% Primary education: 0% Secondary school: 11% University: 89%

Table 38. Characteristics of the pilot before-survey

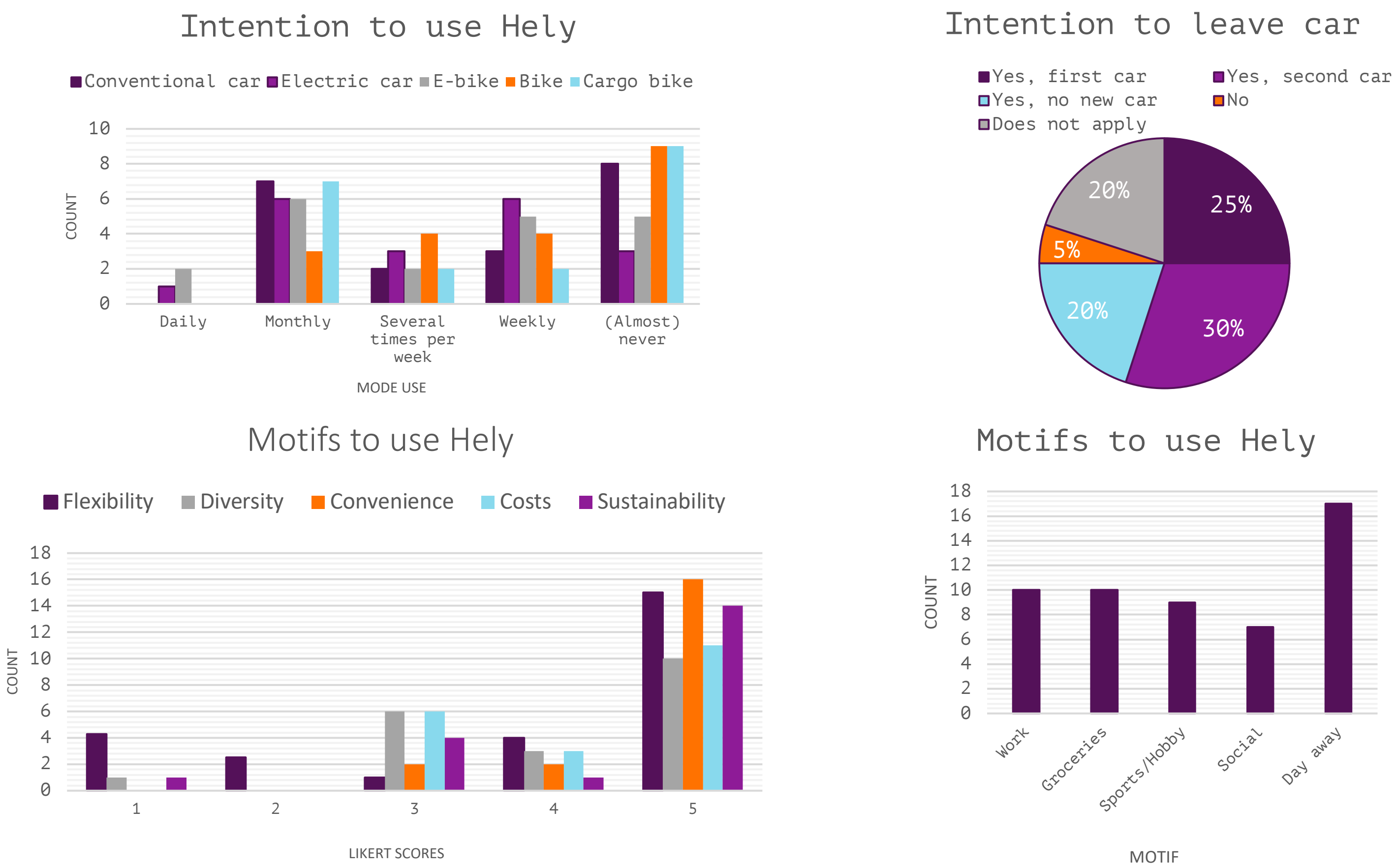

Figure 28. Results pilot survey

Appendix G| Missing data before-survey

It is important to understand what data is missing in the sample before one can act on it constructively. Rubin constructed a theoretical framework on missing data, which is widely accepted within the scientific community (Peugh & Enders, 2004). This framework recognizes three categories that are defined as follows:

1. *Missing completely at random* (MCAR): is defined "when the missing values on a particular variable X are unrelated to other variables in the data set as well as the underlying values of X itself" (p. 526, Peugh & Enders, 2004). The values that are missing are unrelated to other measured variables, so that they represent a random sample within the hypothesized full sample. MCAR is the only type that can be tested empirically.
2. *Missing at random* (MAR): "is less restrictive in the sense that missing values on a variable X can be related to other measured variables but still must be unrelated to the underlying values of X" (p.527, Peugh & Enders, 2004). MAR can only be verified if there is knowledge on the set of missing values.
3. *Missing not at random* (MNAR): "results when the probability of missing values on a variable X is related to the underlying values of X" (p.527, Peugh & Enders, 2004). This is for example when people who cannot read purposely skip long introductory questions.

To test whether data is missing completely at random Little's missing completely at random test in SPSS can be used. This test uses the following hypothesis: "*H0: The data is missing completely at random*" and "*H1: The data is not missing completely at random*". The results show that the H0 should be rejected, based on a 95% confidence interval (Sign=0.023). Hence, the data is not missing completely at random.

Peugh & Enders (2004) define three traditional techniques and two state-of-the-art techniques. The techniques are shortly explained below, after which a choice is made on how to deal with the missing data of this particular research.

1. *Listwise deletion:* simply discards all cases that contain missing values. This may result in big reduction of data and thus in statistical power. Moreover, it probably produces unbiased parameter estimates only when data are MCAR.
2. *Pairwise Deletion:* A pairwise deletion can maybe be best described like a covariance matrix, in which each variance term is computed by using all the cases with complete data on a given pair of variables. This technique has several limitations. First, it is difficult to compare analyses that use different subsamples. It is also known that pairwise deletion may yield impossible values in the covariance matrix. Also this technique needs MCAR to provide unbiased parameter estimates.
3. *Mean imputation:* The mean of each variable is computed and replaces the missing variables. This seems a simple method. However, the covariance of the variables is always polluted by this method, independent of the data being MCAR, MAR, MNAR.
4. *Maximum Likelihood Estimation (ML):* the basic goal of this estimation is to identify the population parameter values most likely to have produced a particular sample of data. The fit of the data is gauged by a log likelihood factor that indicates the probability of a particular sample. This method is advised in many studies. It has one main assumption and that is that of the normal distribution.
5. *Multiple Imputation (MI) method*: is able to generate variability within the missing data. MI does this through distinct three phases: imputation, analysis, and pooling of parameter estimates. The imputation step constructs a series of regression equations, for which a covariance matrix is used. The missing values are then replaced by these results. The goal of this phase is to produce imputed data sets, that are filled in with the values that are drawn (randomly) from a distribution of plausible missing values. After creating these values, the data is analysed and estimates are pooled and averaged together. The final phase pools the parameter estimates and standard errors from the analysis phase. Two final points are important to recognize: (1) MI requires the multivariate normality assumption. However, MI is known to perform OK on certain normality violations. (2) MI produces unbiased parameter estimates for data that is MAR and will produce biased estimators for data that is MNAR (Peugh & Enders, 2004). MI is generally accepted as the most appropriate technique in many circumstances (Manly, & Wells, 2014).

The Likelihood Maximization and Multiple Imputation methods are considered to be most sophisticated for use when dealing with missing data, as they contain less restrictive assumptions. An advantage of MI over ML is that it is a more general applicable method and that the incorporation of variables is easier. Moreover, in terms of practicality, MI is included in the SPSS software package whereas ML is not, therefore MI is chosen for this research.

Multiple Imputation technique

The missing data is provided in Table 20. First it is established whether the missing data is either systematic or random, which can have consequences for the technique that is used later on. This is done by searching for patterns in the missing data (figure 29). The value patterns suggest a randomness to the missing data. This minimizes the possibility that results are biased after MI. Moreover, Figure 29 shows that the biggest missing pattern is the combination of the 'bike use' and 'public transport (PT) use' variables.
The next step is to impute the missing data values through SPSS. The so-called 'Mersenne Twister' is used as random number generator and a default starting point. Five imputations are performed through SPSS, using the Fully conditional specification method, that is suitable for arbitrary pattern of missing values. 10 iterations are executed, and 5 imputations are done. Bike use and PT use variables are imputed, using all other variables for analysis. This results in five sets of data with differently drawn values on the missing data spots. These sets can be pooled together in SPSS when analysing the results of the survey, which provides reliable parameters and results. The pooled dataset is used for analysis, as the mean, standard deviation and variance is closest to the original dataset (Table 21). The pooled dataset has a smaller standard deviation and variance, which means data-points are more closely distributed. To confirm that results are not significantly different due to the MI, the original dataset is used as control-group in analysis.

Table 39. Missing variables

Variables	N	Missing percentage (%)
Bike use	50	37,5
PT use	49	39
Sustainable	79	1
Intention to use e-car	78	2,5
Intention to use cargo bike	79	1
Flexibility	78	2,5
Diversity	79	1
Convenience	79	1
Costs	79	1

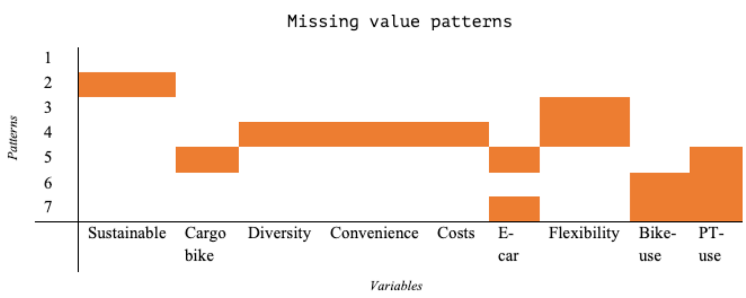

Figure 29. Missing variable patterns

	Valid bike-use	Pooled bike-use	Valid PT-use	Pooled PT-use
N valid	50	80	49	80
N missing	30	0	31	0
Mean	11,24	11,08	4,80	5,2
Std deviation	9,64	7,79	6,43	5,30
Variance	92,96	60,83	41,3	28,1
Minimum	0	0	0	0
Maximum	36	30	30	30

Table 40. MI-results bike- and PT-use

Appendix H| Logged data and weather conditions

Logged data

Hely collects data on all rentals and all accounts in their system. Every user has an ID specifically bound to its account. For every rental that is started, the account ID is registered to that specific rental. Using these ID's the account and rental dataset can be combined so that more in-depth account information is connected to each rental. This enables for example the investigation of gender and subscription period on the travel behaviour. The raw data from the database includes the variables that are highlighted as purple in Table 41. Using various pivot tables and functions in Excel, the orange variables of Table 41 were identified. Lastly, using external sources, the rain variable was added to the dataset. This is explained in more detail below. The dataset was incorporated in SPSS in two different sets. In the first set the users are taken as cases and in the second set the trips are taken as cases, with variables as shown in Table 41 respectively. The first dataset identified user related use of the Hub, the second dataset identified trip characteristics of the Hely Hub.

Users dataset		**Trip dataset**	
Variable	*Definition*	*Variable*	*Definition*
Account_ID	Account number	Vehicle_ID	Specific vehicle
SmallCarMonth	Monthly use small car	Vehicle	Modality
CargoBikeMonth	Monthly use cargo bike	Bucket	Bucket type
EbikeMonth	Monthly use e-bike	Renttime	Duration of rental
XLcarMonth	Monthly use XLbucket	Rain	Weather condition
EcarMonth	Monthly use e-car	Day type	Week or weekend
MPVMonth	Monthly use MPV	Gender	Male/Female
UseType	Occasional/Frequent	Hub	Delft/BSH
Gender	Male/Female	Rental start	Starting hour
Hub	Delft/BSH		
TotalMonth	Total Monthly Use		

Table 41. Datasets and subsequent variables for SPSS

Id	Contract_id	Vehicle_id	Start_time	Stop_time	Cost	Status	Price_definition_	Account_id	Created_at	Updated_at	External_ref
591	2	2005	2018-11-20 10:4	2018-11-20 10:5	1	STOP_CONFIR	2	603	2018-11-20 10:4	2018-11-20 10:5	379887
595	2	2006	2018-11-20 11:0	2018-11-20 15:2	45.85	STOP_CONFIR	3	603	2018-11-20 11:0	2018-11-20 15:2	379895
623	2	2004	2018-11-22 14:3	2018-11-22 15:3	3.73	STOP_CONFIR	1	607	2018-11-22 14:3	2018-11-22 15:3	0
630	2	2005	2018-11-23 07:0	2018-11-23 15:5	37.5	STOP_CONFIR	2	607	2018-11-23 07:0	2018-11-23 15:5	380574
681	2	2005	2018-11-28 05:4	2018-11-28 19:4	37.5	STOP_CONFIR	2	607	2018-11-28 05:4	2018-11-28 19:4	381663
692	2	2007	2018-11-29 11:3	2018-11-29 23:4	8.7	STOP_CONFIR	4	608	2018-11-29 11:3	2018-11-29 23:4	0
680	2	2006	2018-11-27 15:3	2018-11-30 14:3	210	STOP_CONFIR	3	603	2018-11-27 15:3	2018-11-30 14:3	381574
791	2	2005	2018-12-06 13:3	2018-12-06 14:0	3.88	STOP_CONFIR	2	607	2018-12-06 13:3	2018-12-06 14:0	383641
792	2	2008	2018-12-06 14:3	2018-12-06 17:0	3.75	STOP_CONFIR	4	604	2018-12-06 14:3	2018-12-06 17:0	0
793	2	2002	2018-12-06 14:3	2018-12-06 17:0	3.78	STOP_CONFIR	4	619	2018-12-06 14:3	2018-12-06 17:0	0
802	2	2011	2018-12-06 17:0	2018-12-06 17:2	3.15	STOP_CONFIR	3	604	2018-12-06 17:0	2018-12-06 17:2	383708
815	2	2005	2018-12-07 07:0	2018-12-07 07:3	4.38	STOP_CONFIR	2	607	2018-12-07 07:0	2018-12-07 07:3	383804
821	2	2011	2018-12-08 07:2	2018-12-08 10:5	37.28	STOP_CONFIR	3	607	2018-12-08 07:2	2018-12-08 10:5	384063
824	2	2005	2018-12-09 07:3	2018-12-09 17:5	37.5	STOP_CONFIR	2	608	2018-12-09 07:3	2018-12-09 17:5	384270
826	2	2012	2018-12-10 07:5	2018-12-10 10:5	30.98	STOP_CONFIR	3	603	2018-12-10 07:5	2018-12-10 10:5	384478
828	2	2005	2018-12-10 10:5	2018-12-11 08:2	75	STOP_CONFIR	2	603	2018-12-10 10:5	2018-12-11 08:2	384539
843	2	2012	2018-12-11 06:0	2018-12-11 14:4	52.5	STOP_CONFIR	3	607	2018-12-11 06:0	2018-12-11 14:4	384750
844	2	2011	2018-12-11 08:2	2018-12-13 05:3	157.5	STOP_CONFIR	3	603	2018-12-11 08:2	2018-12-13 05:3	384790

Figure 30 Raw data

Weather data

The Koninklijk Nederlands Metereologisch Instituut (KNMI) collects all weather-related data from different weather stations in the Netherlands. Data is free to download on their website (KMNI, n.d.). This research used the information of weather station Schiphol for both Hubs, as this is nearby both Hubs.

To include the weather condition per rental we chose to focus on the amount of rain for that specific day. It is chosen to exclude temperature from the research, as the research period was during the winter so that will not fluctuate much. To do this the dataset provides a variable that shows rain in millimetre/day. Furthermore, we needed a baseline to define a day as "rainy" or "dry". The KNMI considers 10 mm rain per day with at least one period of steady rainfall a "rainy day". Whether it rained specifically on time of a certain rental is too specific to approach at this point. Therefore, we assume that all days with over 10 mm rain are a rainy day, in which people might avoid engaging in unnecessary travelling by foot or bike. The 120-days period of research resulted in 49 rainy and 71 dry days. This data is then connected to the specific rental dates in Excel and finally added in the SPSS-dataset. To confirm that the assumptions made on mm/day do not impede results, during analysis 5 and 15 mm/day were also tried as baseline for rainy days.

YYYYMMDD	Max Temp	Etmaalsom neerslag	Rain?
2018-10-01	131	34	YES
2018-10-02	169	38	YES
2018-10-03	160	-1	NO
2018-10-04	182	-1	NO
2018-10-05	202	0	NO
2018-10-06	198	8	NO
2018-10-07	149	-1	NO
2018-10-08	167	0	NO
2018-10-09	182	0	NO
2018-10-10	228	0	NO
2018-10-11	222	2	NO
2018-10-12	217	-1	NO
2018-10-13	256	0	NO
2018-10-14	238	0	NO

Figure 31. Raw weather-data

Appendix I| Univariate analysis of dataset I

This Appendix shows the significant dependencies of variables that were revealed from the before-survey that are not included in the results. All possible dependencies between variables were tested, however not-significant dependencies were not included in detail and were listed below in Table 38.

Main car user on modal split

An independent t-test is executed to test whether being a main car user influences the modal split of an individual. The tables conclude that it is of influence on the number of trips per car, however not on the number of trips per bike and public transport, based on a 95% confidence interval. N shows that normality is no issue in this analysis, as N>30 for both categories.

Main car user	*Mean*	*Std. Dev*	*N*
NO	5,5	6,7	39
YES	12,8	9,8	41
	Difference	*T*	*P (1-sided)*
t-test	-7,3	-3,8	0,00

Table 42. Main car user and car use

Main car user	*Mean*	*Std. Dev*	*N*
NO	12,5		39
YES	10,5		41
	Difference	*T*	*P (2-sided)*
t-test	2,0	1,0	0,313

Table 43. Main car user and bike use

Main car user	*Mean*	*Std. Dev*	*N*
NO	5,66		39
YES	4,28		41
	Difference	*T*	*P (2-sided)*
t-test	1,4	1,1	0,296

Table 44. Main car user and public transport use

Employment and visit-related trips

This chi-square statistic shows a significant value. However, as N<5 for half of the categories and there is no theory supporting the significance of the two variables, it is not further investigated in the research.

	Visiting		Sum
Employment	NO	YES	= 100%
Fulltime	31	19	50
Part-time	19	1	20
Not working	6	4	10
Total	56	24	80
Chi^2=7,952; df=2; p=0,019			

Table 45. Employment and visiting

Dependent *Independent*	Trip purposes	Car intention	E-car intention	Bike intention	E-bike intention	Cargo bike intention	Car sell-intention	MaaS-Motives
Gender	X	X	X	X	X		X	X
Age	X	X	X	X	X	X	X	X
Income	X	X	X	X	X	X	X	X
Household	X	X	X	X	X	X	X	X
Employment		X	X	X	X	X		X
Education	X	X	X	X	X	X	X	X
Car ownership		X	X	X	X	X	X	X
Main car user	X	X	X		X	X	X	
Car use	X	X	X	X	X	X	X	X
Bike use	X	X	X	X	X	X	X	X
PT use	X	X	X	X	X	X	X	X
Work motif		X	X		X	X	X	
Shop motif		X			X	X	X	
Hobby motif		X	X	X	X	X	X	
Visit motif		X	X	X	X	X	X	
Day away motif		X	X		X	X	X	

Table 46. Variables that tested and showed independency

Appendix J| Before-survey

hely

Welkom!
Bedankt voor je deelname. Hiermee geef je ons inzicht in de mobiliteitsbehoefte die jij hebt. De resultaten vormen de input bij de realisatie van mobiliteitsvoorzieningen van de Hely Hub in jouw buurt. Het onderzoek wordt uitgevoerd door Hely en je kan de vragenlijst in 5 minuten invullen.

Start druk op **ENTER**

1→ Ik ben een

- A man
- B vrouw

2→ Mijn leeftijd is

- A 0 t/m 18 jaar
- B 18 t/m 24 jaar
- C 25 t/m 29 jaar
- D 30 t/m 34 jaar
- E 35 t/m 39 jaar
- F 40 t/m 44 jaar
- G 45 t/m 49 jaar
- H 50 t/m 54 jaar
- I 55 t/m 59 jaar
- J 60 t/m 64 jaar
- K 65 en ouder

3→ Wat is je hoogst genoten opleiding?

- A Geen opleiding
- B Lagere school
- C Middelbare school / Beroepsonderwijs
- D Hogeschool / Universiteit

4→ Wat is het jaarlijks inkomen van uw huishouden?

- A Tot 19.999 euro
- B 20.000 to 39.999 euro
- C 40.000 to 59.999 euro
- D 60.000 to 79.999 euro
- E 80.000 to 99.999 euro
- F 100.000 euro of meer
- G Dat vertel ik liever niet

5→ Om meer te komen over de wensen voor de Hely Hub in jouw buurt hebben we de postcode nodig. Dit kan dus de postcode van je huis of van je werk zijn, afhankelijk van waar je Hely mogelijk gaat gebruiken.

Hier komt het antwoord...

6→ Welke omschrijving past het beste bij je?

- A Ik werk fulltime (40+ uur)
- B Ik werk parttime (tot 39 uur)
- C Ik werk niet
- D Ik ben werkzoekende
- E Ik ben gepensioneerd
- F Ik ben scholier/student
- G Ik ben arbeidsongeschikt
- H Overige

7→ Wat is je huidige woonsituatie?

- A ik woon alleen
- B ik woon samen met mijn partner
- C ik woon samen met mijn gezin
- D ik woon met kinderen, zonder partner
- E ik deel een woning met anderen / studentenwoning
- F ik woon bij mijn ouders

" Door onderstaande vragen te beantwoorden brengen we in kaart wat jouw mobiliteitsbehoefte is en hoe jij je op dit moment verplaatst van A naar B.

Continue druk op **ENTER**

10→ Hoeveel ritten maak je met de volgende vervoermiddelen als hoofdvervoer in een normale week? Een volledige **heen-en-terug verplaatsing** mag je beschouwen als één rit.

Doorgaan druk op **ENTER**

a. Als bestuurder van een auto.

Hier komt het antwoord...

b. Met de fiets.

Hier komt het antwoord...

c. Met het ov.

Hier komt het antwoord...

8→ Hoe ziet het autobezit van jou en jouw gezinsleden er nu uit?

Kies er zoveel als je wilt

- A een eigen auto
- B meerdere auto's
- C een leaseauto
- D Deelauto met vrienden/buren/familie
- E een deelauto-abonnement
- F af en toe autohuur
- G geen autobezit of huur

9→ Ben jij de hoofdzakelijke gebruiker van de auto?

- J Ja
- N Nee

" Met de volgende vragen kan je aangeven in hoeverre je tevreden bent met de manier waarop jij je van A naar B verplaatst.

Continue druk op **ENTER**

11→ Ik ben tevreden met de mobiliteitsvoorzieningen in mijn buurt.

1	2	3	4	5	6	7
Oneens			Neutraal			Eens

12→ Waarom niet?

Hier komt het antwoord...

Om een paragraaf toe te voegen, druk op **SHIFT** + **ENTER**

" Omdat we de mobiliteitsvoorzieningen voor jou willen verbreden met deelvervoer, zijn we benieuwd naar jouw ervaring hierin.

Continue druk op ENTER

13→ Wat is je ervaring met autodelen? (Dit houdt in dat je een auto deelt met meerdere gebruikers)

Kies er zoveel als je wilt

- A Ik leen soms een auto van familie/vrienden.
- B Ik huur af en toe een auto bij een autoverhuurbedrijf (zoals Bo-rent, Sixt of Kohler)
- C Ik maak gebruik van een deelauto binnen een gesloten groep
- D Ik maak gebruik van een deelauto via openbaar platform (zoals Greenwheels, Snappcar of MyWheels)
- E Ik heb geen ervaring met autodelen.

14→ Maak je weleens gebruik van een deelservice voor scooters en/of fietsen (zoals OV-fiets, Mobike en Felyx)?

- J Ja
- N Nee

" Beantwoord de volgende vragen om te laten weten hoe jij aankijkt tegen de komst van Hely.

Hely is een aanbieder van deelvervoer beschikbaar maakt voor alle (buurt)bewoners rondom een Hely Hub. Hely geeft je toegang tot al je favoriete vervoersmiddelen in jouw buurt via één simpele app. Zo kan je altijd een (e-)bike, scooter, bakfiets of (e-)car bij jou in de buurt pakken. Deelvervoer is zo altijd binnen handbereik, eenvoudig en overzichtelijk. Bij deelvervoer betaal je alleen voor je gebruik, dit in tegenstelling tot het bezitten van een eigen vervoermiddel waarvoor je aanschaf-, onderhoud- en overige kosten betaalt, zelfs zonder dat je hiermee op pad bent geweest! Alle vervoersmiddelen op één plek in jouw buurt bereikbaar, dat is de Hely Hub.

Continue druk op ENTER

15→ Voor welke situatie zou je de deel-vervoersmiddelen uit de Hely hub willen gebruiken?

Kies er zoveel als je wilt

- A Naar werk
- B Werkbezoek
- C Boodschappen en winkelen
- D Sport of hobby
- E Visite
- F School/Universiteit
- G Dagje weg of dagactiviteit

16→ In welke mate zou je overwegen om de volgende vervoersmiddelen uit de Hely hub te gaan gebruiken?

Continue druk op ENTER

a. Benzine auto

- A zelden tot nooit
- B maandelijks
- C wekelijks
- D meerdere keren per week
- E dagelijks

b. Elektrische of hybride auto

- A zelden tot nooit
- B maandelijks
- C wekelijks
- D meerdere keren per week
- E dagelijks

c. Fiets

- A zelden tot nooit
- B maandelijks
- C wekelijks
- D meerdere keren per week
- E dagelijks

d. Elektrische fiets

- A zelden tot nooit
- B maandelijks
- C wekelijks
- D meerdere keren per week
- E dagelijks

e. (elektrische) Bakfiets

- A zelden tot nooit
- B maandelijks
- C wekelijks
- D meerdere keren per week
- E dagelijks

f. (elektrische) Scooter

- A zelden tot nooit
- B maandelijks
- C wekelijks
- D meerdere keren per week
- E dagelijks

17→ Wat zijn voor jou voorwaarden om gebruik te maken van deelvervoermiddelen uit de Hely Hub. Geef aan in welke mate de volgende voorwaarden belangrijk zijn.

Continue druk op **ENTER**

a. Flexibiliteit: ik wil nergens aan vast zitten maar wel gebruik kunnen maken als ik het wil.

1	2	3	4	5	6	7

Niet belangrijk — Neutraal — Heel belangrijk

b. Diversiteit: Ik wil graag een grote variatie in vervoersmiddelen.

1	2	3	4	5	6	7

Niet belangrijk — Neutraal — Heel belangrijk

c. Gemak: Ik wil zonder problemen mijn reis kunnen plannen, boeken, deelmobiliteit gebruiken en betalen.

1	2	3	4	5	6	7

Niet belangrijk — Neutraal — Heel belangrijk

d. Kosten: Ik wil niet meer betalen dan ik nu aan mobiliteitskosten heb.

1	2	3	4	5	6	7

Niet belangrijk — Neutaal — Heel belangrijk

e. Duurzaamheid: Ik wil graag duurzame opties kunnen kiezen, zoals een elektrische auto.

1	2	3	4	5	6	7

Niet belangrijk — Neutraal — Heel belangrijk

18→ Ben je bereid van je enige, tweede of nieuwe auto af te zien, wanneer deelmobiliteit in de wijk goed geregeld is? Selecteer de situatie die het meest van toepassing is.

- A Ja, ik ben bereid van mijn tweede auto af te zien.
- B Ja, ik ben bereid van mijn enige auto af te zien.
- C Ja, ik ga nu geen nieuwe auto aanschaffen, terwijl ik dat eerder overwoog.
- D Ik twijfel nog.
- E Nee, ik ben niet bereid van mijn tweede auto af te zien.
- F Nee, ik ben niet bereid van mijn enige auto af te zien.
- G Niet van toepassing

Nogmaals hartelijk dank voor het invullen van de enquete! Aanvullende vragen en opmerkingen kunt u altijd sturen naar kjell@hely.com

again druk op ENTER

Appendix K| After-survey

This section includes the proposed after-survey that can serve as an addition to the before-survey and indicated database of Hely. This helps establishing change in behaviour more clearly and thus indicate possible reduced private car use. This research was too early conducted, and thus lacked statistical power, to be able to include it.

Data collection method

There are two types of survey that can be used in such a study, (1) a repeated cross-sectional survey and (2) a longitudinal panel survey. The difference between both studies is that in the first different groups are compared. For the second approach the same group is queried multiple times. To identify changes in behaviour, a longitudinal panel survey is clearly the preferred option statistically, as then the between-sample variance is eliminated. This ensures that statistically significant changes are identified with a smaller sample size in the "before" and "after" surveys (Richardson, Seethaler, & Harbutt, 2003). However, the sample can still complicate analysis, as the characteristics of the population may change over time or change in composition. Moreover, panel non-response is a problem for longitudinal studies, especially in the "after-survey" (Duncan, 2001). Therefore, it is advised to put sufficient consideration in the respondents' process. Another consideration is that of possible changing background environment (Richardson et al., 2003). If there is a period of time between survey A and B, chance is that the background changes also influence the outcomes of the results. These changes should preferably be monitored also, for example through a control group. However, as this study is conducted in relative short period of 4 months, this research does not include a control group. Therefore, environmental changes cannot be tracked during this research.
The results of both surveys will be compared. For each respondent, we will have a measurement of the parameter of interest in the before and after survey. This means per respondent, there are two measurements. These can be "paired" and will calculate a difference between both moments. Thus, for each group we have three distributions of parameters (the before, the after and the paired differences), each described in terms of a mean and a standard deviation. Apart from the before- and after study, the logged data of Hely will be compared. The data will reveal the change in total use of the individual due to the Hely Hubs in detail. More specifically, The comparison of the methods and subsequent points of interest are then as depicted in Table 47.

Analysis	*Before-survey*	*Logged data*	*After-survey*	*Points of Interest*
I	X		X	• Change in private vehicle use • Change in private car ownership • Change in attitude towards MaaS • Change in attitude towards private car
II		X	X	• User characteristics on mode choice • Travel purpose on mode choice

Table 47. Points-of-interest per dataset comparison

Data analysis: ANOVA with repeated measures

The ANOVA with repeated measures is a variant of the one-way independent ANOVA, in which the same group of people is repeatedly measured. Those results are then compared within the individual. In this model the independent factor is time and the dependent factor is the variable to be tested over time. For this particular ANOVA the effect of the experiment is revealed in the within-subject variance, rather than the between-variance. The within-variance can be differentiated in an error effect, due to external conditions, and an effect due to the experiment. Errors due to data manipulations are equal for all inputs, and are thus systematic. As in the independent ANOVA, the F-ratio is used to test the model. To arrive at this statistic first the total sum of squares (SS_T) is calculated using the following equation, with s_{grand} as the variance of all values and N as the number of all values:

$$SS_T = s_{grand}^2(N-1) \tag{1.6}$$

Next, the repeated measure design uses the means of each level of independent variable and compares these with the overall mean. The values then calculate the sum of squares of the model (SS_m), with n_i as the degrees of freedom for each person, x_i the level of the independent variable and x_{grand} the overall mean.:

$$SS_m = \sum n_i \, (x_i - x_{grand})^2 \tag{1.7}$$

The variation that cannot be explained by the model and its subsequent degrees of freedom, is then defined as follows:

$$SS_R = SS_w - SS_m \;\; ; \;\; df_r = df_q - df_m \tag{1.8}$$

The SS_m reveals the variation that the model explains and SS_R reveals the variation that is due to extraneous factors. The sum of the squares is biased and should therefore be eliminated, which is done by taking the average sum of squares:

$$MS_m = \frac{SS_m}{df_m} \; ; \;\; MSr = \frac{SS_R}{df_R} \tag{1.9}$$

MS_m is then defined as the average amount of variation explained by the model and MSr is defined as the average amount of variation explained by extraneous variables. The F-ratio is the measure of the ratio of the variation explained by the model and the variation explained by the unsystematic error. It is calculated as follows:

$$F = \frac{MSm}{MSr} \tag{1.10}$$

Three assumptions should be adhered to conduct the analysis: (1) a normal distribution, (2) sphericity; the variance of the different scores should be equal, and (3) independence of scores (Field, 2004).

After survey design

The after-survey reveals whether travel behaviour and certain attitudes have changed in the time span between the surveys. The survey again reveals social-demographics and car ownership, to ensure that no household changes have occurred during the period between the two surveys. It is crucial for comparison that exactly the same questions are stated as in the before-survey, for sake of comparison. Specifically, it again reveals trips per week for car, bike and public transport and whether private vehicles are used less and due to what Hely vehicles. Furthermore, it states for what kind of trips the Hely Hubs are used. Next, the values associated to MaaS are tested for the Hely-service. Also, the most important factor to use Hely is queried, just like in the before-study. Lastly, the attitudes towards shared mobility, electric vehicle use and private car ownership is questioned. Fourthly, the respondents are given an option to provide feedback on the survey in the last question. All the variables, the categorization and categories are shown below.
To protect the sample size and for sake of time and ease, the survey was piloted by 14 Hely employees. All have experience with Hely as they use the Spaces Hub occasionally or frequently, therefore the results can be considered representative. Moreover, this way the feedback loop is shortest. The downside is that the method of addressing the respondents cannot be tested. This resulted in the survey as depicted in Table 47 This can be used for establishing change in behaviour.
Every month Hely sends out an NPS score to its clients. This score captures the overall happiness of users with a product or service in one statement. The score is gathered by asking whether the user would recommend the service to its family and friends. The after-survey can be seen as an in-depth questionnaire on this NPS-score. Therefore, it is included as extension of this statement in the next collection of the NPS. The responses are given so-called hash keys to track them during the period between the before/after surveys. These hash keys track the Network ID of a respondent, and thus provide an anonymous trackable ID per respondent. This way their changing behaviour can be revealed on an individual scope, what ensures that behavioural change can be indicated in a smaller sample.

Variables	Categorization	Categories
Gender	Nominal	Man
		Woman
Age	Ratio	0 to 24
		25 to 34
		35 to 44
		45 to 54
		55 to 64
		65 +
Zip code	Nominal	Open
Employment status	Interval	Employed full-time (40 or more hours per week)
		Employed part time (up to 39 hours per week)
		Unemployed; looking for work
		Unemployed; not looking for work
		Student
		Retired
		Unable to work
Education	Ordinal	No education
		Primary education
		Secondary school
		University
Household type	Ordinal	I live alone
		I live together with my partner
		I live together with my family
		I share a house with others
Household income	Ratio	To 19999
		20000 to 39999
		40000 to 59999
		60000 to 79999
		80000 to 99999
		100000 or more
		unknown/don't want to tell
Household car ownership	Interval	No
		Yes
Frequency of bike/car/PT use	Ratio	Open (trips/week)
Reduced private vehicle use	Nominal	Own car
		Own bike
		PT
		Other shared mobility providers
		No reduced private use
Substitute Hely-vehicle	Ordinal	(e-)bike
		cargo bike
		small car
		MPV
		e-car
Purpose trips Hely	Nominal	To work
		Business trip
		Grocery and/or shopping
		Sports or hobbies
		Visit
		School/University
		Day-activity
Flexibility of Hely service	Interval	Likert-scale (1-to-5 scale)
Timely accessibility of Hely service	Interval	Likert-scale (1-to-5 scale)
Geographical accessibility of Hely service	Interval	Likert-scale (1-to-5 scale)
Reliability of Hely service	Interval	Likert-scale (1-to-5 scale)
Attitude towards shared services	Interval	Likert-scale (1-to-5 scale)
Attitude towards electric vehicles	Interval	Likert-scale (1-to-5 scale)
Intention to leave private car	Nominal	Yes, I'm prepared to waive my second car.
		Yes, I'm prepared to waive my only car.
		Yes, I will not buy a new car what I was planning to do.
		I'm still in doubt.
		No, I'm not prepared to waive my second car.

		No, I'm not prepared to waive my first car. This question does not apply to me.

Table 48. After-survey design