
# Bicycle sharing programs: a complement or substitute of urban public transport?

A case study of a bicycle sharing program in The Hague

By A.M. van Marsbergen

# Bicycle sharing programs: a complement or substitute of urban public transport?

A case study of a bicycle sharing program in The Hague

Master Thesis

by

Annemiek van Marsbergen

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| Student number: | 4323319 | |
| Date: | 29-06-2020 | |
| Thesis committee: | Prof. dr. ir. S.P. Hoogendoorn | TU Delft, chair |
| | Dr. ir. N. van Oort | TU Delft, supervisor |
| | Dr. J.A. Annema | TU Delft, supervisor |
| | Dr. ir. D. Ton | TU Delft, supervisor |
| | S. Nijënstein Msc. | HTM, external supervisor |

# Preface

In front of you lies my final thesis as part of the master Transport, Infrastructure and Logistics at Delft University of Technology. In the past months, I have been working on the topic of bicycle sharing programs and especially the combined use with urban public transport. This study was carried out at HTM Personenvervoer N.V. in The Hague.

It would not have been possible to carry out this research without the help of many people. Therefore, I would like to thank everyone who helped me during my master thesis. First, I would like to thank HTM for making this research possible. In particular, I would like to thank Sandra for guiding me during this research, for always making time for me, being enthusiastic about the research and providing me with useful feedback which helped me a lot in improving my research.

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Finally, I would like to thank everyone who have supported me during my master thesis. I would like to thank my family for always being there for me and telling me that everything would turn out all right. I would like to thank my roommates for always listening to my struggles and providing me with motivational talks. Finally, I would like to thank all my friends for cheering me up and supporting me during my thesis.

*A.M. van Marsbergen*
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# Summary: Bicycle sharing programs: a complement or substitute of urban public transport?

*A case study of a bicycle sharing program in The Hague*

A.M. van Marsbergen
Delft University of Technology, the Netherlands

**Abstract**

Recently many bicycle sharing programs have been introduced in cities worldwide. The combined use of shared bicycles and public transport could offer an attractive alternative for private motorised vehicles and could contribute to making cities better accessible and liveable. However, it is unsure whether this combination, especially with urban public transport (bus/tram), is often used or that shared bicycles function more as a substitute of urban public transport. Therefore, this study explores to what extent people use the shared bicycle in combination with urban public transport within a mid-size city, The Hague, in the Netherlands and how the integration between these modalities could be improved. This is examined by analysing the operational trip data of the bicycle sharing program called HTM-fiets, conducting a survey among the users of this bicycle sharing program and performing an expert meeting. The results indicate that in this case the shared bicycle does not complement urban public transport to a large extent in a single ride and seems more used as a substitute of urban public transport. Therefore, it is probably more valuable to focus on integrating the shared bicycle with urban public transport as a whole than to assure a good integration in a single ride. To realise the integrated public transport and shared bicycle system, the shared bicycle could be marketed as a form of public transport and the shared bicycle could be made available in areas with weak urban public transport connections to increase the total network and with that the accessibility in cities.

*Keywords: Bicycle sharing programs, urban public transport, complementary, substitution, modal shift*

## 1. Introduction

Cities all around the world become busier and more densely populated, which consequently leads to more trips being made by people within cities. Since a large share of these trips are made with private motorised vehicles this often leads to high levels of congestion and pollution in cities (Banister, 2008). To keep cities liveable and accessible it is important to realise a mode shift to modalities that are more sustainable and take up less space. A sustainable mode that has recently received a lot of attention is the bicycle, which is flexible, low-cost and if replaced for the car can reduce traffic congestion and pollution (Handy et al., 2014)**.** Also, the combination of bicycles and public transport could be an attractive alternative for private motorised vehicles. If these modalities are used to complement each other, the benefits of both could be combined. Public transport could provide fast and accessible connections and the bicycle could provide flexible transport for the first and last mile (van Mil et al., 2018). However, privately-owned bicycles are not available everywhere to serve as first or last mile transportation. A solution for this issue could be the large-scale bicycle sharing programs (BSPs) that have been introduced in many cities since 2005 (Larsen, 2013).

The combined use of public transport and shared bicycles seems a promising alternative to private motorised vehicles. However, whether the combination of these modalities is often used in reality,

especially shared bicycles in combination with urban public transport (buses or trams), or whether the shared bicycle functions more as a substitute for buses and trams is only researched to a limited extent. Some previous studies have been performed regarding the relationship between shared bicycles and public transport (e.g. Leth et al., 2017; Jäppinen et al., 2013; Shaheen et al., 2013; Martin & Shaheen, 2014; Faghih-Imani & Eluru, 2015). For example, Faghih-Imani & Eluru (2015) found that metro and regional train stations were often chosen as destination by members of the BSP in Chicago, which could indicate that that these two modalities have been used as a complement to each other. Also, Leth et al. (2017) found by comparing travel times of shared bicycle routes with travel times of alternative public transport routes in the city of Vienna that the BSP seemed more a supplement than a competitor to the public transport network. Furthermore, Shaheen et al. (2013) found that in Toronto, Montreal and Washington DC, an overall reduction of bus and rail usage was observed after the introduction of BSPs, while in Minneapolis-Saint Paul an overall increase in rail usage was observed.

While these studies examine different aspects of the relationship between shared bicycles and public transport, they can mainly make assumptions regarding the extent to which shared bicycles are used as a complement or substitute to public transport. Besides, these studies were mostly performed in very large cities and often focussed on the combination with metro or regional rail. This research specifically focusses on the extent to which the shared bicycle is used as a complement to the urban public transport network (bus/tram) within a mid-sized city. Furthermore, the general cycling levels and level of bicycle ownership vary between different countries and might have an impact on the usage of the shared bicycles. This research is performed in the Netherlands, which is a country with a long tradition of cycling and has the highest rate of bicycle use in the world (Heinen et al., 2013). Also, inhabitants of the Netherlands own on average 1.2 bicycles per person (CBS, 2016). Furthermore, it is known that within the Netherlands the private bicycle is often used as an access mode for trips made by train, but less as access mode for urban public transport, which includes bus, tram and metro (Martens, 2007). What the relationship is between shared bicycles and urban public transport in countries where cycling is very common is however researched to a limited extent and is therefore also examined in this study.

The main goal of this research is to investigate the role of shared bicycles with respect to the urban public transport network; is the shared bicycle more a complement or substitute of the urban public transport network and which factors have an influence on this. Besides, this research analyses how the integration between the shared bicycle and bus/tram could be improved. The results can be used to adapt the BSP and urban public transport network in such a way that it better suits the needs of the travellers and thus provide travellers with more and better transportation options, which increases their accessibility. As a result, more people might switch from using private motorised vehicles to the shared bicycle and urban public transport, which could reduce congestion and pollution in cities.

Based on the goal of this research, the following main research question is formulated:

*"To what extent do urban public transport and bicycle sharing programs complement each other and how can the integration of these systems be improved from a user and operator perspective?"*

The remainder of this paper is structured as follows. First, the different methodologies used to provide an answer to the research question are described. Thereafter, the results of this study are presented. The final section provides the conclusion and recommendations for both practice and further research.

## 2. Methodology

First, a literature study is performed to gain insights in the current usage of BSPs around the world, what is currently known with respect to the relationship between shared bicycles and (urban) public transport and which factors possibly influence the combined use of shared bicycles and urban public

transport. To be able to provide an answer to the main research question a case study is used. This is the BSP called HTM-fiets, which is introduced in May 2019 and is located in The Hague (≈540.000 inhabitants), the Netherlands. This BSP uses drop zones where the bicycles can be picked up and returned and a smartphone application is used to lock and unlock the bicycles. The program consists of around 500 bicycles and 65 drop zones. Furthermore, the public transport network of The Hague consists of 12 tram lines and 8 bus lines. To gain insights in many different aspects of the current usage of the HTM-fiets, the operational trip data of this BSP over the period June 1st (2019) till February 29th (2020) is analysed. The results are compared with the usage of other BSPs found in literature to obtain an overall view on the usage of the shared bicycles in the case study city.

To be able to examine the extent to which the HTM-fiets is actually used in combination with urban public transport (bus/tram), an online survey is conducted among the people who have made an account in the HTM-fiets application on their smartphone. The survey is sent by email to the people who had an account in the HTM-fiets application on 20-2-2020. This means the sample includes both people who have used the HTM-fiets and people who have made an account in the application, but have not used the HTM-fiets (yet). The final sample consists of 245 respondents. Within this sample 156 respondents (64%) have used the HTM-fiets and 89 respondents (36%) have not. Besides examining the extent to which the HTM-fiets is used in combination with the bus/tram, the survey is also used to identify factors that have an influence on this and to identify possible measures to improve the integration between the HTM-fiets and bus/tram. Different factors are included based on the literature study, which consists of socio-demographic factors (age, gender, education level, bicycle ownership, level of cycling, level of tram use and level of bus use), trip factors (trip length, trip purpose and start and end location), public transport factors (quality of the lines) and attitude/motivational factors (attitude towards cycling and public transport and reasons for using the shared bicycle). Finally, the survey results are also used to gain insights in the type of users, to provide additional information regarding the usage of the HTM-fiets and to gain insights in possible improvements regarding the HTM-fiets concept in general.

To determine if and to what extent the socio-demographic and attitude/motivational factors have an influence on the extent to which people use the HTM-fiets in combination with the bus/tram, a multinomial logistic regression analysis is used. Furthermore, the respondents who used the HTM-fiets as often in combination with the bus/tram or more often in combination than not, described their last ride with the HTM-fiets in combination with the bus/tram. The respondents who more often used the HTM-fiets not in combination with the bus/tram than in combination, described their last ride with the HTM-fiets not in combination with the bus/tram. The influence of the trip factors and public transport factors on the extent to which people use the HTM-fiets in combination with the bus/tram is assed based on these descriptions.

Finally, an expert meeting is held with five employees of HTM. The results of the data-analysis of the operational trip data and the results of the survey are used as input for this meeting. The expert meeting is used to provide additional insights in possible measures for improving the HTM-fiets concept in general, possible measures for improving the integration between the HTM-fiets and urban public transport and to obtain their vision regarding the integration of shared bicycles and urban public transport.

## 3. Results

### *3.1 Type of users and general usage of the HTM-fiets*

The survey shows that the users of the HTM-fiets in the sample are more often man (67%) than woman (31%), most often have an age between 25 and 44 (53%) and are largely higher educated (78%), which is comparable with users of other BSPs in both cities within the Netherlands and within other cities worldwide (Waes et al., 2018; Ma et al., 2020; Murphy & Usher, 2015). Furthermore, 65% of the users

of the HTM-fiets in the sample owns a bicycle in The Hague, whereas other studies found that people who do not own a bicycle are more likely to use BSPs (Bachand-Marleau et al., 2011). This difference is likely caused by the high level of bicycle ownership within the Netherlands. The respondents who have made an account in the HTM-fiets application but have not used the HTM-fiets (yet), overall have a higher age and lower education level compared to the users in the sample. This could indicate that while older and lower educated people show interest in the concept, it does not directly fit their transportation needs. It could also indicate that the system including the application might be too complicated, which keeps them from using the HTM-fiets.

The data-analysis of the operational trip data shows that the usage of the HTM-fiets is relatively low compared to 75 other studied BSPs located mainly in Europe and the US, which have an average between 0.22 and 8.4 rides per day per bicycle (De Chardon et al, 2017). Furthermore, the HTM-fiets is more often used in the summer months (Jun – Aug) compared to the other months in the research period. Also, on average the HTM-fiets is more used on a weekend day than on a weekday. During the weekdays, no real rush-hour pattern is observed and during the weekend the usage is highest between 10AM and 2PM and also a peak can be observed between midnight and 1AM. The median duration of rides made with the HTM-fiets is 23 minutes, which means most rides are relatively short. Furthermore, 79% of the users have only used the HTM-fiets between 1 and 5 times, which means that the HTM-fiets is more used by occasional users than by frequent users. Based on these usage patterns it seemed as if the HTM-fiets is more used for occasional leisure trips than for regular work or school related trips. This is confirmed by the results of the survey, which showed that more people had used the HTM-fiets for a leisure purpose on their last ride with the HTM-fiets (57%) than for a work/school related purpose (33%). This might be caused by the fact that people have a privately owned bicycle for regular trips or that other transportation means, such as public transport, are already sufficient to accommodate commuting trips.

Furthermore, drop zones located close to facilities, in business areas and around public transport nodes, which are mainly located in the city centre, seem most used. By expanding the concept, for example to different municipalities, this could be important places to locate new drop zones. Drop zones located at the edges of the public transport network and at locations with a weak public transport connection are the least used drop zone types. This could be caused by the lower population densities in these areas and lower number of facilities, which results in a lower number of visitors. The drop zones with the highest usage are the two large train station in The Hague, Den Haag Centraal and Station HS. The survey shows that respectively 43% and 67% of the respondents who picked up or returned the HTM-fiets at Den Haag CS and Stations HS arrived or departed their by train. This indicates that the HTM-fiets is also used as first and last mile transportation of train rides.

The main points of improvement following from the survey and expert meeting that could increase the usage of the HTM-fiets include:

- Increasing the number of drop zones
- Expanding the area in which the HTM-fiets is offered
- Making the drop zones more visible and attractive
- Creating certainty that bicycles are available
- Offering a better bicycle

It has to be taken into account that the possibilities to add drop zones and expand the area partially depend on the permit issued by the municipality. Furthermore, although in this case a large share of the respondents specifically indicate that more drop zones would increase their usage, previous studies have shown that adding more drop zones does not necessarily have a direct relationship with an increase of the total system usage in terms of trips per day per bicycle (De Chardon et al. 2017; Zhang et al. 2016). Therefore, this should be taken into account in deciding on the number of drop

zones (and bicycles) to add to the concept. Furthermore, while most of these aspects are feasible to change, offering a better bicycle does not seem feasible in the short term due to the high investment it would take.

*3.2 Combined usage of the shared bicycle and urban public transport*

The survey shows that the HTM-fiets is not often used in combination with the bus/tram in a single ride by its users (see Figure 1). Of all HTM-fiets users in the sample (156 respondents), 9% has indicated that they use the HTM-fiets as often in combination with the bus/tram as not or more often in combination in a single ride.

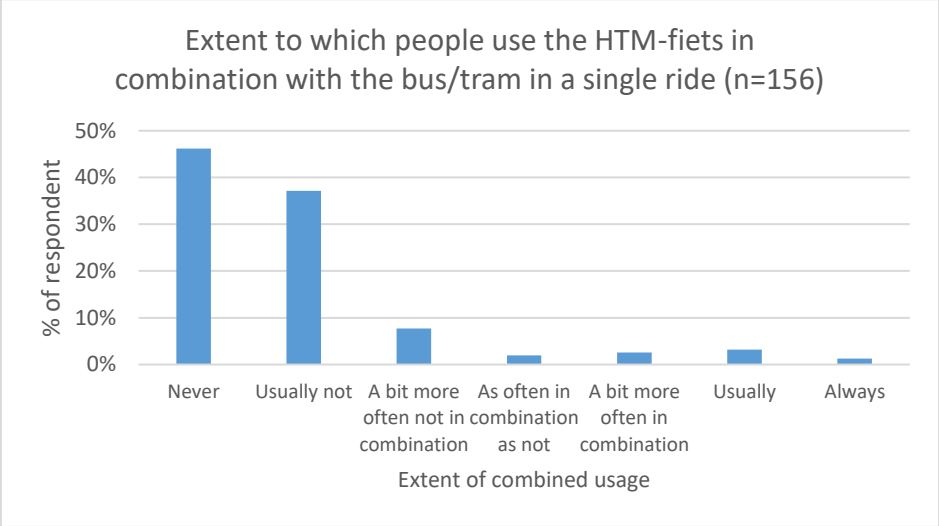


*Figure 1 - Extent to which people use the HTM-fiets in combination with bus/tram*

Of the other respondents who have indicated that they use the HTM-fiets more often not in combination with the bus/tram than in combination or never in combination, 37.3% have used the HTM-fiets as substitute for the tram during their last ride with the HTM-fiets and 8.5% for the bus (see Figure 2). In the current setup it thus seems that the HTM-fiets is more often used as substitute for the bus or tram than as a complement in a single ride. The main reasons why the combination of the HTM-fiets and urban public transport is not often used, which are mentioned by the survey respondents and participants of the expert meeting, include that it is not necessary for most rides, among others because distances in the city are not large enough, and that people specifically use the HTM-fiets instead of public transport because it is for example faster or cheaper. Other reasons mentioned are that people use the HTM-fiets at times (such as in the night) when public transport is less available and that drop zones are not located in the right places to facilitate the combination. On the other hand, the majority (67%) of the people who have not used the HTM-fiets (yet), indicates that they expect to use the HTM-fiets in combination with the bus/tram. It thus seems that there is a difference between how people expect to use the HTM-fiets and how they actually use it.

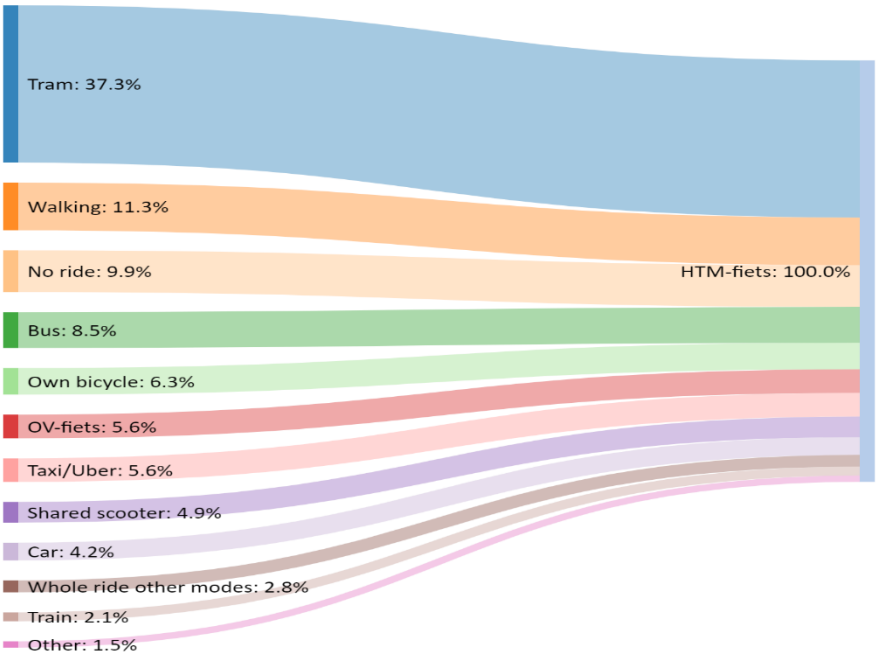


*Figure 2 - Modal shift (Mode used if the HTM-fiets was not available) (n=142)*

*3.3 Factors influencing the extent to which the shared bicycle is used in combination with the bus/tram*
The analysis regarding the socio-demographic factors and attitude/motivational factors showed that a lower education level, a high level of bus use and disagreeing that a drop zone close to home was an important reason to use the HTM-fiets, increases the relative odds that someone belongs to the group that sometimes to always uses the combination of HTM-fiets and bus/tram versus to the group that never uses this combination. The other socio-demographic factors and attitude/motivational factors included in the survey (age, gender, bicycle ownership, level of cycling and tram use, attitude regarding cycling and public transport and the other reasons for using the HTM-fiets) did not have a significant influence on the extent to which people use the HTM-fiets in combination with the bus/tram.

A total of 142 respondents described their last ride with the HTM-fiets not in combination with the bus/tram and 8 respondents their last ride in combination. Due to the low number of described HTM-fiets rides in combination with the bus/tram, the results regarding the influence of the trip factors and public transport factors on the extent to which people use the HTM-fiets in combination with the bus/tram are indicative. However, it does seem as if a longer trip length, a trip purpose related to work/school, a trip that is from the edge to the city centre or vice versa and a trip which includes a ride with a relatively high quality form of public transport (tram instead of the bus), could increase the chance that a trip is made in combination with the bus/tram. Also, people mention that they use the combination specifically to skip waiting time for the next bus/tram line, to cycle to a different and better suitable bus/tram line and because of convenience.

## 4. Conclusion and recommendations

*4.1 Conclusion and recommendations for practice*
It can be concluded from this study that the shared bicycle does not complement urban public transport to a large extent in single rides from A to B within this city type, a mid-sized city with a relatively extensive urban public transport network, and with the current setup of this BSP, including the amount of bicycles and the amount and location of drop zones. The shared bicycle seems more used as a substitute for urban public transport in this case. Based on the data-analysis, survey results and expert meeting it is concluded that it is in this case probably more valuable to focus on integrating the shared bicycle with urban public transport as a whole than to assure a good integration of the

shared bicycle and the bus/tram in a single ride from A to B. Also in cities with comparable characteristics and BSPs this is probably more valuable.

To realise an integrated public transport shared bicycle system, the shared bicycle could be marketed as a form of public transport, next to the bus and tram network. Depending on the needs of the traveller and the circumstances, such as the availability of these transport modes throughout the day, the traveller can then decide which mode or combination of modes suits best. Improvements identified in this study that could contribute to creating one extensive public transport and shared bicycle system are:

- Adding more drop zones and specifically in areas that are less accessible by bus/tram
- Realising an integrated payment system
- Making the shared bicycle visible in large (public transport) trip planning applications

Although the data-analysis showed that drop zones that are currently located in areas with weak public transport connections are among the least used drop zones, adding more drop zones in these areas still improves the accessibility of these areas and increases the number of transport option. Therefore, adding more drop zones in these areas might be important to be able to link the people who live in these areas to the network. From the operator perspective this might initially result in higher costs. However, in case it results in a higher usage of the shared bicycle, bus and tram combined, it will also become beneficial for the operator. Realising an integrated payment system and making the shared bicycle visible in large public transport trip planning application can contribute to positioning the shared bicycle as a form of public transport. However, this could be difficult to realise for technical and cost related reasons. These findings could also be taken into account when introducing a new BSP in general to a city with similar characteristics. In the planning stage, when it is determined where to locate drop zones and how the system works in terms of payment and application, the focus can already be placed on creating one extensive and well-integrated public transport and shared bicycle system and on the marketing of the shared bicycle as a form of public transport.

Overall, focussing on creating one extensive and well-integrated public transport network consisting of the shared bicycle, bus and tram, will be valuable for travellers since it increases their accessibility and number of transportation options. These modalities might then also become a more attractive alternative for private motorised vehicles. In case this results in a decrease of the usage of private motorised vehicles it will also be beneficial for the environment and accessibility of the city.

*4.2 Recommendations for further research*

This study has found whether the shared bicycle functions more as a complement or substitute to urban public transport for a specific city type and BSP. Also, several other studies researched the relation between shared bicycles and public transport, which led to different results regarding whether shared bicycles seem to function more as a complement or as a substitute of public transport. It is recommended to perform more research between different city types and BSPs to examine which characteristics of a city, public transport network and BSP determine specifically how the shared bicycle is used in relation to the public transport network.

Furthermore, this study identified points of improvement for the BSP in general and the integration of the BSP with the bus/tram based on the opinion of people who were already familiar with the concept. Therefore, it is recommended to perform a study regarding the points of improvements from the perspective of people who have no experience with the BSP concept, since they might value different aspects.

Finally, after the period in which this study is performed, a hundred drop zones are added to the HTM-fiets concept in The Hague and the concept has expanded to an adjacent municipality, Zoetermeer, where the concept is slightly different. In Zoetermeer there are more destination oriented drop zones

that are located in places with weak or no public transport connections and signs are placed at drop zones to make them more visible. It is recommended to research after a certain period of time, what the impact of these different measures has been on the general usage of the shared bicycle and the combined usage with public transport. This information could then be used in decisions regarding further development of the BSP and also for the introduction of new BSPs in other locations.

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# 1. Introduction

In this introduction, first the problem background and research gap are described in section 1.1. Thereafter, the research objective and research question are presented in section 1.2. Section 1.3 describes both the scientific and societal relevance of this study and finally in section 1.4 the structure of the rest of this report is described.

## 1.1 Problem background

### 1.1.1 Mobility issues in current cities

Cities all around the world become busier and more densely populated, which consequently leads to more trips being made by people within cities. Since a large share of these trips are made with private motorised vehicles this often leads to high levels of congestion and pollution in cities (Banister, 2008). To keep cities liveable and well accessible it is important to realise a mode shift to modalities that are more sustainable and take up less space. A sustainable mode that has recently received a lot of attention is the bicycle. Bicycles are very flexible in their use, low-cost and if replaced for the car can reduce traffic congestion and pollution (Handy et al., 2014). Besides, the bicycle is an active transport mode and can therefore also have many health benefits for its users. Research found that physical inactivity increases the risk of many adverse health conditions (Lee et al., 2012). Therefore, it is important to stimulate people to become more active and the bicycle could play an important role in this. The bicycle on itself, but also the bicycle in combination with a good working (urban) public transport system could provide a suitable alternative to private motorised vehicles. If these modalities are used to complement each other the benefits of both could be combined. Public transport could provide fast and accessible connections and the bicycle can provide flexible and reliable transport for the first and last mile (van Mil et al., 2018). For this combination to be an attractive alternative for private motorised vehicles it is important that the two modalities connect well with each other.

### 1.1.2 Opportunities of the shared bicycle

Usually not everyone has a privately-owned bicycle available at every location. If there is no public transport stop close to the origin or destination of people and they do not have access to a suitable access or egress mode they might prefer using private motorised vehicles over public transport, while if there was a suitable access or egress mode available, this might be the opposite. A solution for this issue could be the large-scale bicycle sharing programs (BSPs) that have been introduced in many cities since 2005 (Larsen, 2013). These BSPs make a predefined number of bicycles available for everyone to use against some level of payment, which is often either an annual fee or a payment for the rent of a bike on a trip-by-trip basis (Shaheen & Martin, 2015). There are some variations on these BSPs, but the most common setup nowadays is that these bicycles either have to be picked-up and returned at certain drop zones or docking stations or that they are free-floating and could be dropped anywhere within the predefined boarder of the program (Fishman, 2016). People can use these BSPs in combination with public transport to access many locations within a city without having to own a bicycle. Using shared bicycles has as additional benefits for the users that they can use the bicycle for one-way trips and that they don't have to worry about maintenance or theft of their own bicycle (Shaheen & Martin, 2015). Especially the possibility of making one-way trips resulted in new travel opportunities for cyclist that would not be possible without BSPs (Martin & Shaheen, 2014).

### 1.1.3 Research gap

The combined use of public transport and shared bicycles seems a promising alternative to private motorised vehicles. However, whether the combination of both modalities is often used in reality, especially shared bicycles in combination with buses or trams, or whether the shared bicycle functions more as a substitute for buses and trams is only researched to a limited extent. Although some research is performed with respect to the relationship between shared bicycles and public transport

(e.g. Leth et al., 2017; Jäppinen et al., 2013; Shaheen et al., 2013; Ma et al., 2015, Faghih-Imani & Eluru, 2015) these mostly focussed on the combination with metro or regional rail and were performed in very large cities such as Montreal, Vienna and Chicago. This research specifically focusses on the relationship between shared bicycles and the urban public transport network (bus/tram) within a medium-sized city and examines whether these modalities are more a complement or a substitute of each other. Furthermore, the general cycling levels and level of bicycle ownership vary between different countries and might have an impact on the usage of the shared bicycles. This research is performed in the Netherlands, which is a country with a long tradition of cycling and has the highest rate of bicycle use in the world (Heinen et al., 2013). Also, inhabitants of the Netherlands own on average 1.2 bicycles per person (CBS, 2016). Furthermore, it is known that within the Netherlands the private bicycle is often used as an access mode for trips made by train, but less as access mode for urban public transport, which includes bus, tram and metro (Martens, 2007). What the relationship is between shared bicycles and urban public transport in countries where cycling is very common is however researched to a limited extent and is therefore also examined in this study.

Whether shared bicycles are often used in combination with public transport relates to the overall usage of a BSP. Some research is performed with respect to the usage of BSPs and how well these programs work (e.g. Jensen et al., 2010; Faghih-Imani & Eluru, 2015), but this is influenced by multiple factors such as the type of inhabitants, the current cycling level in a city, the size of the city, the number and location of bicycles and docking stations, the quality of other transport modes and external factors such as the weather (Bachand-Marleau et al., 2012; Campbell et al., 2016). Limited research is performed regarding the usage of shared bicycles in countries were cycling is a very common mode of transportation such as the Netherlands. This research will therefore also focus on researching the general usage of a BSP in the Netherlands.

## 1.2 Research objective and research questions

The main goal of this research is to analyse the role of shared bicycles with respect to the urban public transport network; is the shared bicycle more a complement or a substitute of the urban public transport network. Shared bicycles and public transport are both seen as sustainable transportation modes. It is therefore useful to find out whether shared bicycles are used instead of urban public transport or if they are used in combination and thus provide an improved transport option, also for people who used to travel with less sustainable transportation modes. Also, it could be that the shared bicycle is not used in combination and not instead of urban public transport, but is used as a substitute for another transportation mode. To examine this, a case study is used. The case study consists of the in May 2019 introduced BSP called the HTM-fiets, which is located in the city of The Hague in the Netherlands.

From the perspective of the operator of both the public transport network and the BSP, which in this case is the same company, it would be optimal if these two systems integrate well with each other to maximise the usage of both and to compete better with private motorised vehicles. Also, for the traveller it would be beneficial if these systems are well integrated since offering integrated transport services will lead to reduced inconvenience of travel and reduced costs for both the traveller and the operator of transit services (Brand et al., 2017). A study by Brand et al. (2017) concluded that certain improvements in one transport system can result in better integration of this system with systems of other transportation modes. Therefore, this study also examines what influences people to use or not use the shared bicycle in combination with urban public transport and determine which measures can be taken in both systems to improve the integration between these modes. This could ultimately result in a higher usage of the combination of shared bicycles and public transport and also make this combination a better alternative to private motorised vehicles.

Based on the goal of this research the following main research question is formulated:

*"To what extent do urban public transport and bicycle sharing programs complement each other and how can the integration of these systems be improved from a user and operator perspective?"*

Five sub-questions are formulated to be able to give a structured answer to the main research question. These sub-questions are as follows:

1. What is the current state of the research with respect to shared bicycles and the combination of shared bicycles and public transport?
    1a. How are different BSPs across the world currently being used?
    1b. What is currently known regarding the extent to which BSPs and public transport complement each other or are substitutes of each other?
    1c. Which factors could influence the combined use of shared bicycles and public transport?

2. How is the current bicycle sharing program of HTM used and what could be improved about the current setup from both a business and customer perspective?

3. To what extent do users of bicycle sharing programs currently use the shared bicycle in combination with urban public transport and to what extent do they use it as a substitute?

4. Which factors determine to what extent the shared bicycle is used in combination with urban public transport?

5. How can the integration between BSPs and the urban public transport network be improved?

## 1.3 Scientific and societal relevance

This research is relevant from both a scientific and societal point of view. The scientific relevance is apparent from the contribution of this research to the existing literature with respect to the relationship between shared bicycles and urban public transport. This research provides insight in how current users of a BSP use the program and whether they use it more in combination with urban public transport, as a substitute of urban public transport or as a substitute of other transportation modes, within a medium-sized city and within a country with a relatively high level of bicycle usage in general. It will also identify factors that have an influence on the combined usage of shared bicycles and urban public transport. The categories of factors included in this research are socio-demographic factors, trip factors, public transport factors and attitude/motivational factors.

This research has societal relevance since the results of this research can contribute to improving the shared bicycle program on itself as well as the combination with public transport based on the current usage of the BSP. An improved system and integration with public transport can provide travellers in this area with more and better transportation options, which will improve their accessibility. In case an improved system attracts more car users to switch to the shared bicycle, this might also improve the liveability in a city due to reduced congestion and pollution caused by private motorised vehicles.

## 1.4 Report structure

In this first chapter the problem background, research gap, research objective and research questions are identified and formulated. In chapter 2 a review of the existing literature regarding the usage of BSPs, their relation with public transport and regarding factors that possibly influence the combined usage of BSPs and urban public transport is given. A case study is used to provide an answer to the different research questions. Within the case study, different research methodologies are used. These

are a data-analysis on the operational trip data of the BSP, a survey among the users of the BSP and an expert meeting. These different methodologies are described in chapter 3. Thereafter, the objective usage of the HTM-fiets, which is based on the data-analysis of the operational trip data, is described in chapter 4. In chapter 5 the usage of the HTM-fiets from a user perspective, which is based on the survey results and supplemented with information from the expert meeting, is described in chapter 5. The results regarding the combined usage of the HTM-fiets and urban public transport, based on both the survey and expert meeting, are provided in chapter 6. Finally, the conclusion, discussion and recommendations for both practice and further research are described in chapter 7. A visualisation of the report structure is provided in Figure 3.

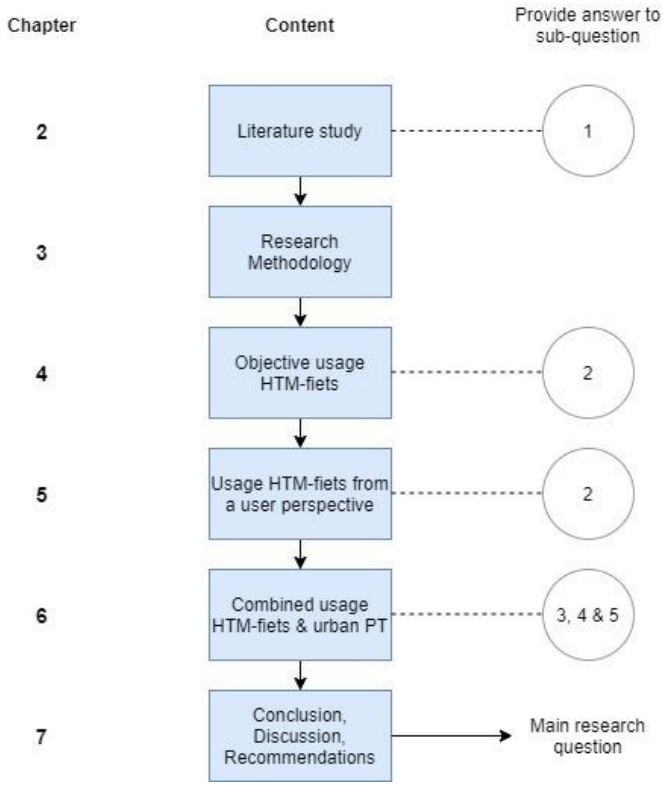


*Figure 3 - Outline thesis*

# 2. Literature study

The combination of bicycles and public transport can provide travellers with a much larger range of trip possibilities than the bicycle or public transport on their own since the benefits of both modes can be combined (Kager, Bertolini & Brommelstroet, 2016). Public transport can provide fast and accessible connections and the bicycle provides flexibility and reliability (van Mil et al., 2018). The bicycle thus supports public transport by increasing the catchment area of public transport stops and public transport supports the bicycle by making longer trips possible within a shorter time period (Pucher & Buehler, 2012). As a result, this combination has the potential to provide a better alternative for private motorised vehicles than these modes on their own. Urban public transport, which mostly consists of bus, tram and metro and regional public transport, which is often the train, are different in this respect. For example, a research performed in the Netherlands showed that 29.3% of access trips to a train station were made by bicycle and only 6.0% of access trips to a bus stop and 2.3% of access trips to a tram or metro stop were made by bicycle (Martens, 2007). This could be related to the fact that train stations usually have a larger catchment area since trains generally operate over larger distances. Furthermore, bicycle facilities are often of higher quality at train stations which makes cycling to train stations more attractive than cycling to tram or bus stops that have less parking facilities. Also, more research is focussed on the combination of bicycle and train compared to the combination of bicycle and urban transit, for example regarding the factors that influence the combined use of the bicycle and train (Van Mil et al, 2018; Weliwtiya, Rose & Johnson, 2019) and the joint access mode and railway station choice of users of the Dutch railway (Debrezion, Pels & Rietveld, 2009).

This study focusses on bicycle sharing programs, which could offer an alternative for the privately-owned bicycle in case this mode is not available or suitable. These BSPs could thus also increase the accessibility of public transport by improving the first and last mile connectivity (Jäppinen et al., 2013). Especially at the egress side of a trip this provides new opportunities. The relationship between shared bicycles and public transport, especially bus and tram, is currently researched to a limited extent and might also be different from the relationship between the general bicycle and public transport. Due to the rapid growth of BSPs in the past years, recently many studies have emerged with respect to various aspects of BSPs. These aspects are, among others, the users, the current usage of BSPs, factors that influence choice behaviour of users, the modal shift and also some with respect to the combination of public transport and the shared bicycle. Some of these studies are discussed more elaborately in this literature study, since this literature study is performed to gain insight in the usage of different BSPs across the world to be able to compare this with the usage of the BSP located in The Hague and to find out what is currently known with respect to the relationship between shared bicycles and public transport. Furthermore, the literature study is used to identify factors that might influence the extent to which people use the shared bicycle in combination with urban public transport. Based on this can be determined which factors are relevant to include in the survey that is conducted as part of this study. This literature study provides an answer to the first sub-question.

Within the literature study different online databases containing scientific literature are used to find studies that are relevant for this research. These databases are Google Scholar and Science Direct. Different combinations of key words are used to find relevant literature. These key words include “bike”, “bicycle”, “shared”, “sharing”, “cycling”, “public transport”, “transit”, “usage”, “factors” and “user characteristics”. If a relevant paper is found, the snowball method is used to find more relevant literature. This means that the bibliography of a relevant paper is searched for other relevant papers.

The rest of this chapter is structured as follows. In section 2.1 studies regarding the users and usage of BSPs are discussed. In section 2.2 relevant literature regarding the combination of shared bicycles and public transport is discussed. Finally, in section 2.3 the factors that possibly influence the extent to which people use the shared bicycle in combination with urban public transport based on previous studies are discussed.

## 2.1 Bicycle sharing programs

In 1965 the first bicycle sharing program was introduced. Fifty bicycles were painted white and put around Amsterdam for everyone to use free of charge. However, this system failed due to vandalism and theft, but the idea of shared bicycles remained and ways to solve these issues were thought of (Larsen, 2013). In the 1990s a few cities started to implement more regulated BSPs that had a coin deposit system, but due to the anonymity these systems still had large issues with theft (DeMaio, 2009). New technological advancements solved the issues with respect to vandalism and theft, as a result, the first large-scale BSPs were introduced. These were called the 3rd generation BSPs and usually contained dedicated docking stations where the bicycles had to be picked-up and returned. These systems also often had technologies to track the bicycles and automated credit card payment systems to prevent vandalism and theft (Shaheen, Cohen & Martin, 2013). One of the first large-scale 3rd generation BSPs was the BSP of Lyon that was introduced in 2005. This BSP consisted of around a hundred self-service docking stations and 1500 bicycles (Larsen, 2013). In the following years BSPs became very popular and in 2015 over 800 cities worldwide offered BSPs (Fishman, 2016). Due to the development of smart bicycle locks and the increasing use of smartphones also 4th generation BSPs have now emerged. Bicycles don't have to be picked-up and returned to specific docking stations anymore, but are free-floating and can be dropped anywhere within the predefined borders of the program. Section 2.1.1 and 2.1.2 discuss the type of users of BSPs and how BSPs are currently used in different cities worldwide.

### 2.1.1 Type of users

Several studies researched what type of people mostly use the shared bicycles and which factors play a role in the likelihood of people to make use of shared bicycles. A study performed by Shaheen & Martin (2015) showed that members of the BSPs of four cities within North America were more often male, younger, more likely to be white and significantly higher educated in comparison with the general population. Also, a study performed by Murphy & Usher (2015) with respect to the BSP in Dublin showed that most members were male (78%), between the age of 25 and 36 and have a higher than average income level. Furthermore, people in Montreal were more likely to use the shared bicycle programs when they have an age between 18 and 24, are male, were university educated, did not own a bicycle and had a relatively high income (Bachand-Marleau, Lee & El-Geneidy, 2012; Fuller et al., 2011).

Within the Netherlands specifically, also a few studies are conducted with respect to the usage of BSPs and these studies identified which type of people make use of the shared bicycles. Gerrevink (2019) conducted a survey among the users of Mobike, which is a free-floating BSP, in Delft and found that most users were male, between 18 and 24 years old and were students. Also, Ma et al. (2020) researched multiple BSPs in Delft including Mobike and the OV-fiets (a docked BSP at train stations). Of the respondents who had used Mobike and the OV-fiets, respectively 69% and 54% of the users were man, 93% and 94% were higher educated and the largest share of people (47% and 46%) belonged to the age category 18 to 24 years old. The city of Delft is home to a large university, which might influence the type of people that make use of the shared bicycles in this city. The high share of higher educated and young people who use the shared bicycles in Delft might be caused by the large amounts of students in this city. Furthermore, Waes et al. (2018) performed a study among the users of Flickbike, which is a BSP with drop zones, in Amsterdam by conducting a survey. They found that 69% of the respondents was man, 86% was higher educated and most respondents were relatively young (between 23 and 37). The most common age category of shared bicycle users in Amsterdam thus seems higher than in Delft.

The general bicycle usage in the Netherlands is very different compared to other countries in terms that the Netherlands has in comparison a relatively high share of active mode use (Pucher & Buehler, 2008). Looking at all trips made by an individual in the Netherlands in 2017, on average 27% of these

trips were made by bicycle (CBS, 2018a). Besides, the Netherlands has a relatively high number of bicycle ownership and a well-developed bicycle infrastructure (Martens, 2013). High cycling rates within a country might also affect the type of users of bicycles. Gerrard et al. (2008) found that in countries with high cycling rates, cycling is more popular by women than within countries with low cycling rates. However, when comparing the users of the BSPs in the Netherlands with the other cities, it appeared that within all cities the shared bicycle is more used by men. Also the education level and age of the users of the different BSPs are comparable.

Overall, previous studies show that both in cities in the Netherlands as well as in some other cities in the US and Europe, users of shared bicycles are more likely to be man than woman, have a relatively young age, are relatively high educated and have a relatively high income level.

### 2.1.2 Usage

A few studies have also researched the usage of current BSPs around the world. Several studies showed that the average trip duration and distance of trips made by shared bicycles are relatively short. Studies regarding the usage of BSPs in Lyon, Chicago and Cork showed that the average duration of rides made by shared bicycle were respectively 14.7 minutes, 20.7 minutes and 9 minutes (Jensen et al., 2010; Faghih-Imani & Eluru, 2015; Caulfield et al., 2017). Furthermore, the average trip distance of the BSPs in Lyon and Chicago were respectively 2.49 and 2.54 kilometres. A study by Castilo-Manzano et al. (2010) found that shared bicycle trips are indeed on average 700 to 800 meters shorter than trips made with a private bicycle.

Previous studies also showed that temporal characteristics have an effect on the usage of BSPs. A study by Faghih-Imani et al. (2014) performed in Montreal showed that the shared bicycle was more used during weekdays as opposed to the weekend, that the shared bicycles were mainly used in the PM period and that the likelihood of using shared bicycles increased on Friday and Saturday nights. Also, a study by Froehlich et al. (2009) showed that users of a BSP in Barcelona tend to use the shared bicycle more on weekdays. On the other hand, a study by Corcoran et al. (2014) regarding the usage of a BSP in Brisbane found that weekends had a significant and positive effect on shared bicycle usage. Furthermore, several studies examined the trip purposes of shared bicycle rides. A study performed by Shaheen et at. (2013) who researched the usage of four different BSPs in North America found that in Montreal and Toronto at least 50% of all trips was work related and within Washington DC and Minneapolis-Saint Paul around 38% of all trips. Some studies also showed that the trip purpose might be dependent on people being an annual member of a BSP or an occasional user. A study regarding the users of a BSP in Brisbane showed that 14% of the long-term subscribers reported ‘leisure or sightseeing’ as trip purpose for their last trip, while 65% of occasional users reported this as the purpose of their last trip (Roy Morgan Research, 2013). Furthermore, of the annual members of a BSP in London, 52% reported that their last trip had as trip purpose commuting to/from work (Transport for London, 2014). From previous studies it also appeared that the usage of specific stations/drop zones depend on their location. It seems that in general BSP stations located near points of interest such as universities and restaurant showed higher usage rates and that higher population densities or job densities contributed to the usage of BSPs (Faghih-Imani et al. 2014, Rixey, 2013).

The standard metric to compare the usage of different BSPs has become trips per day per bicycle, since this controls for variation in the number of bikes in a system (Fishman, 2016). According to the ITDP Bikeshare Planning Guide the target value for a sustainable BSP is between 4 and 8 trips per day per bicycle (Yanocha et al., 2018). Fishman (2016) made an overview of the trips per day per bicycle for twelve large BSPs in the world over the year 2013 (Figure 4). The highest usage per bicycle was found for the BSP in Paris which reached an average of almost eight trips per day per bicycle for the month September. The BSPs with the lowest usage per bicycle were the BSPs of Melbourne and Brisbane, which had an average usage below one trip per bicycle per day during the entire year.

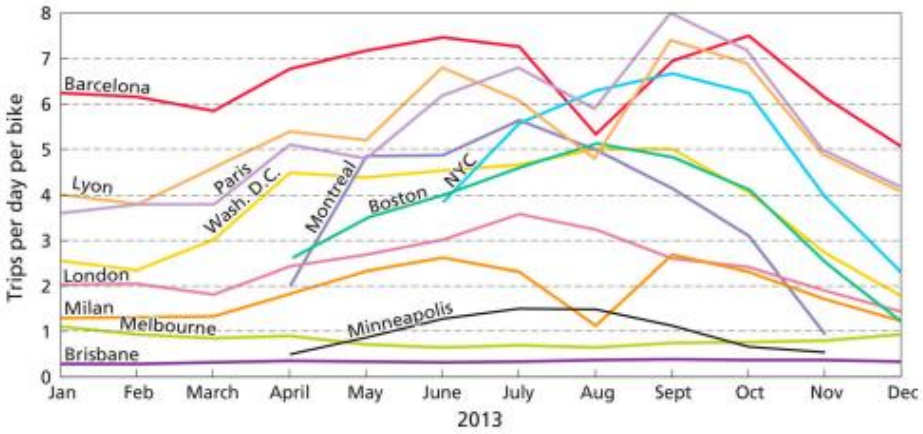


*Figure 4 - trips per bicycle per day for different BSPs (Fishman, 2016)*

Also, De Chardon et al. (2017) compared the performance of different BSPs and used the metric trips per day per bicycle for this. They looked at 75 BSPs with docked shared bicycles that were predominantly located in Europe and the United States. The estimated trips per day per bicycle of these BSPs all had values between 0.22 and 8.4 and the average was 2.4 trips per day per bicycle. A third of these programs had a usage below 1.0 trip per day per bicycle, which means that each day some bicycles are being unused. It also appeared that ten programs had a value below 0.5, which means that most bicycles were not being used on a daily basis. Factors that were found to positively influence this performance include a higher population density, station density and cycling infrastructure, while a greater variability in station sizes had a negative impact on performance. A temperature between 18 and 33 degrees also increased performance while an increase of wind had a negative influence on performance.

In general, De Chardon et al. (2017) found that the larger programs showed higher performance although there were some important exceptions. Some programs with just between 33 and 47 stations had an average between 6 and 8.2 trips per day per bicycle, which is relatively high, while other programs which had 4 to 12 times as many stations showed much lower values for trips per day per bicycle. They conclude from their findings that increasing the number of stations and bicycles does not necessarily increase system performance. This corresponds with a study from Zhang et al. (2016) who researched the impact of expansion of BSPs on the usage of the system. They found that after a first expansion of the program, an overall increase in usage was observed caused by the extra usage of new stations. However, after a second expansion no overall increase in usage was observed anymore, which was mainly caused by a decline in usage of steady users, which are people who used the system over a long period of time. This might be caused by an increase in negative aspects of the system such as a decline in the quality of bikes and availability of bicycles.

Although within the Netherlands cycling is very common, this does not necessarily mean that there will also be a large demand for shared bicycles compared to other countries. In 2016, when there were no providers of shared bicycles in the Netherlands yet, except for the OV-fiets, van Heijningen (2016) researched how bike sharing systems should be designed in the Netherlands to become an attractive transport mode. By conducting a survey van Heijningen (2016) found that just 25% of the respondents would be open to using a shared bicycle for their business or commuting trips. Furthermore, most respondents preferred to use their privately-owned bicycle instead of a shared bicycle. However, in case their own bicycle would not be available they did find the shared bicycle an attractive mode choice. It thus remained uncertain whether a large part of the Dutch population would find the shared bicycle an attractive mode to use. In 2017 the first large shared bicycle companies introduced their BSPs in the Netherlands. Not many studies have yet been conducted on the performance and usage of these BSPs. However, Boor (2019) has researched the usage of Mobike in Delft, which is a free-floating

shared bicycle program introduced in spring 2018. Boor (2019) found that between 1000 and 2100 trips were made per day using a Mobike in Delft. This meant that an average of 1.6 daily trips were made per bicycle. Looking at Figure 4 this seems comparable with the usage of the BSP in Milan and the BSP in Minneapolis in summer. Furthermore, the average trip length of rides made by Mobike in Delft is between 1.7 and 2.3 kilometres. It thus seems that shared bicycles in the Netherlands are also often used for short trips. Boor (2019) also found that many trips were made between the train stations in Delft and the university, which could indicate that the shared bicycle is used as egress mode after a train ride. Besides, the usage was higher on weekdays and the peaks in usage corresponded with lecture hours of the university.

Overall, the usage of BSPs differs for each city, but the general metric to compare the usage of BSPs is trips per day per bicycle. While the target value for a sustainable BSP is between 4 and 8 trips per day per bicycle, values between 0.22 and 8.2 were found for 75 BSPs in different cities worldwide with an average of 2.4 trips per day per bicycle. The usage of BSPs is influenced by multiple factors. Since most BSPs will have different characteristics such as the distance between stations, the amount of stations and bicycles and the tariff system, the usage might also vary across different BSPs. Furthermore, each city has different characteristics and inhabitants, which also impacts the usage of a BSP.

## 2.2 Combination of bicycle sharing programs with urban public transport

Within this section first the relevant literature regarding the relationship between BSPs and public transport is discussed in section 2.2.1. In section 2.2.2 studies regarding the modal shift after the introduction of BSPs are discussed, which provide insight in the extent to which BSPs function as a substitute for public transport. Finally, in section 2.2.3 a synergy of this literature is provided.

### 2.2.1 Relationship between BSPs and public transport

A few studies are conducted with respect to the relationship between BSPs and public transport. Shaheen et al. (2013) conducted a survey among members of the BSPs within four cities in North America. They found that the introduction of the BSPs overall increased cycling and decreased car traffic within the cities. The effect of the BSPs on public transport usage was however less clear. Within the four researched cities some people increased their public transport ridership, while others decreased their public transport ridership after the introduction of the shared bicycles. However, in total an overall reduction of bus and rail usage was observed in the three larger cities (Toronto, Montreal and Washington DC), while in the smaller city (Minneapolis-Saint Paul) an overall increase in rail usage and only a slight decrease in overall bus usage was observed. This difference could be caused by the size and density of the cities and the size and density of the public transport networks. The smaller city also has a less extensive public transport network, which means that the shared bicycles might have provided improved access and egress possibilities to the public transport network. In the larger cities, people might have shifted more from using public transport to the shared bicycle because of congested public transport and an improved speed when using the shared bicycle. They indicate however that more research is needed to substantiate these relations. Furthermore, Martin & Shaheen (2014) performed a study with respect to the users of BSPs in Washington DC and Minneapolis and found that the effect of a BSP on public transport depends on the location where people live. People who live in the urban periphery (suburbs) are more likely to shift modes towards bus and rail transit, whereas people who live more in the urban core use both forms of public transport less after the introduction of BSPs. This is probably because the people who live in the urban periphery will have new opportunities for first and last mile connections to public transport and shared bicycles give people who live in the urban core a possible faster alternative than public transport, especially for short distance trips. This corresponds to a study from Ma et al. (2015) who found that the demand for shared bicycles in the suburbs of Washington DC was very large. This indicates that shared bicycles could help to solve issues with first and last mile transportation and could be complementary to public transport in these areas. From these studies can thus be concluded that the effect that BSPs have on

public transport use depends on multiple factors such as city size, density of the public transport network and if trips start and originate in the urban core or the urban periphery.

Several studies could say something about the relationship between BSPs and public transport by looking at the origins and destinations that were often used. Ma et al. (2015) researched the effect of the BSP of Washington DC on the Metrorail ridership. They found that the stations of the Metrorail were indeed important origins and destinations for trips made with a shared bicycle. Besides, they found that an increase in shared bicycle trips with 10% would generate an increase in transit ridership of 2.8%. This indicates that the shared bicycle could have a positive influence on public transport usage and is thus used in combination with public transport for a certain group of people. Faghih-Imani & Eluru (2015) studied destination preferences of bikesharing users in Chicago and found similar results. The shared bicycle stations close to the metro and regional train stations were often chosen as a destination by members of the programs. This shows that BSPs could support the use of public transport. However, they found that occasional customers less often had public transport stations as destination. This could be related to the fact occasional customers often have different trip purposes such as recreational trips. For occasional customers it thus seemed that BSPs serve more as a substitute for public transport.

A few studies researched the relation between shared bicycles and public transport by looking at travel times between certain locations with or without a BSP to see if shared bicycles could function as a complement or substitute to public transport. Jäppinen et al. (2013) studied the effect that shared bicycles could have on public transport travel times in the city of Helsinki. They found that if shared bicycles are used in combination with public transport, the public transport travel times could be reduced by more than 10%, which is around 6 minutes per each individual trip. The competitiveness and attractiveness of sustainable modes can thus be increased by BSPs that complement public transport. However, the travel times are reduced mostly in the more remote regions. If the destination is close to a public transport hub the reduction in travel time is minimal. Also, in the downtown areas of Helsinki it is found that a part of the public transport trips will be replaced by shared bicycle trips, since this will often be a faster alternative. Leth et al. (2017) performed a spatial analysis and compared travel times of shared bicycle routes with travel times of alternative public transport routes in the city of Vienna to examine if BSPs and public transport were competition or a supplement to each other. They found that at the time of the analysis, the BSP was more a supplement than a competitor to the public transport network. Furthermore, the regions with poor public transport cross-connections could potentially be a good area for BSPs since it seems from the analysis that people use shared bicycles to avoid public transport trips that require a transfer. From this research they could however not conclude that people actually used the shared bicycle as a supplement of public transport since this was only an estimation based on travel time.

### 2.2.2 Modal shift after the introduction BSPs

Several studies researched what type of influence the introduction of a BSP in a city has on the usage of other means of transportation. One of the reasons for implementing a BSP in a city is often to promote the use of sustainable modes of transport and reduce the usage of less environmentally friendly modes such as the car. In Table 1 a summary is given of the outcomes of studies that researched which mode of transportation people replaced by using the shared bicycle. In different cities 1%-13% of the people switched from the car to the shared bicycle. Although the introduction of BSPs in cities thus assures a reduction in car usage, most people switch from other sustainable modes such as public transport, walking and the privately-owned bicycle to the shared bicycle. Especially in Delft within the Netherlands, a very small percentage of the shared bicycle users would have used the car if the shared bicycle was not available. However, the modal shift also depends on the current modal split in a city (Fishman et al., 2013). If for example only a small number of trips within a city is made by car, it is not likely that a large share of the shared bicycle trips are replacing car trips.

A relatively large share of the people in the different cities, between 23% and 51% (see Table 1), use the shared bicycle instead of public transport. This might indicate that for some people the shared bicycle offers a more attractive alternative than public transport. In these cases the shared bicycle functions as a competitor to public transport. The percentage of people who switched from public transport to the shared bicycle is relatively low in Delft compared to the other cities. This might be caused by the fact that public transport is less used in general compared to the other cities.

The studies in Montreal and Lyon also investigated to what extent the shared bicycles generate new trips. It appeared that respectively 3% and 2% of the shared bicycle users in these cities would not have made a trip if the shared bicycle was not available.

*Table 1 - Percentage of bikeshare users that replaced a certain transportation mode by the shared bicycle per city (Source: Bachand-Marleau et al. (2012); Murphy & Usher (2015); Midgley (2011); Gerrevink (2019))*

| | Car | Taxi | Public Transport | Walking | Bicycle | New trip |
|---|---|---|---|---|---|---|
| **BIXI, Montreal** | 2% | 8% | 34% | 25% | 28% | 3% |
| **Dublinbikes, Dublin** | 13% | | 23% | 31% | 32% | |
| **Velo'v ,Lyon** | 7% | | 50% | 37% | 4% | 2% |
| **Bicing, Barcelona** | 10% | | 51% | 26% | 6% | |
| **Mobike, Delft** | 1% | | 25% | 33% | 30% | |

Besides Gerrevink (2019), who researched the modal shift among Mobike Users in Delft by asking them which transportation mode they would have used if Mobike was not available, Ma et al. (2020) performed a more detailed study regarding the usage of different transportation modes by Mobike users in Delft after the introduction of Mobike. Ma et al. (2020) asked the users of Mobike if they increased, decreased or did not change the usage of other transportation modes after the introduction of Mobike. They found that the largest share of people decreased their usage of the bus and tram (40% of the Mobike users), their usage of the private bicycle (35% of the Mobike users) and their level of walking (35% of the Mobike users). However, also 16% of the Mobike users indicated that they increased their usage of the bus/tram after the introduction of Mobike. Ma et al. (2020) state that this might be explained by the fact that they use the Mobike as first and last mile transportation to bus/tram stops because they will have no concern about bicycle parking when using Mobike compared to when using a private bicycle. Furthermore, 37% of the Mobike users reported a decrease in their usage of the car or taxi after the introduction of Mobike. Although it concerns a different type of question this is a relatively high percentage compared to the study of Gerrevink (2019) who found that only 1% would have used the car if Mobike was not available.

### 2.2.3 Synergy of the literature regarding the combination of BSPs and public transport

Overall it seems from previous studies that the extent to which a BSP is complementary or a substitute of public transport depends on city size, size and density of the public transport network and if trips start or end in the suburbs or in the city centre. Shared bicycles seem more complementary to public transport in smaller cities with less dense public transport networks and largely for trips made to or from the suburbs where the shared bicycle can provide a solution for the first and last mile problem in areas that are served less by public transport. On the other side, the shared bicycle seems more used as a substitute in the city centres of large cities with more extensive public transport networks, where the shared bicycle could often provide faster transport and an alternative in case of crowding and congestion within the public transport network. Furthermore, previous studies confirm that shared bicycles could be used complementary to public transport since public transport stops often seem to be popular destinations of shared bicycles and that overall travel time can be reduced if shared bicycles are used in combination with public transport. However, looking at the modal shift that occurred after the introduction of shared bicycle programs it does seem that a relatively large share of users, although

this differs per city, have substituted public transport by the shared bicycle, which means that these modes also function as competition from each other for certain people.

The performed studies with respect to the combination of public transport and shared bicycles all have a different focus. These studies mainly focussed on analysing aspects like the modal shift after the introduction of the BSP, what the effect of shared bicycles are on public transport travel times or what destination choices are of shared bicycle users. However, with respect to the extent in which shared bicycles are a complement or substitute to public transport, these studies can mainly make assumptions that still have to researched to a further extent. Besides, these studies were largely performed in very large cities and often with respect to the combination with metro or regional rail and not with buses or trams. One research really addressed the question if the shared bicycle and public transport were a complement or competition to each other, but this study used a spatial analysis and did not look at which choices users of the BSP actually make. Therefore, this research will focus on to what extent the shared bicycle and urban public transport, which include the bus and tram, complement each other by performing a survey among the users of the shared bicycle program of The Hague.

## 2.3 Factors influencing the combined use of shared bicycles and urban public transport

There are certain factors that influence if and how people use the shared bicycle and a few studies have already focussed on finding these factors. These factors can be used in the formulation of policies that promote the use of shared bicycles (Bachand-marleau et al., 2012). Some of the previous studies regarding this subject had a specific focus on finding factors that influenced the likelihood that people make use of shared bicycles or become members of BSPs, while others were focussed on factors that determine how often people use the shared bicycle. This research is mainly focussed on the combination between shared bicycles and urban public transport (bus/tram). If and which factors have an influence on the extent to which people use the shared bicycle in combination with the bus/tram is still researched to a limited extent. There are however multiple studies that researched the factors that influence the combined use of the general bicycle and public transport (mostly the train), of which some might correspond to the factors influencing the combined use of the shared bicycle and urban public transport.

Table 2 provides an overview of the most relevant studies with respect to factors that influence either if people use the shared bicycle or not, how often people use the shared bicycle and if people use the general bicycle in combination with public transport. Some of these factors might also have an influence on the combined use of shared bicycles and urban public transport.

Based on the literature study it is determined which factors are included in the survey that is part of this study. Not all factors included in the previous studies are relevant for this study, as they are less likely to influence shared bicycle usage in the Netherlands. For example, the cycling infrastructure in the Netherlands is very good in most places and the terrain is very flat. Also, previous research states that weather conditions are of less influence on bicycle usage in countries were cycling is very common such as the Netherlands (Ton et al., 2019) and are therefore also not included. Furthermore, it was important that the survey would not become too long and as a result some factors were excluded for this reason. Lastly, it was not desired that too many questions were asked regarding personal details of respondents. Many people are often reluctant to provide details like income and ethnic background. Ultimately, four different categories of factors are included in this research. These are socio-demographic factors, trip factors, public transport factors and attitude/motivational factors. The following sections discuss which specific factors are included in this research for each of the categories.

*Table 2 – Overview of factors found in literature that influence if and/or how often people use shared bicycles and/ or influence the combined usage of bicycles and PT*

| Author | Topic | Geography | Method | Factors |
|---|---|---|---|---|
| **Bachand-Marleau, Lee & El-Geneidy (2012)** | Understanding factors influencing the likelihood of using BSPs and the frequency of use | Montreal, Canada | Survey + binary logistic regression model and linear regression model. *Dependent variable: previous use BSP (yes/no) and number of uses of the BSP* | Motivators: convenience, avoid risk of theft and maintenance.<br>Likelihood: age, gender, income, owning a bicycle, cycling for recreation only, #of bicycle thefts, driver's license, being a bus user, distance home to downtown, being a year-round cyclist, presence BIXI station less than 500m from home and destination, already combined cycling and transit.<br>Frequency of use: age (not sig.), gender (not sig.), owning bicycle, owning yearly membership, use to avoid risk of theft or maintenance, use for attractive design, #bus stops close to home, distance home to downtown, #of bicycle thefts (not sig.) |
| **Fishman, Washington, Haworth & Watson (2015)** | Finding factors that influence bike-share membership | Brisbane and Melbourne, Australia | Survey + logistic regression model. *Dependent variable: bike share membership (yes/no)* | Impact of mandatory helmet legislation (-), riding activity in the past month (+), convenience as an encouraging factor for private bike riding (+), age (-), income (+), work within 250m of docking station (++), home within 250m of docking station (+) |
| **Faghih-Imani, Eluru & El-Geneidy (2014)** | Finding factors that increase the bicycle flows at stations and usage of the BSP | Montreal, Canada | Data-analysis + multilevel linear mixed regression model. *Dependent variable: arrival or departure rate over station capacity* | Weather (temperature, humidity, rain), time (AM/PM, weekday/weekend), bicycle infrastructure (number/capacity BS stations, length bicycle facility, number of roads), land use (station distance to CBD, distance to metro station, points of interests close to station) |
| **Campbell, Cherry, Ryerson & Yang (2016)** | Understanding which factors influence the decision to switch from existing modes to bikeshare | Beijing, China | Survey + MNL choice model | Trip factors: distance<br>Environmental factors: air quality, congestion (not sig.), rain, temperature<br>Travel behaviour: original mode type (not sig.), original mode not sheltered<br>Population factors: age, education (not sig.), gender (not sig.), income (not sig.), environmental concern (not sig.) |
| **Ma, Yuan, van Oort & Hoogendoorn (2020)** | Examines model shift dynamics and the influential factors on modal shift in response to various bike-sharing systems. | Delft, the Netherlands | Survey + binary logit model. *Dependent variable: shift/no shift to one of the BSPs* | Socio-economic variables: Gender, public transport subsidy, student discount, private bicycle ownership.<br>Commuting trip variables: distance, travelling with multiple modes<br>Motivation variables: no stolen/damaged problem, cheaper than other modes, good quality of bicycles, convenient for short trip<br>(these are only the ones significant for one or more of the different BSPs) |

| | | | | |
|---|---|---|---|---|
| **Martin & Shaheen (2014)** | What are key characteristics of people who increase and decrease their PT use in response to BS? | Washington DC and Minneapolis, USA | Survey + four ordinal regression models. *Dependent variable: modal shift (increase/decrease of rail/bus use)* | Age (+), gender (female = -), income (+ to rail), commute distance (+), population density home location (-)<br>(these are only the significant ones in one or more of the models, for example education, race and population density work location had no significant influence) + = for shift towards rail/bus |
| **Van Mil, Leferink, Annema & van Oort (2017)** | Finding factors that affect bicycle-transit demand | Multiple countries | Literature review | Transit related factors: trip length, station location, bicycle-transit services at stations, directness of routes, service level.<br>First-/last mile factors: regions bike ability (weather, hilliness, daylight), quantity/quality of bicycle infrastructure, bicycle ownership, perceived safety, level of cycling, level of transit use, firs/last mile distance, congestion for cars, quality and price BTM network, car parking facilities, car ownership<br>Context factors: Attitude cycling, attitude rail, perception of barriers, car as status symbol<br>User characteristics: commuter, student, employment, income, frequent rail traveller, gender, level of education, age, travel with heavy luggage, wearing smart clothes. |
| **Shelat, Huisman & van Oort (2017)** | Deriving user and trip characteristics of the bicycle and transit mode in the Netherlands and finding which type of people use this combination most often | the Netherlands | Descriptive analyses from OViN data + latent cluster analysis | Trip characteristics: distance (+), trip purpose (commuting = +), type of main mode (train = +), access/egress distance (larger = + for bike ipv walking)<br>User characteristics: Income, occupation, gender, age, education level, home location, household composition, car availability, PT use frequency |

### 2.3.1 Socio-demographic factors

Socio-demographics are included in this research for two purposes. The first is to see if socio-demographics have an influence on the extent to which people use the HTM-fiets in combination with the bus or tram. The second is to find out what type of people make use of the HTM-fiets.

In studies researching the effect of socio-demographics on mode choice, and more specifically bicycle use, large differences between places were found. Where certain factors highly correlate with bicycle use in some cities, in other cities these factors appeared to be insignificant (van Mil et al, 2018). Furthermore, from a recent study of Ton et al. (2019) in the Netherlands resulted that socio-demographic factors had less impact on mode choice compared to what was stated in literature. Since multiple studies showed that some socio-demographic characteristics did have an influence on the chance of being a bike share user and a user of the combination of the general bicycle and public transport, some user characteristics are included in this study. These are age, gender, education level, bicycle ownership, level of bicycle use and level of public transport use. An explanation of why these factors are included is given in the next sections.

**Age**

Several studies showed that younger people had a higher likelihood to use shared bicycles or become members of a BSP (Bachand-Marleau et al., 2012; Fishman et al., 2015). Furthermore, the largest group of people that combines regular cycling with transit consists of young to middle-aged adults (Shelat, 2017, Krizek & Stonebraker, 2010; Sherwin & Pakhurst, 2010). It thus seems that an increasing age results in a smaller chance to use shared bicycles or combine cycling with transit. However, Martin & Shaheen (2014) performed a study regarding the user characteristics of the people shifting towards and shifting from public transport (bus and rail) after the introduction of shared bicycles and found that a higher age has an association with increased public transport use after the introduction of shared bicycles. Since it is uncertain what the influence is of age on the extent to which people use shared bicycles in combination with urban public transport, age is included in this study.

**Gender**

From previous studies it seems that women are less likely to use shared bicycles compared to men (Bachand-Marleau, 2012; Ma et al., 2020). Furthermore, from the people who use the combination of the general bicycle and transit, the largest share are also men (Sherwin & Pakhurst, 2010). Besides, the study performed by Martin & Shaheen (2014) found that more men than women shifted towards public transport after the introduction of shared bicycles. This indicates that more men start using the combination of shared bicycles and public transport than women. However, the usage of bicycles in general differs per country. It seems that in countries where cycling is not common, significant more men cycle than women, while in countries with high levels of cycling, there is more balance between the cycling levels of men and women (Murphy, 2015; Heinen et al., 2010). Therefore, it could also be that there is a difference in shared bicycle usage between countries regarding gender. In this study will thus be researched what the influence of gender is on the extent to which people use the shared bicycle in combination with bus/tram in a country with high cycling levels.

**Education level**

Previous studies found that bike share users often have a high education level compared to the general population (Fishman et al., 2013). Furthermore, Heinen & Bohte (2014) found in their study that the people who commuted by a combination of bicycle and public transport had the smallest proportion of less educated people compared to all other commuters. This is also confirmed by a study performed by Shelat et al. (2017). It thus seems that the combined bicycle and transport mode is mainly used by people with a higher education level. The reason for this could be that higher educated people more often have longer commute distances because higher specialized jobs are often found at fewer locations, which means a longer commute distance. However, this research is focussed on the

combined use of shared bicycles with bus or tram, which means distances are less long and therefore higher education might not lead to an increased use of this combination. Furthermore, Martin & Shaheen (2014) found that education level did not have a significant effect on the modal shift towards or away from public transport as a result of the introduction of shared bicycles. To confirm if a higher education leads to an increased or decreased use of the combination of shared bicycle and bus and tram, this factor is included in this study.

**Bicycle ownership**
It seems likely that if a person has a private bicycle available, that this person would be more likely to use their own bicycle instead of a shared bicycle. This is confirmed by the research of Bachand-Marleau et al. (2012) which shows that bicycle ownership decreases the likelihood of becoming a bike-share member and also has a negative impact on the frequency with which a person uses shared bicycles. However, in the Netherlands people own on average 1.2 bicycles per person (CBS, 2016), which means almost everyone owns a bicycle. Bicycle ownership is considered in this research to find out if bicycle ownership (in The Hague) also has an impact on shared bicycle usage and specifically the combination with urban public transport in a country were most people own a bicycle.

**Level of cycling**
Both Fishman et al. (2015) and Bachand-Marleau et al. (2012) found that a high usage of the bicycle in general had a positive influence on becoming a bikeshare member. People who already cycle often thus seem more likely to also make use of the shared bicycle than people who cycle very little. Furthermore, people who already cycle a lot in general might be more inclined to use the shared bicycle for the entire trip and instead of public transport since these people are already used to cycling. However, van Mil et al. (2017) stated that a high level of cycling among people also resulted in a higher use of the bicycle-transit combination, although this might largely be in combination with the train. In this research level of cycling is taken into account to find out if and what the influence is on the extent to which people use the shared bicycle in combination with urban public transport.

**Level of urban public transport use**
Bachand-Marleau et al. (2012) found that people who are bus users (have used the bus at least once in the past year) were more likely to be users of the BSP. They expect that this is because shared bicycles could be used in combination with transit trips or for replacing short bus trips. People who use public transport and specifically the bus and tram often, might switch from their current access/egress mode to the shared bicycle in case this is more convenient, for example because it is faster or because they do not have to worry about leaving their own bicycle at the bus/tram stop, but might also replace the trips they made with the bus/tram by shared bicycle. To test if a high level of public transport use negatively or positively influences the extent to which people use the shared bicycle in combination with the bus/tram this factor is included in this study. To gain a more detailed insight, this factor is split into level of bus use and level of tram use.

### 2.3.2 Trip factors
Trip factors are included in this research to find out if and to what extent these factors have an influence on the extent to which people use the shared bicycle in combination with urban public transport. Furthermore, trip factors are also included to get more insight in the usage of the shared bicycle in general and with that complements the outcome of the data-analysis on the operational trip data, for example by finding out the most common trip purposes of users of the BSP. The trip factors considered in this research are the trip length, trip purpose and the start and end location of a trip.

**Total trip length**
In general it appears that trip distance is negatively related with the choice to use the bicycle in general (Munoz, 2016). This is partly due to the speed difference compared to other modes such as the car

and public transport. Covering a large distance would take a lot longer by bicycle than by one of these other transportation modes. The bicycle is most popular for distances between one and five kilometres (Van Mil et al., 2017). Campbell et al. (2016) also found that the demand for bike sharing specifically, is strongly negatively influenced by trip distance. Looking at the combination of bicycles and public transport, the study performed by Van Mil et al. (2017) states that the public transport journey must be of significant length before you would use the bicycle as access or egress mode due to the inconvenience of parking or collecting your bicycle. Furthermore, if the trip is relatively short, people might be more inclined to use the bicycle for the entire trip. Finally, Martin & Shaheen (2014) found that a larger commute distance was significantly associated with a shift towards bus use in Minneapolis. However, commute distance was not significantly associated with a shift towards bus use in Washington and a shift towards rail use in both Minneapolis and Washington. In this research is examined if total trip length plays a role in the extent to which people use the shared bicycle in combination with the bus/tram.

**Trip purpose**

Previous research by van Mil et al. (2017) states that commuting as a trip purpose has a very positive influence on the combined use of the general bicycle and rail. Furthermore, Shelat et al. (2017) also found that the majority of trips made by a combination of bicycle and transit is used to travel to work or education. However, if the combined use of the shared bicycle and urban public transport is also largely used for work or education purposes is less clear. As stated in section 2.2.1 Faghih-Imani & Eluru (2015) found that members of BSPs often had metro or regional train stations as destinations for their shared bicycle trips, while the opposite was true for occasional customers. It thus seemed that occasional users, who more likely have recreational trip purposes, used the shared bicycle more as substitute for the public transport services, while for regular users, who more likely have a trip purpose related to work or school, it seemed to function more as a complement. To examine if trip purpose has an influence on the extent to which people use the shared bicycle in combination with urban public transport this factor is included in this research.

**Start and end location**

Martin & Shaheen (2014) found that a higher population density at the home location of people was associated with a shift away from public transport by these people. Higher population densities usually appear in areas towards the city centre. As also mentioned in section 2.2.1 it could thus be that in the city centres the shared bicycles are more used as a substitute of (urban) public transport while in the outskirts of the city the shared bicycles might function more as a complement. This is probably because bicycles can be a faster alternative than public transport for the relatively short distances in the city centre where public transport often has to deal with congestion, traffic lights and multiple stops. In the outskirts of a city the shared bicycles could provide a new and flexible access and egress mode for public transport, which is usually less dense and extensive in the outskirts of a city so more people are likely to live further away from a public transport stop. The start and end locations of rides made with the shared bicycle are considered in this research to examine if these expectations are true in case of a mid-sized city which has a relatively extensive urban public transport network.

### 2.3.3 Public transport factors

**Quality of public transport line**

Several studies state that public transport stops with higher quality forms of public transport usually have a larger catchment area (Brand et al., 2017; Nijënstein et al. 2016). Higher quality includes a relatively high frequency, a relatively low number of stops, a reliable service and a high level of comfort. It might therefore also be that higher quality transit stops attract more cyclists. In this research is examined if public transport lines with the characteristics of higher quality public transport

are indeed more often used in combination with the shared bicycle than public transport lines with the opposite characteristics.

### 2.3.4 Attitude/motivational factors

Finally, several factors related to the attitude of the users towards cycling and public transport and the reasons for why they use the shared bicycle are included in this study to examine if they have an influence on the extent to which people use the shared bicycle in combination with the bus/tram.

**Attitude regarding cycling and public transport**

In general there are several socio-psychological theories that emphasize the effect that the attitudes of a person could have on a person's behaviour. One of the most well-known theories is Ajzen's theory of planned behaviour (TBP). Several studies regarding influential factors of mode choice have included people's attitudes regarding cycling and public transport. These studies show that including these attitudes have added value in travel mode choice models. In some of these models attitudes explain the variation of travel behaviour more than socio-demographic variables do (Heinen & Bohte, 2014). Furthermore, Sherwin & Parkhurst (2010) also found that the attitude people had towards cycling, for example if they liked cycling, played an important role in the decision to use the combined bicycle and public transport mode. In this research is examined if the attitudes of people towards cycling and public transport also have an influence on the extent to which they use the shared bicycle in combination with urban public transport.

**Reasons for using the shared bicycle**

A research performed by Munoz et al. (2016) states that "psychological factors motivating bicycle choice may be the main determinants of demand". The psychological factors that encourage bicycling demand mentioned in literature include satisfaction with cycling, perceptions of comfort, convenience and awareness, positive social norm and support, high perceived behavioural control, non-commuting cycling habits, 'like riding the bicycle' and being anti-car. Some of these factors are also included in this research to find out if certain psychological reasons for using the shared bicycle play a role in their combined use of shared bicycles and urban public transport. Reasons for using the shared bicycle that are included in this research are because using the shared bicycle is quick, relaxing and fun, environmentally friendly, healthy, safe, flexible, reliable, comfortable, easy to use and because there is a drop zone close to my home.

### 2.3.5 Overview factors

Overall, factors within four different categories are taken into account to examine if they have an influence on the extent to which people use the shared bicycle in combination with urban public transport. These categories include socio-demographic factors, trip factors, public transport factors and attitude/motivational factors. In Figure 5 an overview of all individual factors taken into account in these categories is provided.

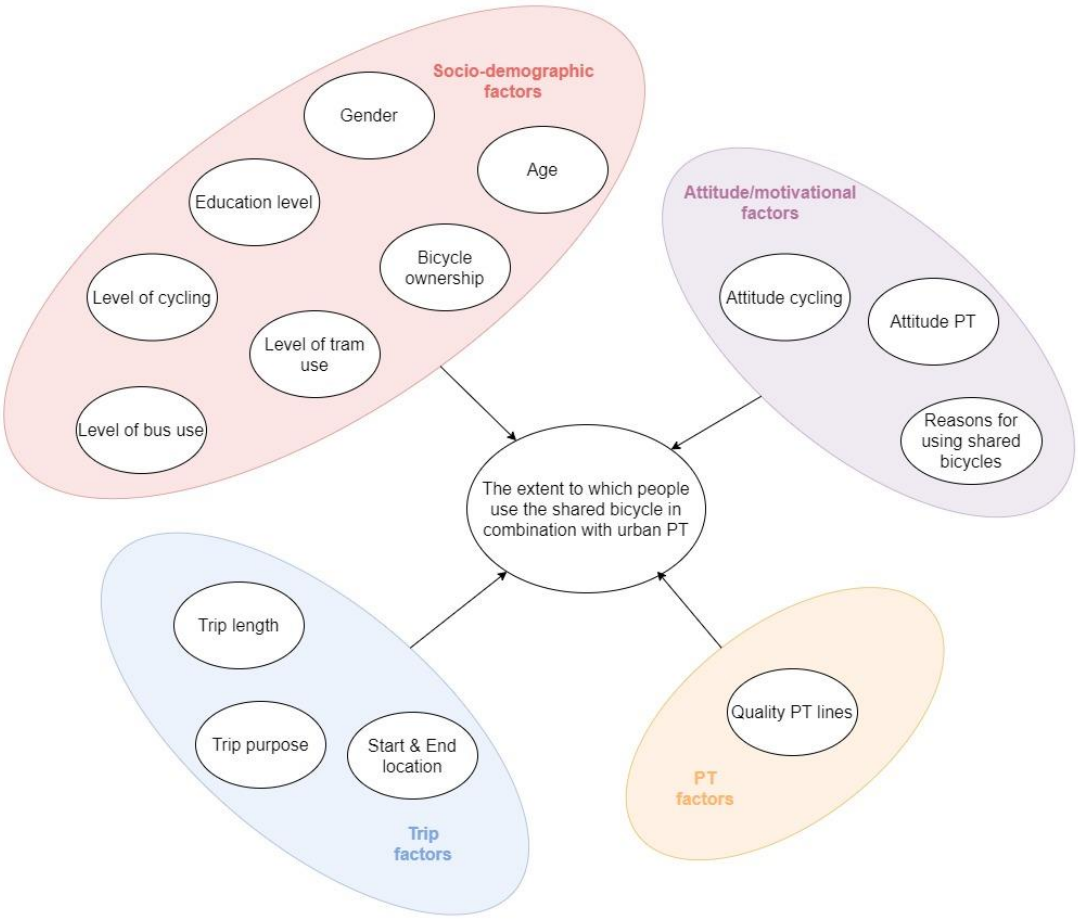


*Figure 5 - Overview of possible factors influencing the extent to which people use shared bicycles in combination with urban public transport (PT)*

# 3. Research methodology

In this chapter the methods used to answer the research questions are described. This research is performed using a specific case study. In section 3.1 is explained why a case study is used and what the context is of this case study. Data for this case study is collected using three different methods. First, operational trip data from the HTM-fiets application is collected and analysed. Section 3.2 explains why a data-analysis is performed on the operational trip data, how the data-cleaning is performed and which output is required to be obtained from this data. Second, a survey is conducted among the people who have made an account in the HTM-fiets application on their smartphone, after which the data is analysed. Section 3.3 explains why a survey is conducted among the users of a BSP, the survey design, the data-cleaning steps and the methods that are used to analyse the survey data. Thirdly, data is collected by having an expert meeting with employees of HTM, which is described in section 3.4. Finally, section 3.5 provides an overview of the research methodology.

## 3.1 Case study

This section first explains why a case study is used. Thereafter, the context of the specific case study used in this research is provided.

### 3.1.1 Why a case study?

This research is executed using a case study. According to Yin (1984) a case study can be defined as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context; when the boundaries between phenomenon and context are not clearly evident; and in which multiple sources of evidence are used". Usually a small geographical area is chosen to perform a case study and it allows the researcher to closely examine data within a specific context (Zainal, 2007). In this research the case study is the BSP of HTM, called HTM-fiets, in The Hague. It is chosen to use a case for answering the research questions because BSPs are already in place in many cities, which gives the opportunity to find out very concretely how a BSP is used and functioning at this moment. An important advantage of a case study is that it presents data of a real-life situation. Besides, a case study can give detailed insights in the behaviour of people (Zainal, 2007). Using a case study also allows to see if what was expected and planned actually occurred (Noor, 2008) and it allows to test if relationships described in literature also occur in real-life situations. Next to the advantages, the case study method also has some disadvantages. A commonly mentioned disadvantage is that scientific generalisation could be difficult (Zainal, 2007; Yin, 1984). Yin (1984) also mentions lack of rigour and case studies often being too long or difficult as disadvantages. The generalizability of the results from this case study is discussed in chapter 7 (Discussion).

The specific case study of the HTM-fiets in The Hague is chosen for this research because of multiple reasons. First, as mentioned in chapter 1, there is limited research performed regarding the combination of BSPs and urban public transport in mid-sized cities. The Hague is a mid-sized city and has an extensive urban public transport network. Therefore, this case study is suited to answer the research questions and fill in the existing gap in the literature. Furthermore, a large amount of data is already available regarding the HTM-fiets, which also makes this a suitable case study from a practical perspective.

### 3.1.2 Context of the case study

**The city of The Hague and its current modal split**

The BSP researched in this study is located in the city of The Hague. This city is located in the western part of the Netherlands and is with around 540.000 inhabitants the third largest city of the country. In this city, commuting trips are most often made by bicycle and car with respectively 38% and 31% of the total amount of commuting trips made, as can be seen in Figure 6. Public transport is less used for this trip purpose with respectively 15% of the total amount of trips. The current use of the different

modalities within The Hague might influence the usage of shared bicycles in the city and also the modal shift after the introduction of the shared bicycles.

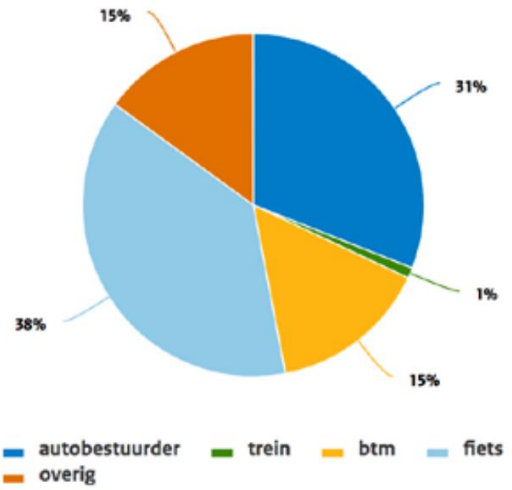


*Figure 6 - Modal split 2016 of commuting trips within The Hague (KiM, 2017)*

**Bicycle sharing program of HTM**

The case study consists of the recently introduced BSP in The Hague by the company HTM. HTM is the transport company of The Hague and is responsible for urban public transport in the city which consists of a bus and a tram network. In May 2019 they introduced their own shared bicycles, called the HTM-fiets, in the Hague. The program consists of around 500 bicycles and 65 drop zones where the bicycles can be picked-up or returned. The locations of the drop zones are shown in Figure 7 in blue. HTM expects that the shared bicycle will increase the catchment area of their public transport network and therefore will be a valuable complement to traditional public transport in the city (HTM, 2018a). This is because the introduction of the shared bicycle could be an incentive for people to use the bus and tram more often, since people can use the shared bicycle as access or egress mode to reach their destination more easily and solve a part of the first and last mile problem of public transport. However, it has to be mentioned that currently a large share of the drop zones are located close to or at bus/tram stops, which could make it difficult to use the HTM-fiets as first mile transportation. Also, if people want to use the HTM-fiets as last mile transportation it could be that there is no drop zone located close to their destination. In this case the HTM-fiets can be paused at the destination, but then the payment will continue. Using the HTM-fiets costs 1 euro per 30 minutes and has a maximum daily tariff of 5 euros. This tariff also applies when the bicycle is paused. In addition to being able to use the HTM-fiets in combination with the bus or tram, the bicycle can also be used for example when public transport is very crowded, congested, absent or not adequate (HTM, 2017).

For HTM it is important to know how their BSP is currently used. With this knowledge HTM can identify aspects of the system that could be changed and improved. For HTM it would be optimal if both the BSP and urban public transport have high usage rates. Therefore, they would like more insights in the combination with public transport. Based on that information they could adjust the total system and find specific locations where the combination of public transport and bicycle strengthen each other the most (HTM, 2019). This way they want to increase the number of users of the shared bicycle and urban public transport which also corresponds to their objective of increasing the amount of travellers that travel in a sustainable way.

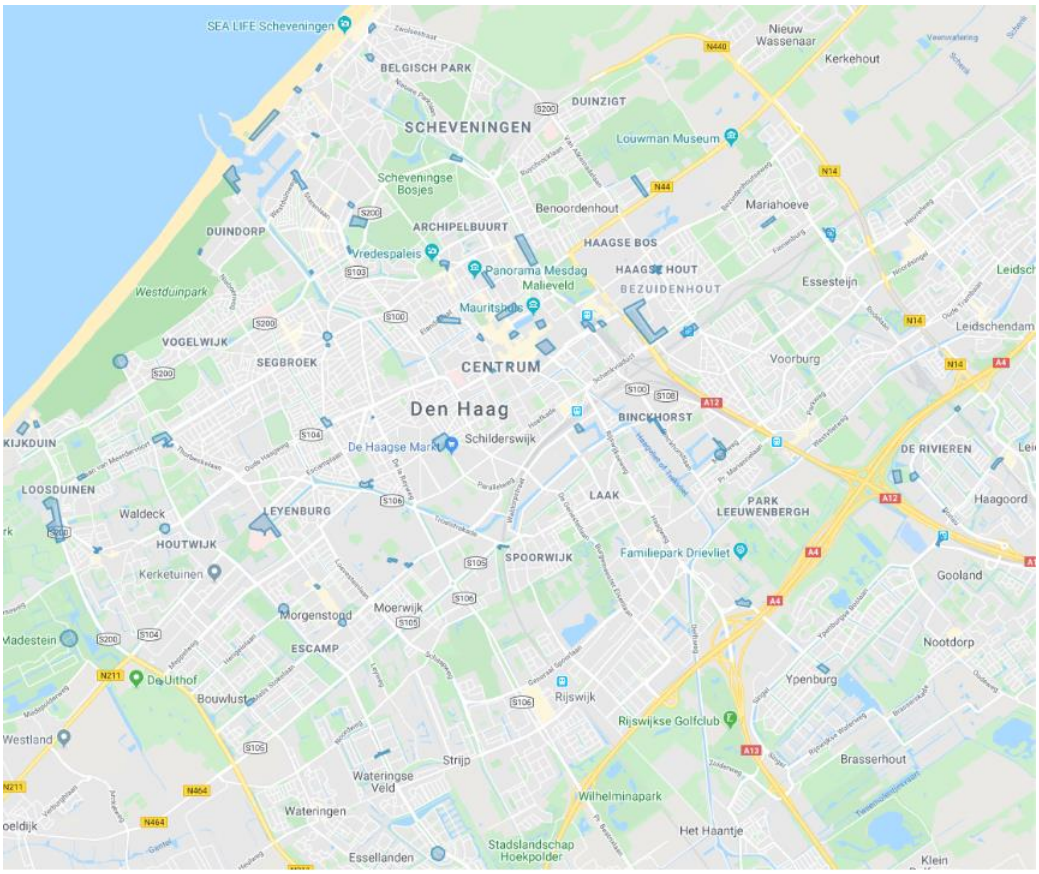


*Figure 7 - Drop zones HTM-fiets*

**Public transport network of HTM**

The public transport network of HTM in The Hague consists of 12 tram lines, including 2 light rail lines, and 8 bus lines, which means the urban public transport network of The Hague is quite extensive. The lines operated by HTM serve multiple municipalities including The Hague, Delft, Leidschendam-Voorburg, Pijnacker-Nootdorp, Rijswijk and Zoetermeer. These municipalities are part of the Metropolitan Region Rotterdam The Hague, who functions as a commissioning party for all public transport in this region since 2005. Over the year 2018, HTM transported around 84 million passengers with the tram and light rail lines and around 16 million passengers with the bus lines (HTM, 2018b). The amount of passengers of the tram and light rail increased with around 2,5% since 2017 and the amount of passenger who travelled by bus stayed approximately the same.

Each quarter of the year a research, called the Klantenbarometer, is performed to find out what the opinion of users of public transport in the region is. It also asks travellers of both the light rail and the tram with which modality they arrived at the boarding stop. Table 3 shows that the majority of people walk to both types of stops. The bicycle is used in respectively 3% and 5% of the cases for the tram and light rail (MRDH, 2019).

*Table 3 - Access modalities tram and light rail*

| Access modality | Tram (Q2 2019) | Light Rail (Q2 2019) |
|---|---|---|
| **Walking** | 74% | 73% |
| **By bicycle** | 3% | 5% |
| **By other public transport** | 20% | 18% |
| **By car** | 3% | 3% |
| **Other** | 1% | 1% |

**Shared mobility in The Hague**

HTM is with its BSP not the only provider of shared mobility in the city of The Hague. Several providers of shared mobility participated in a pilot program set up by the municipality. This includes HTM, Go About, Mobike and Felyx and they could all start operating their systems in spring 2019. Go About works with drop zones, just as HTM, where the bicycles can be picked-up and have to be returned. Mobike operates a free-floating BSP, which means the bicycles can be picked-up and returned anywhere as long as they are parked at locations where this is allowed for bicycles. The pilot prescribes that each operator can deploy a maximum of 500 bicycles at the start of the pilot. Lastly, a company called Felyx participates in the pilot. Felyx is a company that provides electrical shared scooters. They could start with a maximum of 200 scooters, which are free-floating. At the train stations in The Hague also de "OV-fiets" can be rented, which is a docked BSP at train stations. These bicycles have to be picked-up and returned at the same station. For this research it has to be taken into account that the HTM-fiets is not the only shared bicycle offered in the city.

## 3.2 Data-analysis on operational trip data

This section explains why a data-analysis on the operational trip data of the HTM-fiets is performed, which steps are taken in the data-cleaning process and which indicators are required to be generated to provide an answer to the research questions.

### 3.2.1 Why a data-analysis on operational trip data?

A data-analysis is performed on the operational trip data of the HTM-fiets because by using this data insight can be gained in many different aspects of the BSP and an overview of the usage can be obtained. The operational trip data includes the Ride ID, user ID, the vehicle number, the price paid, the distance travelled, the duration, the date, the start time, the coordinates of the pick-up and return location and if and where the bicycle is paused for each individual trip made with the HTM-fiets. A large variety of different indicators and usage patterns can be derived from this data and therefore an analysis of this data can thus give a detailed view of the usage of the HTM-fiets. The data-analysis is performed using different tools within Excel. This data-analysis contributes to answering the second sub-question of this research.

### 3.2.2 Data-cleaning

The supplied operational data consisted of all rides made with a HTM-fiets between the day of introduction (the 15$^{th}$ of May) until the 29$^{th}$ of February. Not all this data was suitable for the data-analysis and therefore certain rides are excluded based on different criteria. Furthermore, this data did not include the name of the start and end drop zones of a ride, but only the coordinates of these drop zones. To link the coordinates with the drop zone names the program ArcGIS is used. The locations of the drop zones were drawn on a map in ArcGIS, which made it possible to link the coordinates with the drop zone names. However, it appeared that the coordinates were not always accurate. Therefore, the drop zones were drawn bigger on the map then they are in reality to include rides that would otherwise end or start just outside the drop zone. However, still some of the end and start locations of a ride would be located outside of a drop zone. Because these locations were not close to a drop zone and in some cases were equally as far from multiple drop zones, it was not clear what the actual start and end drop zones of these rides were and therefore were not linked with a drop zone name. After linking the coordinates with the specific drop zone names for the rides where this was possible, the data-cleaning process was performed. It has to be mentioned that it is known that the distance is not always measured accurately and therefore no rides are excluded from the dataset based on the distance only.

The following steps are taken within the data-cleaning process:

- All rides made in the month May are excluded. This is done because on the 15$^{th}$ of May the HTM-fiets was introduced in The Hague, but not all bicycles were in place yet at that date. Until

the 22th of May bicycles were added to the BSP. Furthermore, many test rides were made in May. This makes the data of May less representable.
- All rides made by HTM personnel to test the bicycles are excluded from the data. A few test rides have been made after the month May and are excluded because they don't represent actual rides made by users.
- All rides made for logistic purposes are excluded. These are rides made to redistribute the bicycles over the drop zones in case some drop zones contain a lot of bicycles while others contain a few. Furthermore, these could also represent rides made to pick-up or return bicycles that have to undergo maintenance or recently had maintenance. This data-analysis focusses on rides made by users and therefore these rides are excluded.
- All rides of which the duration was not registered are excluded. It appeared that for certain rides the duration was not registered and 99.2% of these same rides also had a distance of zero, a paid amount of zero and a non-registered latitude and longitude for the end drop zone. Because all this information was missing it could not be determined if these represent actual rides or not. Therefore, these rides are excluded from the dataset.
- All rides with a duration smaller than 5 minutes that have the same start and end drop zone are excluded. Since it is very unlikely that rides starting in a drop zone and returning to the same drop zone within 5 minutes represent actual rides made with the HTM-fiets, these rides are excluded. It could be that something was wrong with the bicycle that caused people to not make an actual ride and return the bicycle in the same drop zone.
- Finally, after excluding the above mentioned rides, there were still rides left that did not have the name of the start drop zone and the name of the end drop zone. It is known that the GPS location is not always accurate as mentioned before. For most of these rides the coordinates of the start and end drop zones were not located in one of the drop zones. Therefore, these rides don't have drop zone data and could therefore not be taken into account in drop zone specific analysis. However, it seems that most of these rides are actual rides and therefore these rides are taken into account in the general analysis. Some rides still have a distance of zero and a duration smaller than 5 minutes, but since distance is known to be not accurate and it cannot be said with certainty that rides smaller than 5 minutes are not actual rides, these rides are kept in the dataset.

### 3.2.3 Required output

To determine how the current setup of the HTM-fiets concept has been used, different general indicators and usage patterns are extracted from the data using MS Excel. An overview of these indicators and patterns is presented in Table 4.

*Table 4 - Overview indicators and usage patterns*

| Variable data-set | Indicator usage of BSP |
|---|---|
| **Ride ID + Date** | - total number of rides in between the 1st of June and the 29th of February<br>- average number of rides per month<br>- total number of rides for each month<br>- average number of rides per day<br>- average number of rides for each day of the week + difference summer/rest of the year |
| **Vehicle number + Date** | - the overall average number of rides/day/bicycle |
| **Ride ID + Time** | - average number of rides per time period for weekdays and weekend days |
| **User ID + Date** | - total amount of unique users<br>- number of users that use the bicycle frequently or occasionally + difference usage one time users vs. frequent users |
| **Duration** | - the average and median duration<br>- the total number of rides per duration category |
| **Lat/Long of source and end** | - most and least used drop zones and drop zone types<br>- most used drop zones during the summer, weekend and at night<br>- drop zones with the largest shortage or surplus<br>- often used combinations of origin and destination<br>- Possible combined usage of HTM-fiets and tram |
| **Paused and Pause Location** | - share of rides that is paused<br>- locations where bicycles are often paused |

## 3.3 Survey among users of a BSP

This section explains why a survey among the people who have made an account in the HTM-fiets application is conducted. Also, the survey design, the response rate of the survey, the steps taken in the data-cleaning process and the methods used to analyse the survey data are described.

### 3.3.1 Why a survey?

Based on the available operational data it cannot be determined if users of the BSP use the shared bicycle as access or egress mode for the urban public transport network. Therefore, a survey is conducted among the people who have made an account in the HTM-fiets application to gain more insight in the combined use of the shared bicycle and urban public transport from a user perspective. Besides, the survey is used to determine if and which factors influence to what extent people use the shared bicycle in combination with urban public transport. These factors consist of socio-demographic factors, trip factors, public transport factors and attitude/motivational factors and are included based on the literature study as described in the previous chapter. As a result, the survey provides an answer to the third and fourth sub-question. The survey also contributes to answering the fifth sub-question by asking the respondents what their reasons are for using or not using the HTM-fiets in combination with the bus/tram. Besides, the factors that appeared to have a significant influence on the extent to which people use this combination can also contribute to identifying improvements that can be made to better integrate the HTM-fiets with urban public transport. Finally, the survey is also used to identify the type of people that make use of the HTM-fiets, to complement the data-analysis regarding the usage of the HTM-fiets and to identify possible improvements that can be made in the HTM-fiets concept to increase its usage in general. The survey thus also contributes to answering the second sub-question together with the data-analysis.

The survey is distributed online via a link in an email. This offers various advantages. First of all, it offers convenience for both the researcher and the respondent. It is a very time-efficient way to reach a lot

of people, the data of the completed survey will be automatically stored in a data-base and the respondents can complete the survey at a time that is convenient for them and also they can take as much time as they like (Evans & Mathur, 2005). Furthermore, an online survey offers a lot of flexibility in the survey design. Logic can be introduced to direct respondents to questions based on their answers on previous questions, answers can be validated and questions can be made required to eliminate non-response to a question. In this case an important reason for conducting the survey online was also because the usage of the HTM-fiets is spread over the entire city and the usage is not high enough to encounter a lot users per day while surveying in one location. It would therefore be inefficient to conduct the survey face-to-face. Weaknesses of conducting an online survey are however that answering instructions might be unclear resulting in people not finishing the survey, that there might be privacy and security issues and that the response rate could be low (Evans & Mathur, 2005). To limit these weaknesses several steps have been taken. First, before the survey is conducted it is tested to see if the questions and answering instructions are clear and to find out how long it takes to finalise the survey. It is also very important to test the survey to avoid mistakes being made in the interpretation of questions by respondents (Memarian & Uhm, 2012). After the first version of the survey is made, it is tested by a selected group of people. Based on the comments derived from this test, the survey is adjusted and tested for a second time to find out if the adjustments have led to an improved survey. Second, privacy and security issues are limited by not asking for any traceable personal data such as name, address, phone number and email address and by using a reliable survey tool. Finally, to gain a higher response rate the survey is distributed in both Dutch and English and a reminder is sent two weeks after the first email.

Ultimately, every person that has made an account in the HTM-fiets application on their smartphone has first received an email on 20-2-20, which contained both information regarding the new HTM-fiets application and links to the Dutch and English version of the survey (see Figure 28, Appendix 1 for the full email). The reminder email (send on 4-3-20) only contained information regarding the survey and again links to the Dutch and English version of the survey (see Figure 29, Appendix 1).

### 3.3.2 Survey design

This section covers the types of questions asked in the survey and provides argumentation for choosing these question types. Furthermore, the survey logic is described. The final design of the entire survey can be found in Appendix 2. Figure 8 provides an overview of the survey design. The survey consisted of three parts. First, all respondents were asked to answer some questions regarding personal characteristics using closed-form questions. These included questions regarding age, gender, education, bicycle ownership (specifically in The Hague) and whether they are an employee of HTM. The latter is asked to determine if there is a difference in how HTM employees and non-HTM employees use the HTM-fiets, since employees of HTM might have a different view regarding the HTM-fiets and the bus/tram because they work for the company that offers these services. The other socio-demographic factors are asked to determine what type of people make use of the HTM-fiets and if these factors influence the extent to which people use the HTM-fiets in combination with the bus/tram. Thereafter, they were asked if and how often they had used the HTM-fiets, providing them with multiple answer options. The respondents who had used the HTM-fiets at least once were directed to different follow-up questions than the respondents who had not used the HTM-fiets as shown in Figure 8.

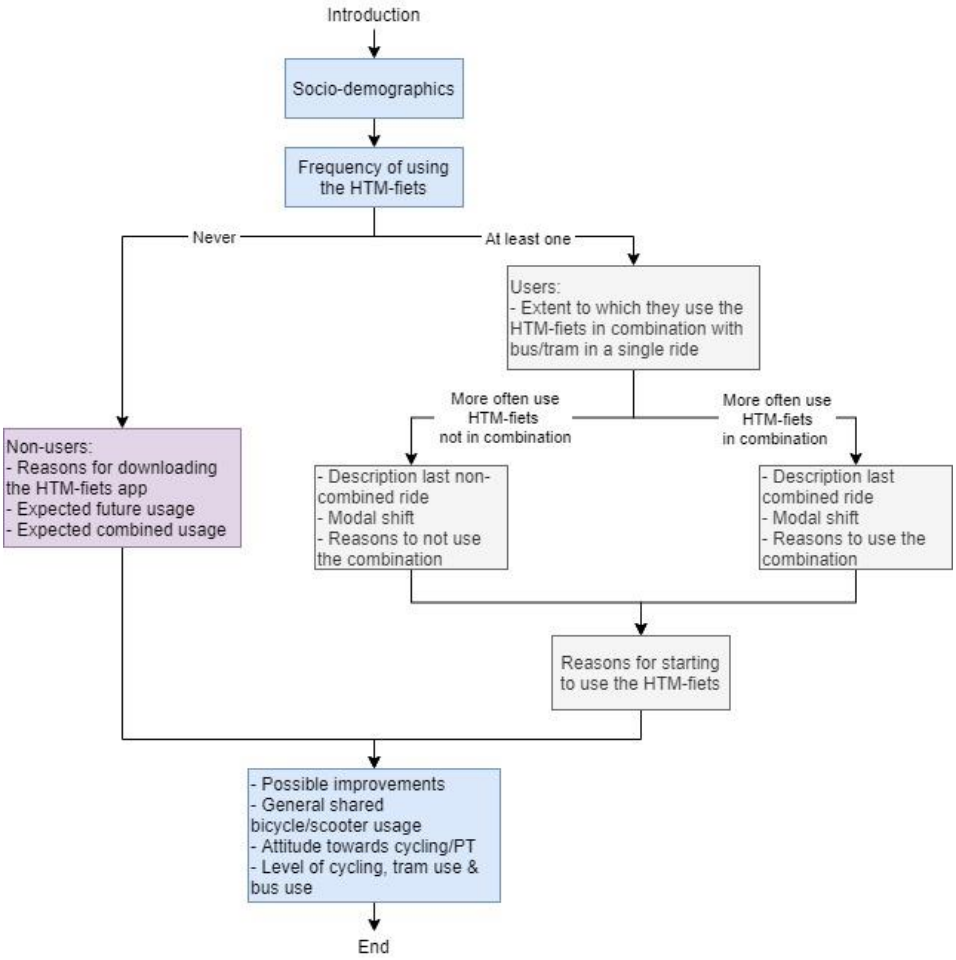


*Figure 8 - Overview survey design*

**Respondents who have used the HTM-fiets**

The respondents who had used the HTM-fiets were asked in the second part to what extent they used the HTM-fiets in combination with urban public transport in a single ride. This question was answered on a 7 point scale from never to always to obtain a detailed answer. In case the respondents largely used the HTM-fiets in combination with the bus or tram (answers 4 to 7 on the scale) they were asked to describe their last ride with the HTM-fiets in combination with the bus/tram in a single ride. If they largely used the HTM-fiets not in combination with the bus or tram (answers 1 to 3 on the scale), they were asked to describe their last ride made with the HTM-fiets not in combination with the bus/tram in a single ride.

The respondents were asked to describe their last ride instead of for example their most common ride or past several rides for multiple reasons. First, it was expected that it is easier for respondents to recall their last ride and describe this in a specific way than to determine their most common ride or describe multiple rides. This should ensure that as few people as possible quit the survey. Furthermore, if everyone describes their last ride, this should provide an overall representative image of all rides made by these respondents. However, since this survey was conducted in February and March this could lead to an overrepresentation of rides made in the winter period, which might differ from rides made in summer. This is considered when interpreting the results. The description of the last trip by the respondents include the start and end drop zone, the time period, the used bus/tram lines and the main trip purpose. These trip characteristics are used to determine if they possibly influence if people use the HTM-fiets in combination with the bus/tram or not. Furthermore, the descriptions of the last

rides are used to provide additional insights in the usage of the HTM-fiets, next to the data-analysis, and also to determine if some aspects are in line with the results of the data-analysis.

The second part of the survey also included questions that are used to identify the (potential) modal shift as a result of the introduction of the shared bicycles. Respondents had to indicate which mode of transportation they would have used for the part of the trip for which they now used the HTM-fiets, in case the HTM-fiets (and other shared bicycles) would not have been available. This is used to determine the extent to which people use the HTM-fiets as substitute for urban public transport and for other means of transportation. Thereafter, respondents were asked through an open question why they used or did not use the HTM-fiets in combination with the bus/tram. By asking an open question, respondents are not guided in their answer and as many as possible reasons could be identified. Finally, these respondents were asked what motivated them to use the HTM-fiets. To gain detailed insight in this aspect a 5 point Likert scale was used to answer this question. The respondents were given several statements regarding this subject and could answer to what level they agreed with the statements (1 being completely disagree and 5 being completely agree). This question was also asked to determine if these motivations for using the HTM-fiets have an influence on the extent to which people use the HTM-fiets in combination with the bus/tram.

**Respondents who have not used the HTM-fiets**

The respondents who indicated in the first part that they had not used the HTM-fiets, were asked in the second part why they downloaded the HTM-fiets application. This was asked using an open question to provide detailed insight in the reasons why people have downloaded the app, but did not use the HTM-fiets (yet). Furthermore, they were asked if they still intent to use the HTM-fiets on a 5 point scale ranging from definitely not to definitely yes. If they indicated that it was likely that they would use the HTM-fiets in the future (answers 3 to 5 on the scale), they were asked if they expect to use the HTM-fiets in combination with the bus or tram. This was asked to determine how non-users look at the combined usage and to test if the expectation matches the reality of people who had used the HTM-fiets.

In the final part of the survey, all respondents were asked which improvements of the concept would lead to them making more use of the HTM-fiets or starting to use of the HTM-fiets. To gain detailed insight in this aspect a 5 point Likert scale was used to answer these questions. The respondents were given several statements regarding different types of improvements that might increase their usage of the HTM-fiets and could answer to what level they agreed with the statements (1 being completely disagree and 5 being completely agree). Furthermore, the respondents were asked to what extent they had used other types of shared bicycles and scooters in the past, on a 3 point scale from never to regularly, to get more insight in the type of people that use the HTM-fiets. Finally, the respondents were asked about their general level of cycling and level of bus use and tram use. Multiple answer options were provided ranging from never to very frequent (4-7 times per week). Besides, the respondents were asked about their general attitude towards travelling by bicycle and by public transport. Using two statements, respondents could indicate on a 5 point scale from completely disagree to completely agree if they liked travelling by bicycle and by public transport. The answers to the questions regarding their general level of cycling and level of bus and tram use and their attitude regarding cycling and public transport are also used to determine if these aspects have an influence on the extent to which people use the HTM-fiets in combination with the bus or tram.

To obtain valid and complete responses certain questions had answer validation, for example that age could only be a whole positive numeric value between zero and hundred, and most questions were required to answer before the respondent could continue with the survey. However, in most cases an answer option was provided for when people did not know the answer to a question, so they would not exit the survey in case they could not answer a certain question. The questions with respect to

personal characteristics all had the option 'I would rather not say' in case respondents did not want to answer one of these questions.

### 3.3.3 Response rate and data-cleaning

The email with the link to the survey was sent to all people that had an account in the HTM-fiets application at the moment the survey was sent. A total of 423 people started with the survey. 185 of these people did not complete the entire survey and are therefore not included in the data-analysis. This means that 247 completed responses remained. The response rate was much lower after the first email compared to the reminder email. This might be caused by the fact that the first email had as main message that the new HTM-fiets application was launched while the second email only featured the survey. Therefore, an email specifically sent to ask people to participate in a survey leads to a higher response compared to an email that also contains other information. Consequently, this approach could best be used for future surveys.

After the partially completed responses were removed, a check on the realism of the answers was done. It appeared that one respondent clicked on the first answer at every question and is therefore not seen as a reliable respondent and removed from the data. Furthermore, two responses where identical to each other which meant the survey was submitted twice by the same person. One of these responses is therefore removed from the data. It seemed that all the other responses were plausible and not identical to each other. The final sample thus consists of 245 respondents. Furthermore, there were a number of questions which had 'other, namely:' as answer option. These answers are checked to see if they actually did fit in one of the provided answer options or if one answer was given multiple times and a new category could be created. The latter was the case with the question regarding which means of transportation people would have travelled the part of the trip for which they now used the HTM-fiets with. Taxi/Uber was not one of the provided answer options, but seven people gave this answer and therefore a new category 'Taxi/Uber' was added.

### 3.3.4 Data-analysis methods

The output of the survey provides insight in many different aspects of how the people who have made an account in the HTM-fiets application use and view the HTM-fiets. By applying several different data-analysis methods using SPSS and MS Excel, this output is analysed to be able to provide an answer to the research questions.

**Representativeness sample**

The first step in the data-analysis is testing if the sample is representative for the population to be able to generalise the results from the sample to the population. Since the target group of this survey are people who used the HTM-fiets or showed interest in using the HTM-fiets by downloading the application, only these people received the survey and are thus the population. However, no data is available regarding the personal characteristic of these people. Therefore, it is difficult to determine if the sample is representative for the population. By comparing the age, gender and education level of the users in the sample with users of other BSPs in cities within the Netherlands and other cities in the world, it is still possible to give an indication of the representativeness of the sample. Finally, it is determined if HTM employees use the HTM-fiets differently in terms of frequency of use and the extent to which they use the HTM-fiets in combination with bus/tram, by looking at the distribution within these variables between HTM employees and non-HTM employees.

**Differences between certain groups of people**

Based on the question how often respondents have used the HTM-fiets since the introduction, the sample is split in two groups, namely people who have used the HTM-fiets and people who have not, but still downloaded the app (users and non-users). To test if there is a difference in the socio-demographic characteristics age, gender, education level and bicycle ownership between these

groups, Chi-square independence tests are performed in SPSS. This specific test is used because these groups represent a nominal variable. Within certain variables, answer categories are grouped together to meet the requirement of the Chi-square test, which states that not more than 20% of the cells can have an expected frequency of less than 5. Based on the results can be determined if there is a significant difference between the user characteristics of users and non-users.

**Factors influencing the extent to which the HTM-fiets is used in combination with the bus/tram**
To test if and which factors influence the extent to which people use the shared bicycle in combination with urban public transport, different methods are used. First, the trip factors and public transport factors (trip length, trip purpose, start and end location of a trip and the quality of public transport lines) are evaluated in a qualitative way, based on the descriptions of all last rides made with the HTM-fiets in combination with the bus/tram. This means that it is determined what the average trip length of the combined rides is, what the most common trip purpose is and if most combined rides are made from or to the edges of the city or within the city centre. Furthermore, it is analysed what type of public transport is most often used in combination with the HTM-fiets, meaning whether the HTM-fiets is more used with higher quality forms of public transport (trams) or lower quality forms of public transport (city buses).

For the other factors, the socio-demographic factors and attitude/motivational factors (age, gender, education level, bicycle ownership, level of cycling, bus use and tram use, attitude towards cycling and public transport and reasons for using the HTM-fiets), it is first tested if these factors are significantly different for the extent to which people use the HTM-fiets in combination with the bus/tram. This is done using the Chi-square independence test since the dependent variable (the extent to which people use the combination) is seen as a categorical variable. Since Chi-square tests require that not more than 20% of the cells have an expected frequency of less than 5, certain answer categories are grouped together within multiple variables. The outcome of the Chi-square tests gives an indication of which factors influence the extent to which people use the HTM-fiets in combination with the bus/tram. The factors which showed (almost) significant differences are included in the regression analysis as independent variables.

As mentioned before, the measurement level of the dependent variable (the extent to which people use the HTM-fiets in combination with the bus/tram) is categorical. This means linear regression cannot be applied since the assumption that the observed data should contain a linear relationship is violated when the outcome variable is categorical (Field, 2009). Therefore, a multinomial logistic regression analysis is performed which is suitable for this type of data. This regression analysis is used to explain the relationship between the dependent variable and the independent variables. It will show the relative odds that a person with certain characteristics (the independent variables) belongs to the group who relatively often uses the combination versus the group who never uses the combination. Before the regression analysis can be performed it has to be checked if the assumptions that are required for multinomial logistic regression analysis are met. These assumptions include that the dependent variable should be measured at the nominal level, that there are one or more independent variables that are either nominal, ordinal or continuous, that all observations are independent, that the dependent variable has mutually exclusive and exhaustive categories, that there is no multicollinearity, that there is a linear relationship between any continuous independent variables and the logit transformation of the dependent variable and finally that there are no outliers, high leverage values or highly influential points. It appeared that these assumptions are met and thus a multinomial logistic regression can be performed on this data (see Appendix 4).

**Reasons for (not) using the combination and points of improvement**
This survey also includes several open questions. These include the reasons why people (not) use the HTM-fiets in combination with bus/tram, what other improvements (next to the ones mentioned in the survey) would make the respondents use the HTM-fiets (more) and why certain people

downloaded the HTM-fiets app, but did not use the HTM-fiets (yet). For each open question, all the answers are analysed and in case similar answers were provided these were grouped together in one answer category.

## 3.4 Expert meeting

Next to the data-analysis of the operational trip data and the survey, a small expert meeting is held with five employees of HTM working in this field, to provide additional insights in different aspects of this study. The results from both the data-analysis and survey are used as input for the expert meeting. Before presenting the results, the experts are asked about their expectations regarding the usage of the HTM-fiets in general and regarding the combined usage of the HTM-fiets and bus/tram. After presenting the results several subjects are discussed including the type of users and usage patterns, which improvements in the concept are most important and feasible for increasing the usage of the HTM-fiets and if and how a better integration between the HTM-fiets and urban public transport should be realised. As a result, the expert meeting contributes to answering the second and fifth sub-question.

## 3.5 Overview

The different sub-questions, and with that the main research question, are answered using several research methods. An overview of the different research methodologies, the deliverables of each methodology and which sub-questions are answered is given in Figure 9.

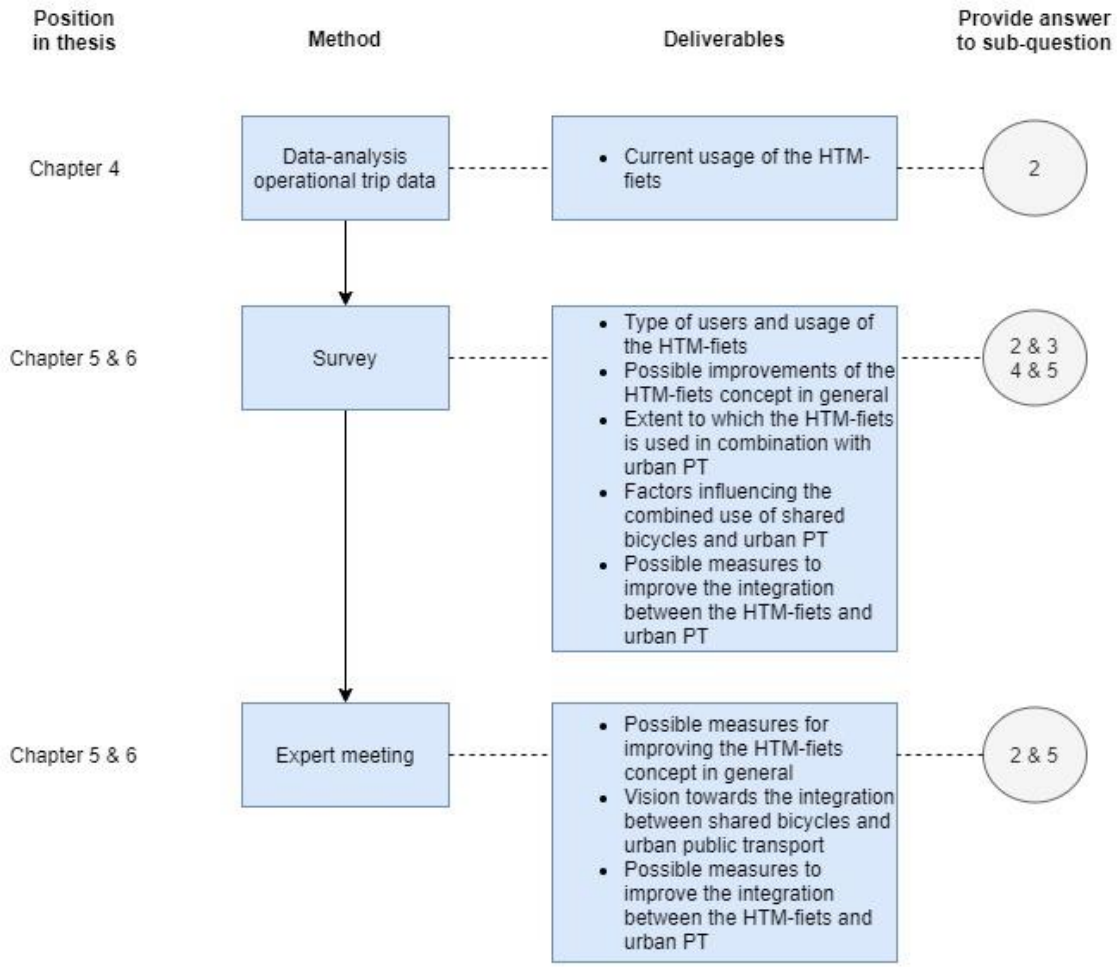


*Figure 9 - Overview research methodology*

# 4. Results: Objective usage of the HTM-fiets

In this chapter insights are provided regarding the objective usage of the HTM-fiets, based on the data-analysis of the operational trip data. As mentioned in the methodology chapter, this data-analysis is performed on the operational trip data of the HTM-fiets from the 1st of June till the 29th of February. First, the general indicators and usage patterns resulting from the data are described in section 4.1. Thereafter, the usage per drop zone (type) is described in section 4.2. Finally, in section 4.3, an overview of the results is provided.

## 4.1 General indicators and usage patterns

The data-analysis of the operational trip data shows that the usage of the HTM-fiets is relatively low compared to 75 other studied BSPs located mainly in Europe and the US, which have an average between 0.22 and 8.4 rides per day per bicycle (De Chardon et al, 2017). The median of the duration of the trips made by the HTM-fiets is 23 minutes, which means half of the total number of rides is shorter than 23 minutes and half is longer. A large part of the rides made with the HTM-fiets is thus relatively short. However, the average duration is 2 hours, which shows that the HTM-fiets is also used for longer periods of time. This differs slightly from some BSPs in other countries where for example the average duration was 15 minutes in Lyon and 22 minutes in Chicago (Jensen et al., 2010; Faghih-Imani & Eluru, 2015). Figure 10 shows the distribution of the duration. It can be seen that the largest part of all rides are between 10 and 20 minutes. In total 61% of the rides is shorter than 30 minutes. The large difference between the number of rides that have a duration of 20 to 30 minutes and that have a duration of 30 to 40 minutes might be related to the pricing system since renting a HTM-fiets costs 1 euro per 30 minutes. The orange bars in Figure 10 indicate rides with a duration longer than 6 hours, which corresponds to 9.7% of the total number of rides. This indicates the share of rides for which a bicycle is rented for a much longer term than for most rides. A reason why the HTM-fiets is also rented for longer periods could be related to the fact that there is a daily tariff of 5 euros.

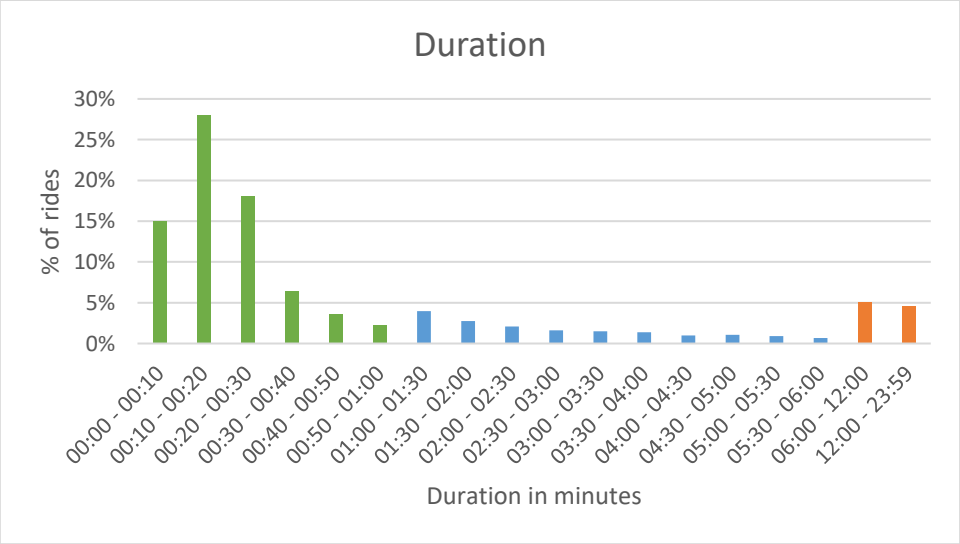


*Figure 10 – Percentage of rides per duration category*

**Rides per month**

There is a difference between the number of rides made within each month as can be seen in Figure 11. The total number of rides per month in June, July and August were larger compared to the total number of rides within each of the other months. An explanation for this could be that the weather in the Netherlands is usually better in June, July and August. This is also the holiday period, which could mean that more people were performing leisure activities and that there might have been more tourists in the city who could have made use of the HTM-fiets. The data-analysis shows that the drop

zones with the highest share of rides to and from a drop zone taking place during the summer months are mainly drop zones located close to the beach (see Appendix 6 for more information regarding these specific drop zones). It could thus indeed be the case that the higher usage in these months is related to the better weather and the holiday period. Previous studies also show that the usage of BSPs is usually higher in the summer than in the winter (Fishman, 2016). However, in the middle of the summer (around August) there can be a decrease observed in the usage of several BSPs (e.g. in Barcelona, Lyon and Milan) (see Figure 4), which could be related to the very high temperatures in this period. This decrease in the middle of the summer is not observed for the HTM-fiets.

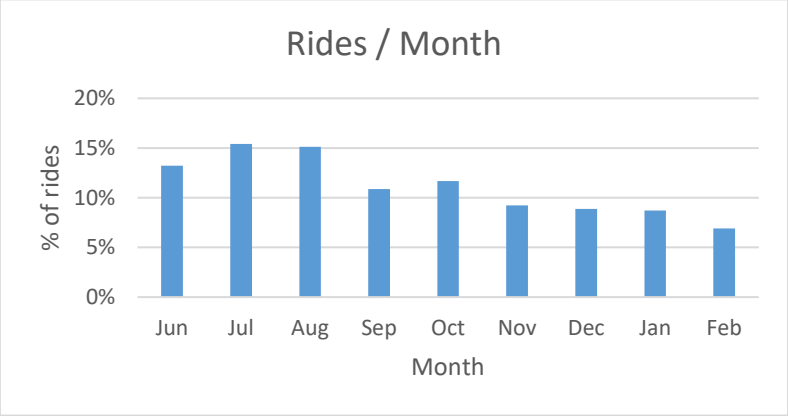


*Figure 11 – Percentage of rides per month*

**Rides per day of the week**

The HTM-fiets is on average more used on a weekend day as opposed to on a weekday (see Figure 12). Therefore, it seems like the HTM-fiets is used more for leisure trips, that take mainly place during the weekend, than for commuting or school related trips, which take place during the weekdays. This corresponds with the fact that the drop zones with the highest share of rides to and from a drop zone being made during the weekend, are mainly locations where leisure activities can be performed, such as the beach, museums and a large indoor sports centre and P+R facility. Only a few drop zones clearly have more rides starting or ending there during the weekdays than during the weekend (see Appendix 7 for more information regarding these specific drop zones). Previous studies show that it could differ per BSP whether shared bicycles are more used during the weekend or on weekdays. While it seems that the BSPs in Montreal and Barcelona are more used on weekdays, in Brisbane the weekend is associated with a higher usage of the BSP (Faghih-Imani et al., 2014; Froehlich et al., 2009; Corcoran et al.,2014).

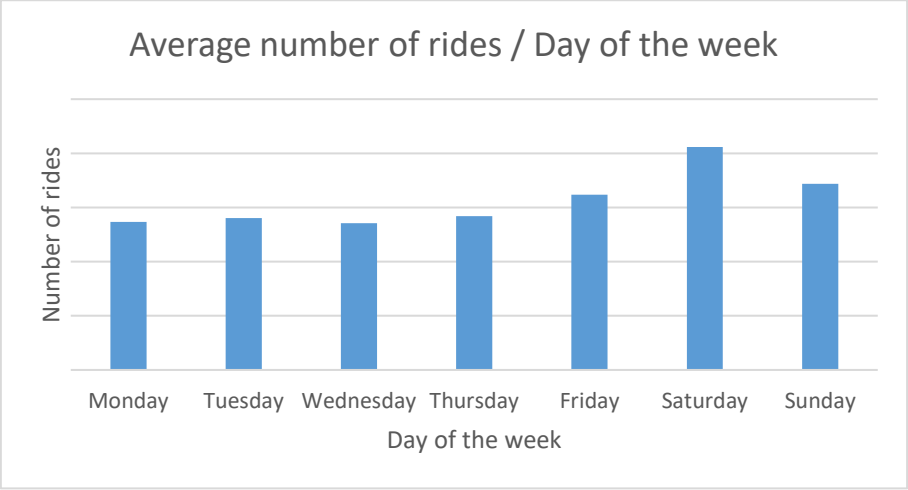


*Figure 12 - Average number of rides per day*

The distribution of rides over the days of the week is a little different within the summer months compared to the rest of the research period (Sep – Feb). In the summer months there are clearly more rides made per day in the weekend than during the weekdays. Between September and February less rides are made on all days of the week. However, there is a larger decline in rides made on Saturday and Sunday than in rides made on Monday till Friday. This might also be related to the fact that it is likely that more people make leisure trips during the weekend in the summer months than in the autumn/winter due to the better weather during summer.

**Rides over time of day**

Also, a difference could be observed between weekdays and weekends in the time periods in which the HTM-fiets is used most often. Figure 13 shows the number of rides per time period for an average weekday in blue and for an average weekend day in orange. A comprehensive Table with the total number of rides per time period for each day of the week is presented in Appendix 8.

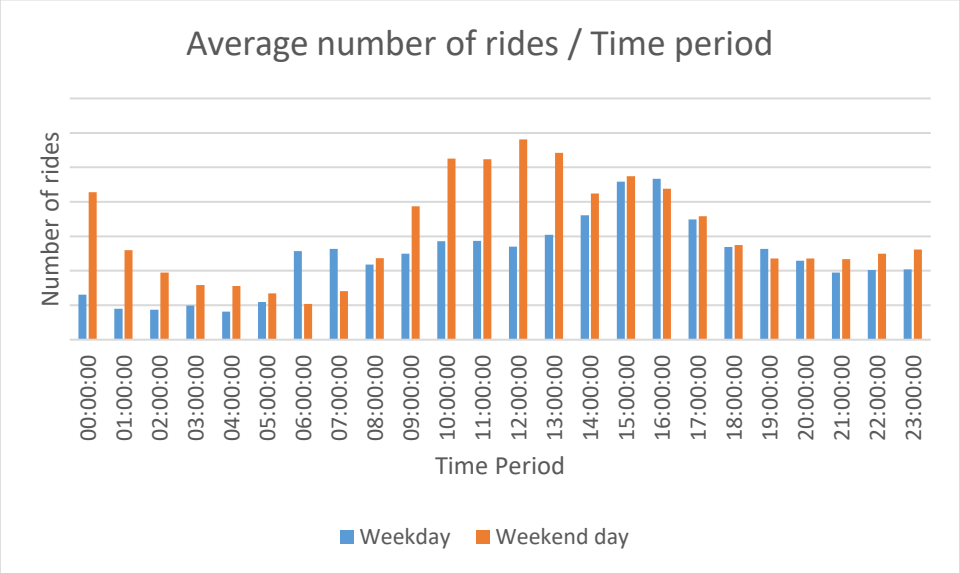


*Figure 13 – Rides over time of day*

By looking at the two patterns in Figure 13 it can be seen that on weekdays most rides are made between 3PM and 5PM, which could be caused by people returning home from school or work, although this would be relatively early for people returning from their work. Looking more closely at the 10 drop zones of which the largest share of the total rides on weekdays start between 3PM and 5PM, it appears that four of these drop zones are located in business areas while the others are not (see Appendix 9). The peak in trips between 3PM and 5PM on weekdays is probably thus also caused by other type of trips than just work or school related trips. Furthermore, the HTM-fiets is more often used between 6AM and 8AM on weekdays than on a weekend day, which could also be partially caused by people travelling to their work or education on weekdays.

The distribution of rides during the day looks very different for Saturday and Sunday compared to a weekday as can also be seen in Figure 13. During the weekend most trips are made between 10AM and 2PM, which could indicate people performing leisure activities or people who are sightseeing. Furthermore, in the weekend more rides are made in the hours after midnight (thus in the night from Friday to Saturday and from Saturday to Sunday), especially between midnight and 1AM, than in the other nights of the week. This is probably caused by people returning home after going out which happens more often in the weekend. By looking at the drop zones that are most used during the hours after midnight, it can indeed be seen that most rides start at a drop zone in the city centre with many restaurants and bars (Grote Markt). Thereafter, most rides start at Station HS and at a place with many

restaurants and bars along the beach (Kurhaus) (see Appendix 10). Station HS is one of the large train stations in the city and is connected to the night network of the train. The HTM-fiets might thus be used by people returning home after midnight from other cities in the Netherlands. A reason for people to use the HTM-fiets after midnight could be that regular public transport is not available anymore after this time and people can only make use of night buses, that operate on Friday and Saturday night. The night buses are relatively more expensive than the HTM-fiets (they have a flat tariff of 5 euros), don't cover all areas of the city and sometimes make large detours to reach a destination. From the most used drop zone in the city centre (Grote Markt), most people cycle to drop zones where the night bus also passes (see Appendix 10). This could thus indicate that there are people who prefer taking the HTM-fiets over taking the night bus.

**Frequency of use**

The data-analysis shows that most people who make use of the HTM-fiets are occasional users. Of the people who have used the HTM-fiets, 79% used the HTM-fiets between 1 and 5 times in total (left side Table 5). Just 1% used the HTM-fiets more than 40 times between June and February. Since the research period consists of 39 weeks this is on average around 1 time per week or more. However, people who just started using the HTM-fiets in the past few months might not have used the HTM-fiets often yet, but this doesn't mean they will not use the HTM-fiets more often in the coming months.

*Table 5 – Percentage of users that have made a certain number of rides*

| **All users** | | **Least frequent users** | |
|---|---|---|---|
| **Number of rides made** | **Percentage of users** | **Number of rides made** | **Percentage of users** |
| **1 – 5 rides** | 79% | **1 ride** | 35% |
| **5 – 10 rides** | 12% | **2 rides** | 20% |
| **10 – 20 rides** | 6% | **3 rides** | 11% |
| **20 – 30 rides** | 2% | **4 rides** | 8% |
| **30 – 40 rides** | 1% | **5 rides** | 5% |
| **> 40 rides** | 1% | | |

On the right side of Table 5 the number of rides made by the least frequent users are presented in more detail. It appears that more than one third of the people that have used the HTM-fiets only used it once so far. However, here also applies that these people could still make more rides in the future. Most of the onetime users made a ride with the HTM-fiets during one of the summer months as can be seen in Figure 14. This might partially be caused by the larger number of tourists and day-visitors in the summer months.

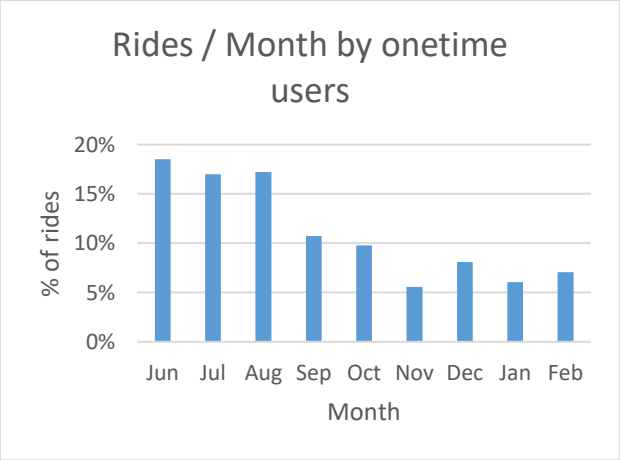


*Figure 14 – Percentage of rides per month by one time users*

To see if there is a difference in how onetime users and frequent users (people who used the HTM-fiets 40 or more times) use the HTM-fiets, the total rides per day of the week between these two groups are compared. Figure 15 shows that a large share of the onetime users (42%) have used the HTM-fiets on Saturday or Sunday. On average more rides by onetime users are made on a weekend day than on a weekday. Figure 16 shows that the frequent users have made on average slightly more rides on a weekday than on a weekend day. However, there is not a very large difference between the number of rides made on a weekday and on a weekend day by frequent users. While the HTM-fiets is thus more used on Saturday and Sunday than on a weekday by onetime users, a different pattern is observed for frequent users.

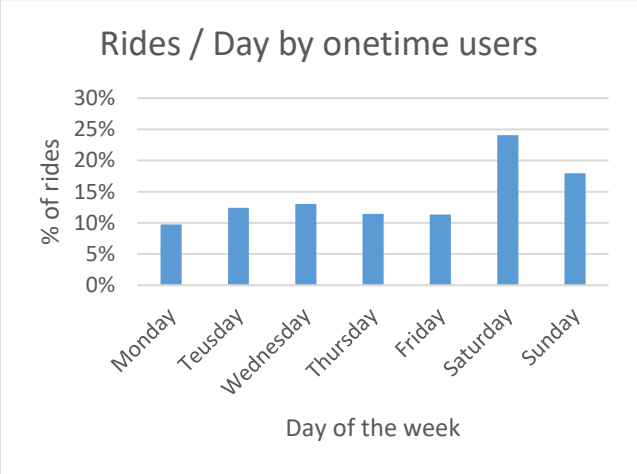


*Figure 15 – Percentage of rides per day of the week by onetime users*

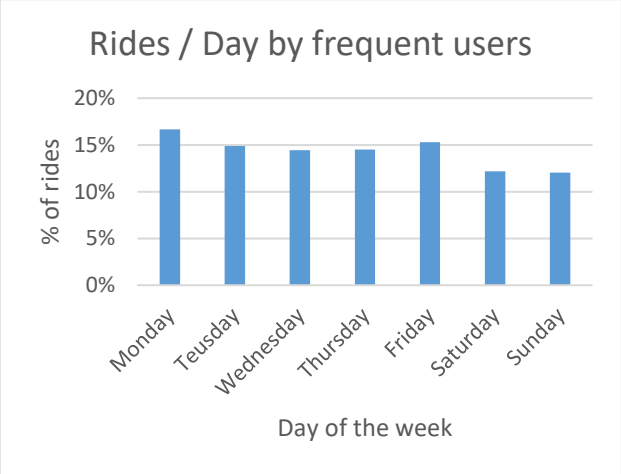


*Figure 16 – Percentage of rides per day of the week by frequent users*

## 4.2 Usage per drop zone (type)

**Most/least used drop zones**

In total there are 65 drop zones where people can pick-up and return the HTM-fiets. Table 6 shows which of these drop zones are the ten most and least used drop zones in the period from the 1st of June till the 29th of February (see Appendix 5 for the list including all drop zones). The two largest train stations of the city of The Hague (Den Haag Centraal and Station HS) are the most used drop zones. Both Den Haag Centraal and Station HS have the highest usage on Saturday and while Den Haag Centraal is mostly used between 9AM and 5PM, most rides to and from Station HS are between 9AM and 11AM, between 3PM and 6PM and in the night between 12AM and 1AM and between 3AM and 4AM. The fact that these large train stations are the most used drop zones could indicate that a large share of HTM-fiets users use the HTM-fiets in addition to their train journey. However, the drop zones located near two of the smaller train stations in the area (Station Ypenburg and Station Mariahoeve) belong to the least used drop zones. It is thus not self-evident that drop zones close to train stations generate a large demand for the HTM-fiets. Another reason why the drop zones that are located next to the two largest train stations are most used could be because these are very central locations in the city.

*Table 6 - Most and least used drop zones*

| Most used drop zones | Least used drop zones |
|---|---|
| Den Haag Centraal | Plesmanlaan |
| Station HS | Leidschenveen |
| Valkenboslaan | Madurodam |
| Kalvermarkt-Stadhuis | Lunterenstraat |
| Grote Markt | Station Ypenburg |
| Kurhaus | Laan van 's-Gravenmade |
| Elandstraat | Laan van Poot |
| Valkenbosplein | Station Mariahoeve |
| Leyenburg | Houtrust |
| Javabrug/Dr. Kuyperstraat | Donau |

Figure 17 shows where the most and least used drop zones are located in the city of The Hague. The larger the circle, the more rides have taken place to and from these drop zones. It can be seen that the most used drop zones are mainly located in the city centre and close to the beach. The drop zones located at the edges of the city are generally used to a lesser extent.

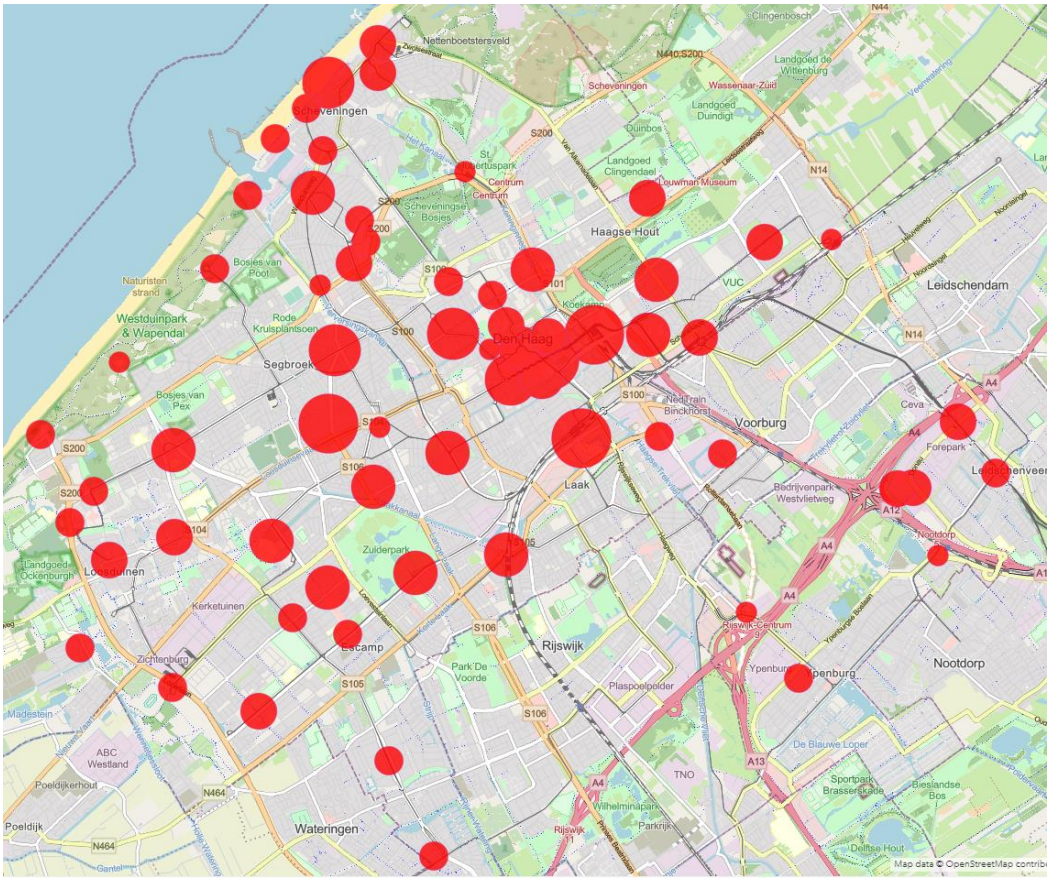


*Figure 17 - Usage per drop zone expressed in circles varying in size depending on the usage*

Because users of the HTM-fiets can return the bicycle at any drop zone, there could arise an imbalance of supply and demand of bicycles at a drop zone. In this case redistribution of the bicycles needs to take place. However, over the period from the start of June till the end of February, it appeared that over this entire period there are not many drop zones where a large imbalance has occurred (see Appendix 11 for more information).

**Most/least used drop zone types**

To be able to make a better comparison between the most and least used drop zones a classification of the drop zones is used. Before the HTM-fiets went into operation all planned drop zones were classified as being a certain type of drop zone. Each drop zone could be classified as being one or more drop zone types depending on its location. A total of seven drop zone types were distinguished, namely: close to a facility, a business location, close to a node/junction, a residential area, a recreational area, located at a possible cross connection between PT lines, a location with weak PT and located at the edge of the PT network. The data-analysis shows which type of drop zones are used most and least often. Since some drop zone types occur more often than others, the total number of trips to and from a specific drop zone type is divided by the number of drop zone that are classified as being that drop zone type (the number of drop zones classified as a certain type can be found in Appendix 12).

*Table 7 – Most/least used drop zone types*

| Drop zone type | Ranking |
|---|---|
| **Facility** | 1 |
| **Business** | 2 |
| **Node/Junction** | 3 |
| **Residential area** | 4 |
| **Recreational area** | 5 |
| **Cross connection** | 6 |
| **Weak PT** | 7 |
| **Edge network** | 8 |

The drop zone types 'facility' and 'business' attract on average most rides (see Table 7). This is in line with the expectations since destinations, as opposed to origins, are often more clustered and tend to attract more people. The drop zone types that attract on average the least rides are the ones located at the edge of the public transport network and at places where public transport is weak. This could be caused by the fact that the population density is lower in these areas. Also there are often less facilities located in these areas, which means there might also be less visitors. Furthermore, there are not many drop zones located beyond the edge of the public transport network. If there are no other drop zones located beyond the edge of the public transport network, people have less destinations to travel to from drop zones located at the edge of the public transport network. This also means that it is often not possible to use the HTM-fiets as first or last mile transportation to and from public transport, since there are often no drop zones to pick-up or return the bicycle beyond the public transport network. The reason why drop zones located at areas with weak public transport are one of the least used drop zone types might be related to why these areas have weak public transport. These areas often have weak public transport because the demand for public transport is lower in these areas due to for example a low population density or a high car usage. The same factors could influence the low usage of the HTM-fiets to and from these drop zones.

**Origin and destination pairs**

From the data-analysis results which specific origin and destination pairs (OD pairs) were used most often. The data-analysis shows that 20.5% of the total number of rides with drop zone data are made from and to the same drop zone. This means that people pick-up the bicycle at a drop zone, make a trip and return the bicycle at the same drop zone. Most of the rides to and from the same drop zone are to and from Den Haag Centraal, Valkenboslaan and Station HS. The ten OD pairs with the highest number of rides, excluding OD pairs where the origin and destination are the same drop zone, are shown in Table 8.

*Table 8 - Most common OD pairs*

| Origin | Destination |
|---|---|
| Forepark | ADO stadion |
| ADO stadion | Forepark |
| Leyweg (Tophalte) | Station HS |
| Kurhaus | Valkenboslaan |
| Grote Markt | Valkenboslaan |
| Valkenboslaan | Grote Markt |
| Javabrug/Dr. Kuyperstraat | Den Haag Centraal |
| Valkenboslaan | Kurhaus |
| Station Moerwijk | Leyenburg |
| Den Haag Centraal | Javabrug/Dr. Kuyperstraat |

Table 8 shows that the most used OD pair is from a public transport stop (Forepark) to a large soccer stadium (ADO stadion) and the other way around. At this public transport stop both lines of the RandstadRail and a metro line stop, which are relatively high quality forms of public transport. This stop is thus well accessible by public transport from large parts of the city, but is not close enough to the soccer stadium to make it ideal for walking the first or last mile. In this case the HTM-fiets could thus offer first or last mile transportation between the public transport stop and a destination. However, it appeared that almost all of these rides are made by just four people. While they might still use the HTM-fiets as first or last mile transportation for public transport, there are not large numbers of people who use the HTM-fiets this way between Forepark and ADO stadion. The rides between four of the other most used OD-pairs are also made by just a few people, which makes it hard to draw conclusions from this data. However, between Grote Markt and Valkenboslaan and between Javaburg/Dr. Kuyperstraat and Den Haag Centraal there are a larger number of people who use the HTM-fiets between these drop zones. Between both of these OD-pairs, also a fast urban public transport connections is available. It could thus be that people use the HTM-fiets as an alternative for public transport between these locations. Furthermore, around Javaburg/Dr. Kuyperstraat are many offices located. The HTM-fiets might be used as first and last mile transportation between this drop zone and Den Haag Centraal before or after a train journey and thus provide a connection to more regional and national public transport.

**HTM-fiets in combination with bus/tram**

This data-analysis cannot conclude with certainty whether people use the HTM-fiets in combination with the bus or tram in The Hague. However, there are 10 drop zones classified as being located in areas with weak public transport, which means there is no tram stop located very close to or at these drop zones. Some might be accessible by bus, but this analysis only focusses on the combination with tram (relatively high quality public transport) because the bicycle is generally more often used in combination with higher quality forms of public transport. An analysis is performed to see if people might have used the HTM-fiets as last mile transportation from the nearest tram stop that also has a drop zone for the HTM-fiets. This is done by checking what the most common origin drop zones are of the people travelling to these drop zones with weak public transport. It appeared that for five of these drop zones the most common origin was indeed the closest tram stop that also had a drop zone for the HTM-fiets. For three other drop zones, one of the three most common origins was the closest tram stop that also had a drop zone for the HTM-fiets (see Appendix 13). This could thus indicate that the HTM-fiets is used as last-mile transportation to drop zones that are not directly connected to the tram network themselves. For three of these eight drop zones it appeared that the closest tram stop with a drop zone was one of the three large train stations in The Hague. In these cases, the HTM-fiets could have been used as last-mile transportation after a tram ride, but also after a train ride.

**Pause location**

People who rent the HTM-fiets can pause the bicycle. By clicking on pause in the smartphone application the bicycle can be locked and again opened at the desired time. This can be done at any location and the payment will continue. From the data results that 33% of all rides are paused. For 33.6% of these paused rides the coordinates of the pause location are not registered and 60.9% of these rides were paused in the start and/or end drop zone of a ride. Furthermore, 0.8% of the paused rides were paused inside another drop zone and 1.5% of these rides had a pause location with coordinates outside a drop zone. For the last 3.3% of the rides it could not be determined if the pause location was inside or outside a drop zone since these rides are not included in the drop zone related analysis because the coordinates of the start and/or end drop zone were located outside the drawn drop zones.

The rides that are paused within the same drop zone as where the bicycle is picked-up or returned might not have been intentionally paused to temporarily leave the bicycle, but could have been paused during the process of picking-up or returning the bicycle. This can however not be said with certainty based on the available data. The pause location of the rides that are paused outside a drop zone could give an indication of possible new locations for drop zones, especially if many bicycles are paused around the same area. These locations are shown on a map in Figure 18. Each location where a bicycle has been paused is indicated with a green circle on the map. The blue circles on the map indicate the locations of the drop zones and the purple lines represent the tram lines in the city. Overall the pause locations are relatively spread out over the city and there are not many locations where a large number of bicycles are paused close to each other. However, the pause locations could still indicate in which areas of the city the density of the drop zones might not be sufficient. This could for example be in the area north of the city centre.


*Figure 18 - Pause locations*

## 4.3 Overview

When comparing the usage of the HTM-fiets with the usage of other BSPs around the world, the HTM-fiets concept currently has a relatively low usage. Furthermore, the HTM-fiets is used on average more on a weekend day than on a weekday and the HTM-fiets has a higher usage per month in the summer months (June, July and August) than in the other months. Therefore, it seems as if the HTM-fiets is more used for leisure purposes, which usually take more often place during the weekend and in the summer months, than for work or school related purposes, which take mainly place during the weekdays. This is in line with the finding that most people who have used the HTM-fiets are occasional users and have used the HTM-fiets between 1-5 times (79%).

Drop zones located close to facilities or in business areas are in general the most used drop zone types. Therefore, this could be important location types to add drop zones in case the concept is going to be expanded. Drop zones located at the edge of the public transport network or at locations with weak public transport are the least used. This is largely in line with the fact that drop zones in the city centre seem in general more used than drop zones at the edges of the city. Since public transport is less or not available at drop zones with weak public transport, it might be expected that more people use the HTM-fiets to or from these locations because it provides a new transport option. However, usually there is less public transport in these areas since the demand is also lower, which could also affect the lower demand for the HTM-fiets. The two drop zones with the highest usage of all drop zones are Den Haag Centraal and Station HS, which are the two large train stations in the city. This could indicate that the HTM-fiets is also used in combination with a train ride.

There are indications that people use the HTM-fiets as last mile transportation to the drop zones with weak public transport. This shows that there might be potential in the combination between the HTM-fiets and urban public transport from and to locations with weak public transport. On the other hand, the most used OD-pairs by multiple people are located in the city centre where also good urban public transport connections are available. In these cases, it seems that the HTM-fiets might be used as a substitute of urban public transport instead of a complement. However, from this data this cannot be concluded with certainty. In chapter 6 more insight is provided regarding this aspect based on the survey, which is conducted among the users of the HTM-fiets.

# 5. Results: Usage of the HTM-fiets from a user perspective

This chapter describes the usage of the HTM-fiets from a user perspective based on the results of the survey conducted among the users of the HTM-fiets. Also, the expert meeting is used to provide additional information regarding some aspects. First, in section 5.1 the descriptive statistics and representativeness of the sample are described. Furthermore, section 5.2 provides more information regarding what type of people the users and non-users of the HTM-fiets are. Section 5.3 provides more insight regarding the usage of the HTM-fiets. Furthermore, possible improvements to increase the general usage of the HTM-fiets are described in section 5.4. Finally, an overview of these results is provided in section 5.5.

## 5.1 Descriptive statistics and representativeness

The total sample consists of 245 respondents. The population consists of all people who have made an account in the HTM-fiets application. This includes both people who have actually used the HTM-fiets and people who have not used the HTM-fiets (yet). Therefore, while everyone in the sample has made an account in the HTM-fiets application, the sample also includes both people who have and have not (yet) used the HTM-fiets. These two groups are called users and non-users. Although the non-users have not used the HTM-fiets (yet), this group did show interest in the concept by making an account. The users and non-users are distinguished based on the survey question that asked the respondents how often they have used the HTM-fiets since the introduction of this BSP. The results of this question are shown in Figure 19.

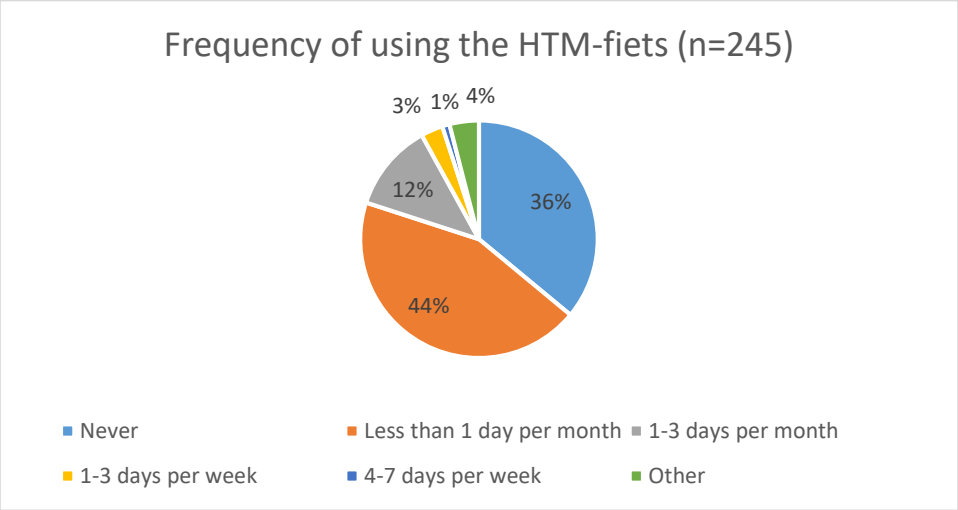


*Figure 19 - Frequency of using the HTM-fiets*

Figure 19 shows that 89 respondents (36.3%) did not use the HTM-fiets once, while they had made an account in the HTM-fiets application on their smartphone and are thus the group of non-users in the sample. Furthermore, 156 respondents (63.7%) did use the HTM-fiets and are therefore the group of users in the sample. The largest group of these respondents have used the HTM-fiets less than one day per month. This corresponds to the results of the data-analysis, which showed that a large share of users were occasional users and have used the HTM-fiets only 1-5 times in total. Nine respondents (3.7%) used the HTM-fiets on a weekly basis. Furthermore, 9 respondents (3.7%) answered with 'other: namely..' and based on their answer it could not be determined to which of the other categories they belonged. However, they all had used the HTM-fiets at least once and therefore belong to the group of users. These respondents answered for example with 'In the summer, not any other time' and 'sometimes weekly and currently not'.

Four different socio-demographic factors are included in the survey, which are age, gender, education level and bicycle ownership (in The Hague). For each socio-demographic variable a Chi-square independence test is performed to determine if there is a significant difference between users and non-users with respect to these socio-demographics in the sample. Before performing these tests, primary education and practical vocational education are combined in a new group within the variable education level. This is to assure that less than 20% of the cells have an expected count less than 5, which is a condition that has to be met for performing a Chi-square independence test. Also, the variable age is split into 4 different groups. These are younger than 25, 25-44, 45-64 and 65 and older. The first group represent young people and students. The second and third group represent working people and the fourth group represents people who are retired and elderly.

A significant difference was found in age (Chi2(3) = 17.542, p= 0.001) and education level (Chi2(2) = 11.877, p=0.003) between users and non-users. To test the strength and direction of these relationships, the correlation coefficients are determined. Age has a significant correlation coefficient of -0.243 (p= 0.000), which in this case means that people with a higher age belong more often to the group of non-users. Education level has a significant correlation coefficient of 0.223 (p = 0.001), which in this case means that people with a higher education level belong more often to the group of users. Overall users of the HTM-fiets thus seem to have a lower age and a higher education level compared to the non-users. There is no significant difference in gender and bicycle ownership in The Hague between users and non-users. Furthermore, the respondents were also asked whether they are an employee of HTM or not. There is also no significant difference in employment at HTM between users and non-users (see Appendix 14 for all results of these Chi-square independence tests).

An overview of the distribution of age, education level, gender, bicycle ownership in The Hague and employment at HTM of the HTM-fiets users and non-users in the sample is provided in Table 9. This table shows that most HTM-fiets users are between 25 and 44 years old, have completed a degree in higher education, are more often man than woman and more often own a bicycle in The Hague than not. The same is true for non-users, except that most non-users are between 45 and 64 years old. The relatively high percentage of users and non-users that own a bicycle in The Hague could indicate that these are largely people who live in The Hague.

*Table 9 - Distribution of socio-demographics for users and non-users*

| | | **People with an account in the HTM-fiets app** | |
|---|---|---|---|
| | | **Users (n=156)** | **Non-users (n=89)** |
| **Age** | < 25 years | 18.6% | 14.6% |
| | 25 – 44 years | 52.6% | 30.3% |
| | 45 – 64 years | 25.6% | 46.1% |
| | 65 and older | 3.2% | 9.0% |
| **Education level** | Lower education | 3.2% | 9.0% |
| | Secondary education | 17.3% | 29.2% |
| | Higher education | 77.6% | 53.9% |
| | Other/I'd rather not say | 1.9% | 7.9% |
| **Gender** | Woman | 31.4% | 37.1% |
| | Man | 66.7% | 61.8% |
| | Other/I'd rather not say | 1.9% | 1.1% |
| **Bicycle ownership in The Hague** | Yes | 65.4% | 60.7% |
| | No | 34.6% | 39.3% |
| **Employee of HTM** | Yes | 5.8% | 7.9% |
| | No | 94.2% | 92.1% |

**Representativeness**

It is important that the sample is representative for the population because the results from the sample will then also hold for the entire population. Since this study is focussed on the people that have made an account in the HTM-fiets application on their smartphone, this group is the full population. However, there is no socio-demographic data, such as age, gender and education level, known for this population. Therefore, the socio-demographics of the users in the HTM-fiets sample are compared to the socio-demographics of users of other BSPs, which followed from other studies that researched the users of shared bicycle programs (in the Netherlands) by performing a survey. This way it is still possible to give an indication of the representativeness of the users in the sample and to discuss general conclusions.

As described in the literature study, Waes et al. (2018) researched the shared bicycle usage of Flickbike in Amsterdam and Ma et al. (2020) the shared bicycle usage of Mobike in Delft, both by conducting a survey. Both studies found that 69% of the respondents was man and most respondents were higher educated, respectively 86% in Amsterdam and 93% in Delft. Furthermore, most respondents in Amsterdam were relatively young (between 23 and 37) and in Delft 47% of the respondents belonged to the age category 18-24 years, while only 1% belonged to the age category older than 45 years. Outside of the Netherlands there are also studies conducted regarding the user characteristics of shared bicycle users. For example, Murphy & Usher (2015) researched the usage of the shared bicycle program in Dublin. It appeared that 78% of the users was man and almost 60% of the users had an age between 25 and 36. Furthermore, other studies also found that people who did not own a bicycle were more likely to use BSPs (Bachand-Marleau et al., 2011), while most HTM-fiets users do own a bicycle in The Hague (65%). This difference might be caused by the fact that the majority of people who live in the Netherlands own one or more bicycles, which is in contrast to many other countries.

The HTM-fiets sample consists of slightly less men (67%) and also the education level (78% is higher educated) is a little bit lower compared to the studies described above. However, still a large part of the users in the HTM-fiets sample is man and higher educated which thus corresponds to the other studies. Furthermore, it seems that the number of people that is relatively young is slightly higher within the other studies. In the HTM-fiets sample there is still a relatively large share of users between 45 and 65, which seems lower in the other studies. Overall it seems that in general the socio-demographics are quite similar and therefore the users in the HTM-fiets sample are seen as representative for users of shared bicycle programs.

In addition, the HTM-fiets sample is compared with general cyclist in The Hague and the Netherlands. Most bicycle rides in The Hague are made by people with a higher education level (KiM, 2015). Furthermore, women make more bicycles rides in general in the Netherlands than men (KiM, 2015). It thus seems that higher educated people cycle more in general and also use shared bicycles more often. The users in the HTM-fiets sample differ from general cyclists in the fact that in general more bicycle rides are made by women, while shared bicycles are more often used by men.

Finally, a small share of the total HTM-fiets sample consists of HTM employees (6.5%). Since employees of HTM might have a different view regarding the HTM-fiets and the bus/tram because they work for the company that offers these services, HTM employees and non-HTM employees are compared in the frequency with which they use the HTM-fiets and the extent to which they use the HTM-fiets in combination with the bus or tram. A Chi-square independence test showed that there are no large differences between HTM employees and non-HTM employees regarding these aspects (see Appendix 15) and there is thus no need to distinguish between these groups.

## 5.2 Type of users and non-users

Next to the socio-demographics, the users and non-users of the HTM-fiets were asked several other questions to get more insight in the type of users and non-users.

**Users of the HTM-fiets**

The HTM-fiets users in the sample were also asked about their level of cycling, tram use and bus use in general and their attitude towards cycling and public transport in general. Figure 20 shows that 75% of the users of the HTM-fiets cycle on average at least once every week and 47% even more than 4 days per week. Most people who use the HTM-fiets thus also cycle often in general. This corresponds with other studies that found that a high usage of the bicycle in general had a positive influence on becoming a bikeshare member (Fishman et al., 2015; Bachand-Marleau et al.,2012). Furthermore, 53% of the HTM-fiets users use the tram on a regular basis (at least once per week) and 26% uses the bus at least once per week. Most HTM-fiets users thus in general cycle more often than that they use urban public transport.

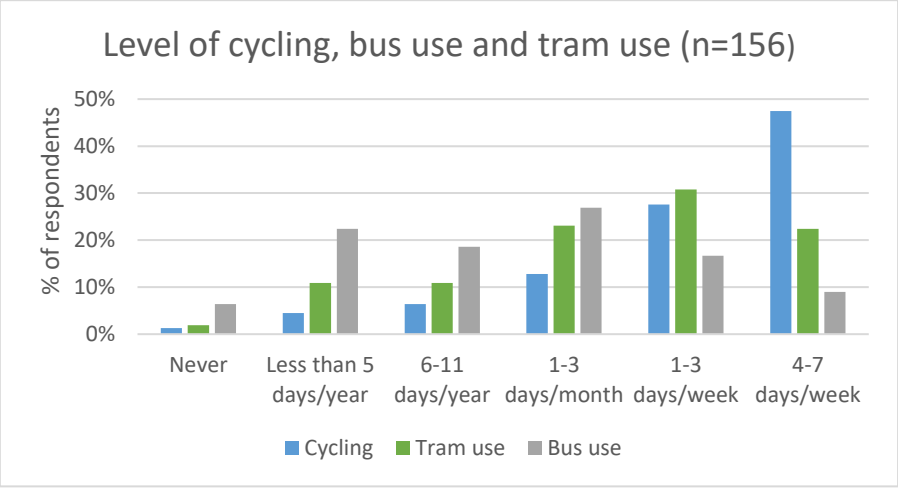


*Figure 20 - Frequency of cycling, tram use and bus use of HTM-fiets users*

Figure 21 shows that 88% of the HTM-fiets users (completely) agreed with the statement that they like travelling by bicycle. HTM-fiets users are in general thus people who like to cycle. The attitude towards travelling by public transport is a little less positive, but still 53% of the HTM-fiets users (completely) agreed to the statement that they like travelling by public transport.

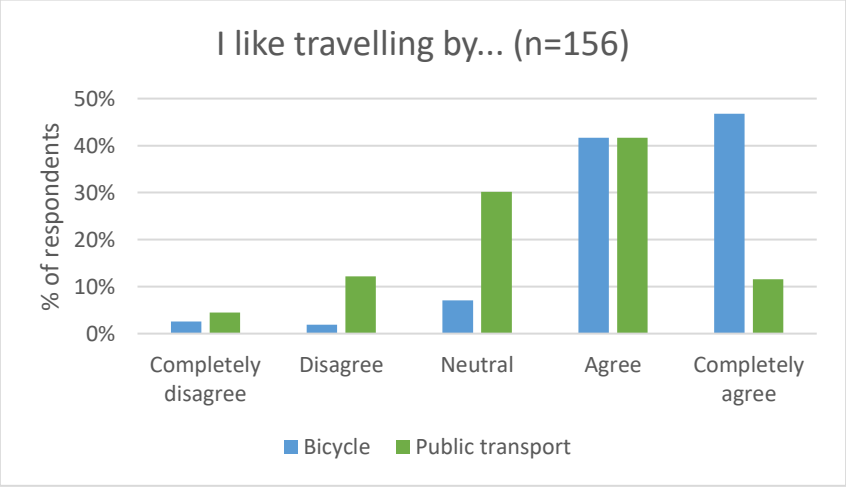


*Figure 21 - Extent to which HTM-fiets users like travelling by bicycle and public transport*

**Non-users of the HTM-fiets**

The non-users (89 respondents) were also asked if they expect to use the HTM-fiets in the future. Figure 22 shows that 78.8% of the respondents answered with 'maybe', 'probably yes' or 'definitely yes'. This means that the majority of the non-users expect to use the HTM-fiets in the future and can therefore be seen as potential users. This also appears from the answers given to the open question asking why these respondents have downloaded the HTM-fiets application. Similar answers given to this question are grouped together in one answer category. Most non-users provided an answer in the category that they downloaded the application because they possibly want to use the HTM-fiets in case needed. To a lesser extent respondents also mentioned that they wanted to see how it works or out of interest/curiosity (all individual answers to this question can be found in Appendix 16).

The respondents who 'maybe', 'probably' or 'definitely' expect to use the HTM-fiets (70 respondents) were also asked whether they expect to use the HTM-fiets in combination with urban public transport (bus/tram). Figure 23 shows that most of these respondents (67.1%) expect to use the HTM-fiets in combination with the bus or tram in a ride from A to B.

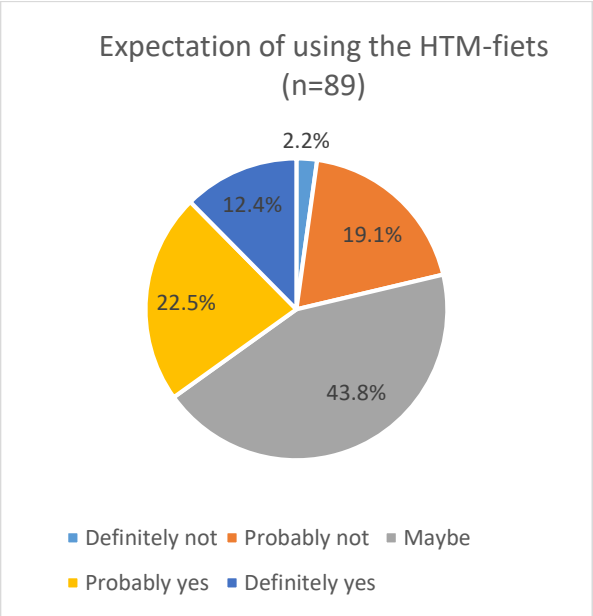


*Figure 22 - Expected usage HTM-fiets (non-users)*

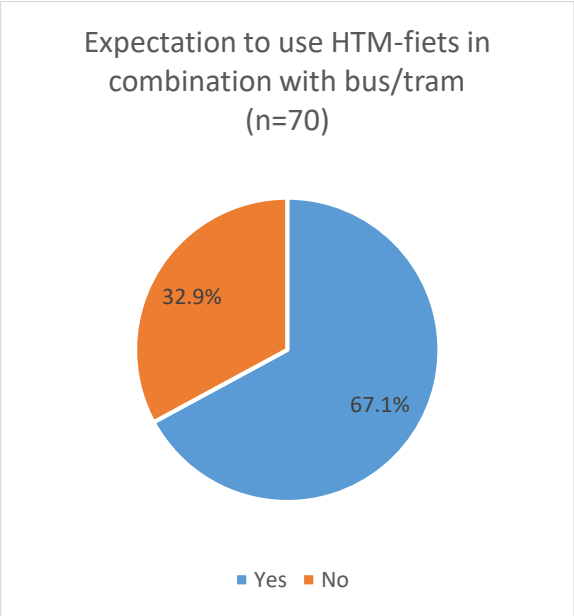


*Figure 23 - Expected combined usage (non-users)*

**Shared bicycle/scooter usage of HTM-fiets users and non-users**

Finally, both the users and non-users were asked whether they had already used other types of shared bicycles or shared scooters before. Table 10 shows that from the respondents who have made use of the HTM-fiets, 62% have used the OV-fiets before. More than half of the respondents thus also has experience with another type of shared bicycles. Furthermore, 24% have used free-floating shared bicycles before, 6% shared bicycles with drop zones and 35% shared scooters. It thus seems that the respondents have the least experience with BSPs similar to the HTM-fiets.

Overall the respondents who have not used the HTM-fiets also have less experience with other bicycle sharing programs or shared scooters. Most non-users have not used these before, especially no other BSPs with drop zones like the HTM-fiets (see Table 10). An exception is the OV-fiets. Almost half of the respondents who have not used the HTM-fiets, have used the OV-fiets sometimes or on a regular basis.

*Table 10 - Experience users and non-users with shared bicycles/scooter*

| | Users (n=156) | | | Non-users (n= 89) | | |
|---|---|---|---|---|---|---|
| | **Never** | **Sometimes** | **Regularly** | **Never** | **Sometimes** | **Regularly** |
| **Free-floating shared bicycles** | 76% | 19% | 5% | 82% | 15% | 3% |
| **Shared bicycles with drop zones** | 94% | 6% | 1% | 99% | 1% | 0% |
| **OV-fiets** | 38% | 37% | 25% | 57% | 24% | 19% |
| **Shared scooters** | 65% | 23% | 11% | 83% | 11% | 6% |

## 5.3 Usage of the HTM-fiets

Based on the descriptions of the last ride made with the HTM-fiets by the respondents, more insights can be obtained regarding the usage of the HTM-fiets. In this section the trip purpose and used drop zones are discussed. As mentioned in section 3.3.2 an overrepresentation of rides made in the winter could occur as a consequence of asking people to describe their last ride. Within the survey was asked in which month their last ride took place. It appeared that indeed 53% of the described rides took place in the winter months (December – start of March), while 22% took place in summer (May – August) and 20% in autumn (September – November). The other 6% of the respondents could not recall anymore when their last ride took place. This distribution is considered when interpreting the results in this section.

**Trip purpose**

Trip purpose can be split into two main categories namely work/school, which represent more regular type of trips, and leisure, which represent more occasional trips. Figure 24 shows that the HTM-fiets is overall more used for leisure purposes. From the data-analysis it already seemed that a large share of rides made with the HTM-fiets had a leisure purpose because the largest share of rides are made by occasional users, more rides were made in the summer months and on average more rides were made on a weekend day than on a weekday. This could however not be said with certainty based on the data used in the data-analysis, but the results of the survey substantiate that it indeed seems that more rides are made for leisure purposes. Table 11 shows in more detail for which trip purposes the HTM-fiets has been used. 25% of the respondents have used the HTM-fiets to travel from or to their work, while the HTM-fiets is less used to travel from or to education or for business trips. Furthermore, most leisure trips consisted of a trip to the beach, museum or cinema etc. and visiting friends or family. Of the described rides made in the winter, 60% had a leisure purpose and 33% a work/school related purpose and of the described rides made in summer, 50% had a leisure purpose and 35% a work/school related purpose. It thus seems that there is not a large difference in trip purpose between these periods.

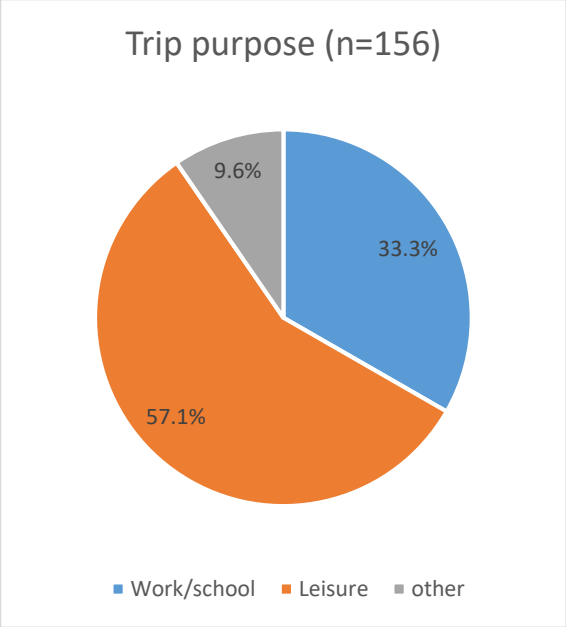


*Figure 24 - Distribution trip purpose last ride HTM-fiets*

*Table 11 - Distribution trip purpose last ride HTM-fiets*

| Trip purpose | Number of rides (n=156) |
|---|---|
| **Work/school** | |
| - From/to work | 25.0% |
| - From/to education | 6.4% |
| - Business trip | 1.9% |
| **Leisure** | |
| - Trip to beach/museum/ cinema etc. | 16.7% |
| - Visiting family/friends | 12.2% |
| - Visiting restaurant/bar | 10.9% |
| - Sightseeing/recreational cycling | 10.3% |
| - Shopping | 3.8% |
| - Sport club | 3.2% |
| **Other** | |
| - Other | 9.6% |

The results of the questions regarding the frequency with which users use the HTM-fiets and the trip purpose of their last ride can also be combined. Occasional users can be defined as people who have used the HTM-fiets less than once per month or 1-3 times per month and frequent users as people who have used the HTM-fiets 1-3 times per week or 4-7 times per week. The occasional users consist of 138 respondents of which 33% used the HTM-fiets for a work/school purpose and 57% for a leisure purpose on their last ride. The frequent users consist of only 9 respondents, which makes it hard to draw conclusions for this group. Nevertheless, 56% of these respondents used the HTM-fiets for a work/school purpose and 44% for a leisure purpose on their last ride. It thus seems that frequent users more often use the HTM-fiets for work/school related purposes than occasional users.

Furthermore, most described rides with a leisure purpose took place between 9AM and 7PM and visiting friends/family and visiting a restaurant/bar also often took place during the evening and night, which is as expected. Work related trips seem not only concentrated in the morning and evening peak, but are more distributed throughout the whole day. This might partially explain why the data-analysis did not show a real rush hour pattern, in addition to the fact that the HTM-fiets seems in general more used for leisure trips than for work trips (see Appendix 17 for the specific number of rides with a certain trip purpose per time period).

**Usage drop zones**

The respondents also indicated from and to which drop zone they cycled on their last ride with the HTM-fiets. Figure 25 shows the most and least used drop zones by the respondents during this ride. The larger the circle, the more rides have taken place to and from these drop zones. The number in the circles shows the total number of rides to and from the drop zones by the respondents. The most used drop zones are located around the city centre, which also followed from the data-analysis of the operational trip data.


*Figure 25 - Usage per drop zone expressed in circles varying in size depending on the usage (survey)*

Table 12 shows the ten drop zones with the most rides to and from these drop zones mentioned by the respondents. The two drop zones where most respondents started or ended their ride are Den Haag Centraal and Station HS. This corresponds with the results of the data-analysis, which showed that these are overall the two most used drop zones. Furthermore, most of the other drop zones in Table 12 (Elandstraat, Kurhaus, Grote Markt, Valkenbosplein and Valkenboslaan) are also in the top ten most used drop zones resulting from the data-analysis. It thus seems that the rides described by the respondents relatively well correspond to the results of the data-analysis.

*Table 12 – Ten drop zones with the highest number of rides mentioned in the survey*

| Drop zone | Number of rides to and from drop zone |
|---|---|
| **Den Haag Centraal** | 30 |
| **Station HS** | 15 |
| **Elandstraat** | 12 |
| **Kurhaus** | 11 |
| **Laan van NOI** | 10 |
| **De Savornin Lohmanplein** | 9 |
| **Grote Markt** | 9 |
| **Valkenbosplein** | 9 |
| **Valkenboslaan** | 8 |
| **Theresiastraat** | 8 |

Of all 156 respondents who have used the HTM-fiets, 31 respondents (19.9%) indicated that they used the HTM-fiets during their last ride before or after a train ride. Almost 20% of the respondents thus used the HTM-fiets to cycle to the train station or to cycle from the train station to their destination. Table 13 shows how many respondents who used the HTM-fiets to travel from or to a drop zone

located near one of the three large train stations in The Hague, actually arrived or departed there by train. This table shows that for example 67% of the respondents who arrived or departed with the HTM-fiets at the drop zone near Station HS, arrived or departed at Station HS by train and thus used the HTM-fiets in combination with the train. This percentage is slightly lower for Den Haag Centraal and Laan van NOI.

*Table 13 - Usage of the combination HTM-fiets and train*

| Drop zone (station) | Respondents who arrived/departed by train |
|---|---|
| **Den Haag Centraal** | 13 (43%) |
| **Station HS** | 10 (67%) |
| **Laan van NOI** | 4 (40%) |

**Discussion type of users and usage of the HTM-fiets in the expert meeting**
The type of user of the HTM-fiets that emerged from the survey and the usage patterns of the HTM-fiets that resulted from both the data-analysis and survey are discussed during the expert meeting as described in the methodology chapter (see Appendix 3 for a summary of the expert meeting). Regarding the type of user, a higher usage amongst people between 18 and 24 year old was expected because of the presence of a university of applied sciences located in the city. However, the survey showed that the HTM-fiets is more often used by people that are older than this age. Furthermore, it was not expected that a large part of the users of the HTM-fiets also had a privately-owned bicycle in The Hague. This shows that the HTM-fiets still provides convenience to people who own a bicycle in The Hague themselves, for example because people don't have to worry about parking or theft of their own bicycle when using shared bicycles and it also provides the opportunity to make one-way trips. Finally, there were no prior expectations regarding education level and gender. The reason why more men make use of the HTM-fiets might be because men are sooner satisfied with the setup of the bicycle and see less obstacles.

Regarding the usage of the HTM-fiets it was expected that the HTM-fiets would indeed be more used during the summer period and that it would be a good transportation option for leisure activities and during the night time when public transport is less available. Something that was not necessarily expected was that the HTM-fiets would be relatively little used for commuting purposes, which can be derived from the frequency of use and the time periods in which the bicycle is most used, which both follow from the data-analysis, and the most common trip purposes that followed from the survey. It thus seems that the HTM-fiets offers more of an extra travel possibility for occasional trips than it is used as a structural replacement for another existing transportation mode. This might be because it is likely that people who live and work in the city have a privately-owned bicycle for regular trips that they make on a daily basis. Furthermore, the HTM-fiets might also face competition from the OV-fiets regarding commuting trips since the OV-fiets can be paid with the OV-chipkaart, which might make it easier for commuting, and has a lower daily tariff.

## 5.4 Possible improvements to increase the general usage of the HTM-fiets

Both the users and non-users were asked to indicate for eight different aspects on a scale from completely disagree to completely agree if a certain improvement of the HTM-fiets concept would lead to them using the HTM-fiets more or lead to them starting to use the HTM-fiets. This is asked to identify in which aspects improvements would lead to the largest increase in usage. Since there is no major difference in the answers between the users and non-users, the answers of both groups are combined to provide an overall image. The results are shown in Table 14 and are thus based on 245 respondents.

*Table 14 - Reasons when respondents would use the HTM-fiets more (n=245)*

| | Completely disagree | Disagree | Neutral | Agree | Completely agree |
|---|---|---|---|---|---|
| **More drop zones** | 2% | 4.90% | 23.30% | 34.70% | 35.10% |
| **A drop zone closer to my destinations** | 4.50% | 4.50% | 28.20% | 30.20% | 32.70% |
| **Certainty that a bicycle is available** | 2.90% | 7.80% | 38.40% | 35.90% | 15.10% |
| **A drop zone closer to home** | 9.80% | 12.20% | 30.60% | 18.40% | 29% |
| **Lower price** | 5.30% | 20% | 38.40% | 21.20% | 15.10% |
| **Less broken bicycles** | 4.10% | 10.60% | 49.80% | 23.30% | 12.20% |
| **A more comfortable bicycle** | 4.50% | 16.70% | 43.70% | 20.80% | 14.30% |
| **A better app** | 5.30% | 12.70% | 50.60% | 16.70% | 14.70% |

The statements with which the highest percentage of people completely agreed with were that they would make more use of the HTM-fiets if there would be more drop zones, if there would be drop zones closer to their destinations and if there would be a drop zone closer to their home. These three aspects are all related to the amount and locations of the drop zones. More drop zones in general could indirectly also lead to more drop zones closer to people's destinations and homes. It thus seems that implementing more drop zones is an important aspect that could lead to a higher usage of the HTM-fiets. The opinion regarding if a drop zone closer to home would lead to more usage is more divided than regarding the other two drop zone related aspects. The people who don't agree with the statement that a drop zone closer to home would lead to more usage might already have a drop zone located close to their home or it could also mean that they don't live in the city of The Hague. The next aspect that most people agreed to that it would increase their usage, is if there is certainty that there is a bicycle available. It seems that people value that there is always a bicycle available at a time and place when they need one just as would be the case with a privately-owned bicycle.

The points of improvement with the highest share of people that don't agree that these improvements would lead to them making (more) use of the HTM-fiets are if the price would be lower or if the bicycle would be more comfortable. Making improvements in these aspects would thus lead to a lower increase in overall usage than the before mentioned improvements in drop zone related aspects and bicycle availability. It could thus be that a relatively large share of users and non-users are already satisfied with the price and level of comfort. Therefore, the price and comfort of the HTM-fiets might be used as selling points while promoting the HTM-fiets. Furthermore, most people are neutral regarding the influence of a better app or less broken bicycles on their HTM-fiets usage. Improvements in these aspects are thus also less likely to result in a large increase in usage.

Next to the provided statements, all respondents were asked in an open question if there were any other points of improvement which would lead to them start making use of the HTM-fiets or using the HTM-fiets more. The answers could be divided in different categories. These categories are made by analysing all answers and grouping similar answers together. The results for both the users and non-users are presented in respectively Table 15 and Table 16. A list of all the individual answers can be found in Appendix 18 and 19. Table 15 shows that most users made a comment regarding the drop zones. Most respondents state again that they would like more drop zones, but also other aspects are

mentioned such as expanding the area where bicycles can be picked up and returned to other municipalities around The Hague. Also making the drop zones more attractive and visible, for example by placing better signs to show where you can pick up and drop off the bicycles, is mentioned. The second aspect that is mentioned often is that better bicycles could lead to more usage. Different parts of the bicycle are mentioned such as that they would like a luggage rack, gears and a handbrake on the bicycle. Furthermore, some aspects regarding the price and the payment method are mentioned, for example a tariff for rides shorter than 30 minutes and a lower daily price. Currently the HTM-fiets can only be paid by putting money on your account in the HTM-fiets application. Some respondents state that they would make more use of the HTM-fiets if they could pay with the OV-chipkaart, which is the smartcard with which you pay for all other public transport in the Netherlands.

*Table 15 - Reasons when users would use the HTM-fiets more (open question)*

| Answer category | Number of respondents | Answer sub-category | Number of respondents |
|---|---|---|---|
| **1. Drop zones:** | 25 | - More drop zones | 14 |
| | | - Expanding the area | 5 |
| | | - More attractive and visible drop zones | 4 |
| | | - No drop zones | 2 |
| **2. Better bicycles:** | 17 | - In general | 4 |
| | | - Luggage rack | 4 |
| | | - Gears | 4 |
| | | - Handbrake | 3 |
| | | - Lighting | 2 |
| **3. Price/Payment:** | 9 | - Lower price/different tariffs | 5 |
| | | - Pay with OV-chipkaart | 2 |
| | | - Integrate with PT subscription | 2 |
| **4. No broken Bicycles/better maintenance** | 4 | | |
| **5. Other** | 23 | | |
| **6. No other improvements** | 17 | | |

Table 16 shows that non-users partially mention the same aspects as the users, but some differences occur. For example, three respondents specifically mention that a reason for starting to use the HTM-fiets is if there are more drop zones located at places that are difficult to reach with public transport. As mentioned before, currently most drop zones are located close to or at public transport stops. If there are also drop zones located in different areas, the HTM-fiets might provide a new transport option to places where these non-users might like to go. Furthermore, six respondents mention that they would start making use of the HTM-fiets if they would offer electrical bicycles.

*Table 16 - Reasons why non-users would start using the HTM-fiets (open question)*

| Answer category | Number of respondents | Answer sub-category | Number of respondents |
|---|---|---|---|
| **1. Drop zones:** | 18 | - More drop zones | 7 |
| | | - Expanding the area | 5 |
| | | - At places difficult to reach with PT | 3 |
| | | - More attractive and visible drop zones | 3 |
| **2. Price/Payment:** | 5 | - No start balance | 2 |
| | | - Pay with OV-chipkaart | 2 |
| | | - Lower price | 1 |
| **3. Electrical bicycles** | 6 | | |
| **4. Other** | 8 | | |
| **5. No other improvements** | 17 | | |

Looking at both the answers to the statements and open questions regarding possible points of improvements, it overall seems that improvements in drop zone related aspects would lead to the largest increase in usage of the HTM-fiets. Especially adding more drop zones, which increases the number of origins and destinations between which people can travel, could have a large influence on the usage. Also a higher certainty that bicycles are available and a better quality of the bicycles emerge from the survey as important aspects that could increase the usage of the HTM-fiets. Additionally, within the expert meeting with HTM employees is asked if these points of improvement were expected, which are missing and which improvements are most important and feasible to change (see Appendix 3 for a summary of the expert meeting).

First, the experts agreed that more drop zones is indeed one of the most important improvements that could be made to increase the usage of the HTM-fiets concept. However, they also mentioned that this is partially dependent on the permit issued by the municipality, since the permit states how many and at which type of locations drop zones can be located. Different tariffs and being able to pay with the OV-chipkaart are also points of improvement that were expected. However, making it possible to pay with the OV chipkaart is difficult from both a technical and cost perspective. Furthermore, they agreed that the HTM-fiets is currently a basic bicycle, but changing this to a higher quality bicycle is not feasible in the short term. Currently they already have the maximum number of bicycles permitted by the municipality and making a new investment in changing these bicycles might only be feasible on a longer term if the concept is successful and is allowed to be expanded. However, providing good maintenance is something that can be realised and it is already tried to make sure there are no broken bicycles offered to the users. Finally, it was expected that more people would agree to the statement that a better app would lead to higher usage, but this was not one of the most important improvements that emerged from the survey. Overall the experts agreed that the points of improvement that emerged from the survey could indeed be most important for people who already use the HTM-fiets, but they might not be the most important for new customers. They state that to attract new customers it is important to make clear which 'problem' the HTM-fiets solves for potential new customers and that people can try the bicycle in an accessible and easy way.

Although the survey and expert meeting showed that especially more drop zones could lead to an increase in usage, previous studies have shown that an expansion of a BSP does not necessarily correspond with a higher usage of the total system (De Chardon et al., 2017; Zhang et al., 2016). Since the initial stations or drop zones are usually located in areas with high demand, it is not always likely that expansion in other areas lead to the same overall number of trips per day per bicycle (De Chardon et al., 2017). However, in case of small BSPs where individual user demand is not satisfied because the

number of stations serve too few origins and destinations, usage could increase by adding stations or drop zones. Since a large share of the users of the HTM-fiets indicate that they would make more use of the HTM-fiets if there were more drop zones, it is expected that in this case an increase in the number of drop zones could lead to a higher usage of the system. On the other hand, it should be taken into account that continuing to add drop zones (and bicycles) on the long term thus does not always lead to overall higher usage of the system. Furthermore, the study by Zhang et al. (2016) did show that expanding the BSP does attract new users. Also, adding new stations or drop zones in areas located more in the outskirts of the city mainly attracts new users. In case of the HTM-fiets it is also expected that expanding the area in which the HTM-fiets is offered will indeed attract new users.

## 5.5 Overview

Overall it seems that most users of the HTM-fiets are between 25 and 44 years old, have completed a degree in higher education, are more often man than woman and more often own a bicycle in The Hague than not. The non-users overall seem to have a higher age and lower education level compared to the users. This could indicate that while older and lower educated people show interest in the concept by making an account in the HTM-fiets application, it does not directly fit their transportation needs or that the use of the system, including the application, might be too complicated. In addition to the data-analysis of the operational trip data, the survey shows regarding the usage of the HTM-fiets that the HTM-fiets seems more used for leisure purposes than for school or work related trips. Of the different leisure purposes, the largest share of people indicated that they have used the HTM-fiets for a trip to the beach, museum or cinema etc. Furthermore, occasional users seem to use the HTM-fiets more often for leisure purposes and frequent users slightly more for work or school related trips. Finally, the survey results showed that trips to or from work took place throughout the whole day and not just in peak hours. Together with the fact that the HTM-fiets seems more used for leisure purposes than work/school related trips, this might explain why the data-analysis did not show a real rush hour pattern.

Based on both the survey and expert meeting, improvements are identified that could increase the general usage of the HTM-fiets. The most important and feasible improvements are related to the amount and locations of drop zones. Most respondents indicate that more drop zones, drop zones closer to their destinations and closer to their home would increase their usage of the HTM-fiets. Furthermore, expanding the program to municipalities around The Hague and making the drop zones more attractive and visible are also mentioned. The experts agree that changes related to the drop zones could lead to an increased usage and that this is also feasible to change, although it is partially dependent on the permit issued by the municipality. Other possible improvements resulting from the survey and expert meeting include providing certainty that bicycles are available, providing better bicycles, changing the pricing/tariffs and making it possible to pay with the OV-chipkaart. However, providing better bicycles is not feasible on the short term and making it possible to pay with the OV chipkaart is difficult from both a technical and cost perspective. Overall, chapter 4 and 5 together provided an answer to the second sub-question ‘How is the current bicycle sharing program of HTM used and what could be improved about the current setup from both a business and customer perspective?’.

# 6. Results: Combined usage HTM-fiets and urban public transport

This chapter provides the results regarding the combined usage of the HTM-fiets and urban public transport. These results are based on both the survey and expert meeting. First, section 6.1 describes the extent to which people use the HTM-fiets in combination with the bus/tram. Section 6.2 shows the modal shift after the introduction of the HTM-fiets, which also gives an indication of the extent to which the HTM-fiets is used as substitute for the bus/tram. Thereafter, the factors that influence the extent to which the HTM-fiets is used in combination with the bus/tram are described in section 6.3. Possible improvements for a better integration between the HTM-fiets and urban public transport are described in section 6.4. Finally, section 6.5 provides an overview of the results.

## 6.1 The extent to which people use the HTM-fiets in combination with the bus/tram

An important aspect of this study is to examine to what extent users of the HTM-fiets, use the HTM-fiets in combination with the bus or tram. Figure 26 shows that the majority of HTM-fiets users (83.3%) never or usually not uses the HTM-fiets in combination with the bus or tram in a single ride. Only 9% of the respondents use the HTM-fiets as often in combination with the bus/tram as not or more often in combination with the bus/tram than not in combination in a single ride. It can thus be concluded that the current setup of the HTM-fiets concept does not attract many people to use it in combination with the bus or tram and that the HTM-fiets is thus not often used as a complement to the urban public transport network in a single ride. This is in contrast with the expectation of non-users, of which 67% expects to use the HTM-fiets in combination with the bus/tram in a single ride ride. It thus seems that there is a difference between how people expect to use the HTM-fiets and how they actually use it. What causes this difference cannot be derived from the survey results. However, when you have not used the HTM-fiets yet, it might seem a promising first or last mile solution, but if you actually start using the HTM-fiets, it might appear that drop zones are not located close to your home or close to your destinations, which makes it less suitable for first or last mile transportation.

Based on the extent to which people use the combination of the HTM-fiets and bus/tram, respondents either described their last ride with the HTM-fiets not in combination with the bus/tram or in combination with the/bus tram. The respondents who answered with as often in combination as not till always in combination, described their last ride in combination with the bus/tram (14 respondents). The other respondents (142 respondents) described their last ride not in combination with the bus/tram.

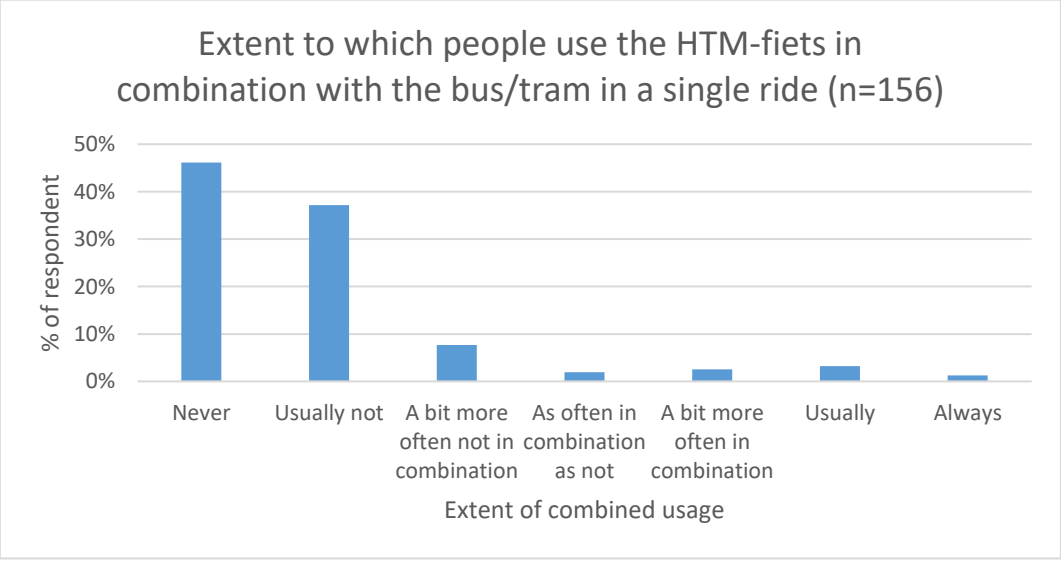


*Figure 26 - Extent to which people use the HTM-fiets in combination with bus/tram*

## 6.2 Modal shift

The fact that not many people use the HTM-fiets in combination with the bus/tram does not necessarily mean that they use the HTM-fiets instead of the bus/tram. Therefore, the respondents who described their last ride with the HTM-fiets not in combination with the bus/tram (142 respondents), were asked which means of transportation they would have used if the HTM-fiets was not available for the part of the trip for which they now used the HTM-fiets. Figure 27 shows for each modality the percentage of respondents that would have used that specific mode if the HTM-fiets was not available.

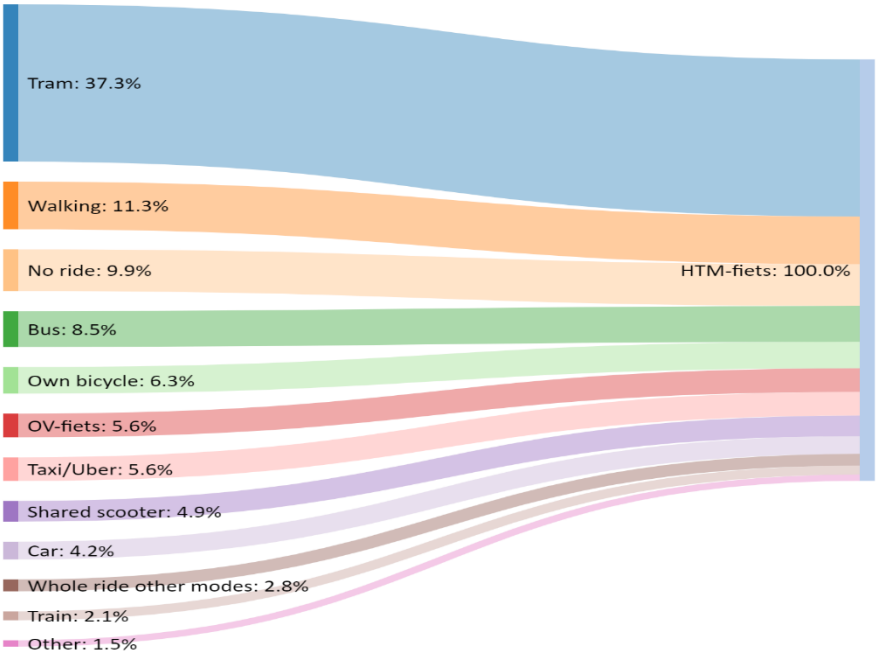


*Figure 27 - Modal shift (mode used if the HTM-fiets was not available) (n=142)*

It can be seen that a large part (37%) of these respondents would have used the tram if the HTM-fiets was not available. The HTM-fiets is thus often used instead of the tram, which makes these two modes a competition from each other. The HTM-fiets seems less often used instead of the bus, but this might also be related to the fact that the bus is in general less used than the tram. Still 8% would have used the bus if the HTM-fiets was not available and thus uses the HTM-fiets as substitute for the bus. The total percentage of HTM-fiets users that have used the HTM-fiets instead of public transport (tram, bus and train) is 47%. In comparison, at five other BSPs located in Montreal, Dublin, Lyon, Barcelona and Delft, respectively 34%, 23%, 50%, 51% and 25% of the people switched from public transport to the shared bicycle (Bachand-Marleau et al. (2012); Murphy & Usher (2015); Midgley (2011); Gerrevink (2019)). The percentage in The Hague is thus within the range of the other studies.

Furthermore, 11% of the respondents would have walked if the HTM-fiets was not available. This is not necessarily beneficial for the city since this represents a switch between two sustainable modes of transportation, where the bicycle takes up more space than walking. Also, 10% of the respondents would have used de car or the taxi/Uber if the HTM-fiets was not available. In Montreal, Dublin, Lyon, Barcelona and Delft respectively 10%, 13%, 7%, 10% and 1% of the people switched from the car or taxi to the shared bicycle (Bachand-Marleau et al. (2012); Murphy & Usher (2015); Midgley (2011); Gerrevink (2019)). The percentage of people who have switched from the car in The Hague is comparable with Montreal, Dublin and Barcelona, but higher than in the other two cities. One of the main goals for introducing a BSP in a city is often that it could reduce car usage within the city and the HTM-fiets thus indeed ensures that the car is a bit less used. Furthermore, 10% of the respondents would not make the entire ride in case the HTM-fiets was not available. This means that the HTM-fiets also generates new rides that otherwise would not have been made. Finally, 6% of the respondents

would have used their own bicycle if the HTM-fiets was not available. Although 65% of the respondents have a privately-owned bicycle in The Hague, only a small percentage would use their own bicycle for the part of their trip for which they used the HTM-fiets.

To improve the sustainability and liveability of a city it is especially beneficial when people use shared bicycles instead of the car or taxi. Therefore, it is useful to know whether the people who would have used the car or taxi in case the HTM-fiets was not available, are a different group of people than the ones who would have used another transportation mode, to be able to target this group specifically. However, by looking at the crosstabs of all socio-demographic variables and whether people would have used the car/taxi or a different transportation mode, no large differences could be observed in the socio-demographics between these two groups. Although not significant, the largest difference could be observed in the attitude towards public transport. The group who would have used the car/taxi in case the HTM-fiets was not available, in general has a less positive attitude towards public transport than the group who would have used another transportation mode.

Based on the results described in the previous section and this section can be concluded that of all HTM-fiets users in the sample (156 respondents), 9% has indicated that they use the HTM-fiets as often in combination with the bus/tram as not or more often in combination with the bus/tram than not in combination in a single ride. This shows that the HTM-fiets is not often used in combination with urban public transport. Of the other respondents who have indicated that they use the HTM-fiets more often not in combination with the bus/tram than in combination or never in combination in a single ride, 45% have used the HTM-fiets as substitute for the bus/tram during their last ride. In the current setup it thus seems that the HTM-fiets is more often used as substitute for the bus or tram than as a complement in a single ride. With this an answer to the third sub-question 'To what extent do users of bicycle sharing programs currently use the shared bicycle in combination with urban public transport and to what extent do they use it as a substitute?' is provided.

## 6.3 Factors influencing the extent to which people use the HTM-fiets in combination with bus/tram

This section describes what the influence of different types of factors is on the extent to which people use the HTM-fiets in combination with the bus/tram in a single ride. As described in the methodology chapter, the influence of the trip factors and public transport factors are analysed in a qualitative way, whereas the influence of the socio-demographic factors and attitude/motivational factors are analysed in a quantitative way using SPSS.

**Trip factors and public transport factors**

The trip and public transport factors consists of the trip length, the trip purpose, the start and end location of a trip and the quality of the public transport lines. Before conducting this analysis, the start and end drop zones and the boarding and exit stops of the bus/tram, of the rides described by the 14 people who were supposed to describe their last ride with the HTM-fiets in combination with the bus/tram in a ride from A to B, were checked if they actually described these type of rides. It appeared that three people had described a ride where they used the bus or tram to go somewhere and then returned to their origin with the HTM-fiets. Furthermore, for three other rides the description was not right, which means that the origin and destination drop zones did not match with the boarding and exit stop of the public transport ride they filled in. The other eight rides did seem actual rides where the HTM-fiets was used in combination with the bus or tram in a trip from A to B and are thus included in this analysis. A summary of these eight rides is presented in Table 17. Due to the low number of described combined rides, the results in this section are indicative and should be interpreted carefully.

*Table 17 - Description HTM-fiets rides in combination with bus/tram*

| | HTM-fiets | Tram/bus | Trip length | Edge | Purpose |
|---|---|---|---|---|---|
| **1.** | Donau – Forepark | Line 3: Forepark – HMC Westeinde | 7.8 km | Yes | Work |
| **2.** | Mauritskade – Kalvermarkt Stadhuis | Line 9: Kalvermarkt Stadhuis – Den Haag CS | 1.6 km | No | Leisure |
| **3.** | Vroondaal – Uithof | Line 4: Uithof – Den Haag CS | 8.7 km | Yes | School |
| | **Tram/bus** | **HTM-fiets** | **Trip length** | **Edge** | **Purpose** |
| **4.** | Line 9: Circus theatre – Madurodam | Madurodam – Den Haag CS | 4.8 km | Yes | School |
| **5.** | Line 4: Den Haag CS – Leidschenveen | Leidschenveen - Leidschenveen | 7.5 km | Yes | Doctor visit |
| **6.** | Line 3: Den Haag CS – Valkenbosplein | Valkenbosplein - Valkenboslaan | 4.6 km | No | Work |
| **7.** | Regional bus: ? - Den Haag CS | Den Haag CS – Den Haag CS | ? | ? | Leisure |
| **8.** | Regional bus: Leliekeverstraat – Station Ypenburg | Station Ypenburg - Beatrixkwartier | 7.6 km | Yes | Leisure |

Table 17 shows that the HTM-fiets is used twice in combination with a regional bus (EBS, Arriva or Connexxion) and six times in combination with a tram line (2x line 3, 2x line 4 and 2x line 9). Tram lines are often more high quality forms of public transport than city buses, which means they go faster, have a lower stop density and a higher frequency. Although the sample is small, the HTM-fiets seems more often used in combination with the tram than with city buses and thus seems more often used with relatively higher quality forms of public transport. Table 17 also shows the total trip length of each combined trip. This total trip length is determined based on the shortest distance on bicycle paths between the start and end location of each combined trip, which includes both the HTM-fiets ride and bus/tram ride. It thus represents the distance that would have been travelled if the entire ride had been made by bicycle. The average trip length of the combined trips is 6.1 kilometre. In total there are 142 rides with the HTM-fiets described that are not in combination with the bus/tram. However, some respondents could not recall their start and/or end drop zone and some rides were made from or to the same drop zone, which means the trip length of these rides could not be determined. As a result the trip length of 102 non-combined rides is known. The trip length of these rides is also determined based on the shortest distance between the start and end drop zone on bicycle paths. These rides have an average trip length of 4.1 kilometre. However, it has to be taken into account that people might have taken a detour and did not cycle directly from the start to the end drop zone. The actual average trip length thus might have been larger. Performing an independent samples t-test shows that the difference in trip length between combined rides and non-combined rides is significant ($t= 2.658$, $p= 0.009$). It thus seems that combined rides generally have a longer trip length compared to HTM-fiets rides that are not combined with the bus/tram.

As described in the literature study, Martin & Shaheen (2014) concluded from their research that it seemed that the shared bicycle was more often used as complement to public transport from or to the edges of the city and as substitute for trips within the city centre. In this case the HTM-fiets is both from or to the edge of the city as well as within the city centre not often used in combination with public transport. However, in Table 17 can be seen that five of the eight combined trips (63%) were made with certainty from the edge of the city to the city centre or vice versa and 25% within the city centre. This shows that the shared bicycle seems more often used as a complement to public transport from or to the edges of the city than within the city centre. Furthermore, Imani & Eluru (2015) found that members of BSPs often had metro or regional rail stations as destinations and it thus seemed that regular users of shared bicycles, who more likely have trip purposes related to work or school, combined it often with public transport. They found that occasional users, who more often have a trip purpose related to leisure activities, had less often public transport stations as destination. In case of the HTM-fiets, both work/school related trips and leisure trips are more often made not in combination

with the bus/tram than in combination, since in total more non-combined trips are made. However, four of the eight combined trips (50%) had a trip purpose related to work or school and three of the eight (37.5%) had a leisure trip purpose. This shows that the shared bicycle seems more often used in combination with the bus/tram for trips with a work/school related purpose than for trips with a leisure purpose.

**Socio-demographic factors and attitude/motivational factors**

A Chi-square independence test is used to test if the socio-demographic factors (age, gender, education level, bicycle ownership, level of cycling, bus use and tram use) and attitude/motivational factors (attitude towards cycling and public transport and reasons for using the HTM-fiets) are significantly different for the extent to which people use the HTM-fiets in combination with the bus/tram. Before performing these tests some categories within variables are grouped together to meet the requirements for performing these tests. First, it was expected that there would be a larger distribution within the extent to which people used the HTM-fiets in combination with the bus/tram and therefore a 7 point scale was used to answer that question in the survey. However, as shown in Figure 26, only a small amount of people answered with 'a bit more often not in combination' to 'always in combination'. Therefore, these 5 categories are grouped together in a new category called 'sometimes to always'. The remaining three categories are thus 'never', 'usually not' and 'sometimes to always'. Which categories within the socio-demographic and attitude/motivational factors are grouped together can be found in Appendix 20.

The Chi-square independence tests showed that the socio-demographic factors and attitude/motivational factors were not significantly different for the extent to which people use the HTM-fiets in combination with the bus/tram. However, there were some factors which showed an almost significant difference. To give an indication of the factors that still likely have some influence on the extent to which people use the HTM-fiets in combination with the bus/tram, the factors with a significance of 0.15 and smaller are presented in Table 18 (see Appendix 21 for results of the other factors). These factors are education level, level of bus use and a drop zone close by home as reason to use the HTM-fiets. This means for example that there is almost a significant difference in the extent to which lower educated people use the combination and the extent to which higher educated people use the combination. Looking at the crosstabs (see Appendix 21), it can be seen that people with a lower education level more often use the HTM-fiets in combination with the bus or tram than people with a higher education level. Furthermore, it seems that people who use the bus often also use the HTM-fiets more often in combination with the bus or tram. Finally, it seems that the people who did not agree that a drop zone close to their home was an important reason to start using the HTM-fiets, more often use the HTM-fiets in combination with the bus or tram.

*Table 18 – Factors that are almost significantly different for the extent to which people use the HTM-fiets in combination with bus/tram*

| Factor | Chi-square independence test |
|---|---|
| **Education level** | Chi-value = 5.884 with p=0.053 |
| **Level of bus use** | Chi-value = 5.239 with p=0.073 |
| **Drop zone close by home as reason to use the HTM-fiets** | Chi-value = 4.317 with p=0.116 |

The three factors presented in Table 18 are the factors included in the multinomial logistic regression analysis. This regression analysis shows which factors have a significant influence on the relative odds of sometimes to always using the combination versus never using the combination of HTM-fiets and bus/tram. It also shows to what extent these factors influence these relative odds. After performing the regression analysis, the model fitting information and goodness-of-fit are analysed first to determine how well the model fits the data (see Appendix 22 for the full results). The model fitting information shows that the likelihood ratio test has a Chi-Square value of 15.078 and a p-value of

0.020, which means that the final model significantly predicts the dependent variable better than the Intercept Only model. Furthermore, the goodness-of-fit shows that the Pearson Chi-Square statistic is not significant (Chi-Square = 12.629, p-value=0.125), which means that the model fits the data well.

The outcome of the multinomial logistic regression is presented in Table 19. The reference category for this model is the category 'never'. Table 19 shows that level of bus use and a drop zone close by home as reason to use the HTM-fiets, are significant predictors of the extent to which people use the HTM-fiets in combination with the bus/tram (Sig. < 0.05). Education level has a p-value of 0.054, which means education level is almost a significant predictor.

*Table 19 - Parameter Estimates Multinomial Logistic regression model*

| | | Beta | Std. Error | Wald | df | Sig. | Exp(B) |
|---|---|---|---|---|---|---|---|
| **Sometimes to always** | **Intercept** | -1.172 | 0.548 | 4.571 | 1 | 0.033 | |
| | **[Education=low]** | 1.058 | 0.549 | 3.709 | 1 | 0.054 | 2.881 |
| | **[Education=high]** | 0 | | | 0 | | |
| | **[levelbususe=low]** | -1.093 | 0.531 | 4.239 | 1 | 0.040 | 0.335 |
| | **[Levelbususe=high]** | 0 | | | 0 | | |
| | **[DZcloseby=disagree]** | 1.238 | 0.509 | 5.928 | 1 | 0.015 | 3.450 |
| | **[DZcloseby=agree]** | 0 | | | 0 | | |

The following equation can be subtracted from the results presented in Table 19:

$$\ln\left(\frac{P(extent\ combi\ use = sometimes\ to\ always)}{P(extent\ combi\ use = never)}\right) = -1.172 + 1.058 * (education = low) - 1.093 * (bus\ use = low) + 1.238\ (DZ\ close\ by = disagree)$$

This equation shows in what way the different factors influence the relative odds of sometimes to always using the combination of HTM-fiets and bus/tram versus never using this combination. The regression coefficients can be interpreted as follows:

The relative odds of sometimes to always using the combination versus never using the combination:

- will increase by 1.058 if moving from a high education level to a low education level. This means that people with a lower education level have a greater chance of sometimes to always using the combination of HTM-fiets and bus/tram.

- will decrease by 1.093 if moving from high bus usage to low bus usage. This means that people who have a high level of bus usage have a greater chance of sometimes to always using the combination of HTM-fiets and bus/tram.

- will increase by 1.238 if moving from agreeing that a drop zone close by home was an important reason for using the HTM-fiets to disagreeing that this was an important reason. This means that people who disagree that a drop zone close to home was an important reason for them to start using the HTM-fiets have a greater chance of sometimes to always using the combination of HTM-fiets and bus/tram.

The regression coefficients of all factors are about the same size, which means there is no large difference in the extent to which they influence the relative odds of sometimes to always using the combination versus never. However, the regression coefficient of the factor 'drop zone close by home as reason to use the HTM-fiets' is slightly larger which means this factors has the largest influence.

Based on this survey it is difficult to explain why these factors influence the extent to which people use the HTM-fiets in combination with the bus/tram. However, regarding education level it has been found in other studies that higher educated people more often use the regular bicycle in combination with public transport, and more specifically the train, since higher educated people often have a longer commute distance, as described in the literature study. It thus seems that this is not the case with shared bicycles and urban public transport. Furthermore, the reason why people with a higher bus usage more often use the combination of the HTM-fiets and the bus/tram, might be because the HTM-fiets could provide a new first and last mile transportation option for the bus rides that these people already often make. However, this relation should be researched to a further extent. Finally, the people who did not agree that a drop zone close to their home was an important reason for them to start using the HTM-fiets, might not have agreed to this because there is no drop zone located close to their home. Therefore, it could be that they can't use the HTM-fiets from their home, but they can use the HTM-fiets after a journey by bus or tram which they started close to their home. If there is a drop zone close to your home you might be sooner inclined to use the HTM-fiets for your entire journey. This relation should also be researched to a further extent. Overall it seems that education level, level of bus use and a drop zone close to your home being an important reason to use the HTM-fiets, are factors that significantly influence the extent to which people use the HTM-fiets in combination with the bus or tram.

The other factors taken into account in this research (age, gender, bicycle ownership, level of cycling, level of tram use, attitude regarding cycling and public transport and the other reasons for using the HTM-fiets) seem to not have a significant influence on the extent to which people use the HTM-fiets in combination with the bus/tram. From previous studies resulted that a lower age and being male were significantly associated with an increased usage of the shared bicycle and the combination of bicycle and public transport. Furthermore, it was found that an increased age and being male was associated with a shift towards public transport after the introduction of shared bicycles, which indicated that the shared bicycle and public transport are then used complementary to each other. However, this study thus showed that both age and gender did not have a significant influence on the extent to which the shared bicycle is used in combination with the bus/tram. Regarding the level of cycling and level of public transport usage of people, previous studies showed that a high level of bicycle usage and being a bus user had a positive influence on being a shared bicycle user. This study showed that while a high level of bus use is also significantly and positively associated with the extent to which the shared bicycle is used in combination with the bus/tram, a high level of cycling did not have a significant influence on this. Furthermore, while previous studies stated that including people's attitude had added value in travel mode choice models, it appeared from this study that the attitude regarding cycling and public transport did not have a significant influence of the extent to which people use the shared bicycle in combination with the bus/tram.

**Reasons why respondents use or do not use the HTM-fiets in combination with the bus/tram**

In addition, the respondents who more often used the HTM-fiets not in combination (142 respondents), were asked in an open question what their reasons were to not use the HTM-fiets in combination with the bus or tram. The respondents who more often used the HTM-fiets in combination (14 respondents), were asked in an open question what their reasons were to use the HTM-fiets in combination with the bus or tram. These answers can provide more insight in why people use or do not use this combination.

The answers to why people did not use the HTM-fiets in combination with the bus or tram could be divided in 10 different categories that are shown in Table 20. These categories are made by analysing all answers and grouping similar answers together. A list of all the individual answers can be found in Appendix 23. Table 20 shows that for most people it just was not necessary to use the HTM-fiets in combination with the bus or tram because the HTM-fiets was sufficient for the entire trip. It thus seems that they can travel from origin to destination in a convenient way by bicycle alone. Furthermore, a lot

of people specifically use the HTM-fiets instead of the bus/tram and therefore don't use it in combination. Some people explain that this is because the HTM-fiets is faster or cheaper or that they have less access/egress time with the HTM-fiets compared to with public transport. Also, 11 respondents mentioned that they use the HTM-fiets when the bus or tram is not available, for example because it is night time or because there is a disruption in the public transport service. In this case it is not possible to use the combination.

Furthermore, 12 respondents mentioned something related to the locations of the drop zones as reason for why they don't use the combination. For example, that there are not enough drop zones or not located in the right places to make using the combination attractive. One respondent specifically mentioned that it is not possible to cycle to bus/tram stops because the drop zones are often located at the bus/tram stops. It is indeed the case that most drop zones of the HTM-fiets are located at bus/tram stops. This means that if you want to use the HTM-fiets to travel from the bus/tram stop to your destination, you often cannot return the bicycle at your destination. In that case the bicycle can only be paused, which means that you keep paying rent. This might still be interesting if you have for example a short business meeting, but if you want to stay at your destination for a longer period you pay the daily rate, which is 5 euro. This could make it less attractive to do this on a daily basis. It also means that if you don't live close to a bus/tram stop there is in most cases also no drop zone located close to your home, which does not give you the opportunity to travel from your home to the bus/tram stop by HTM-fiets.

Three other reasons that were mentioned to a lesser extent were that the total distance of the trip was too small to use both transportation modes so one mode was more convenient, that the combination is too expensive, which is among others because there is no integrated transfer tariff, and that using them both would lead to a transfer that is inconvenient. Answer category eight includes people who answered that they had no specific reason and also includes all answers that were not related to why people did not use the combination between the HTM-fiets and the bus or tram. These answers were for example only specific reasons why they used the HTM-fiets or only something they did not like about the HTM-fiets itself.

*Table 20 - Reasons why people don't use the HTM-fiets in combination with bus/tram*

| Answer category | Number of respondents |
|---|---|
| **1. It wasn't necessary to use them both, the HTM-fiets was sufficient for the trip** | 30 |
| **2. Specifically used the HTM-fiets instead of bus/tram** | 20 |
| **3. Combination not convenient due to locations drop zones** | 12 |
| **4. Used the HTM-fiets if bus/tram were not available (e.g. at night)** | 11 |
| **5. Distance too small to use the combination** | 5 |
| **6. Combination not convenient because it would be expensive** | 4 |
| **7. Combination not convenient due to transfer** | 2 |
| **8. Other** | 34 |

During the expert meeting is also discussed what possible reasons could be why the HTM-fiets is not often used in combination with the bus/tram in a single ride (see Appendix 3 for a summary of the expert meeting). Originally it was among others intended that the HTM-fiets could be used as first or last mile transportation after a bus or tram ride with HTM. However, it appeared that the HTM-fiets is usually not used for this purpose. According to the experts an important reason for this might be the locations of the drop zones, as also mentioned by the survey respondents. Another reason mentioned by the experts is that the distances in the city might be too short for using both the HTM-fiets and the bus or tram within one ride from A to B. This is also mentioned as a reason by some of the survey respondents. The Hague is a relatively compact city which makes most rides within the city suitable for

using the bicycle alone. Finally, it is mentioned that the public transport network might already be extensive enough to make most places well accessible by public transport alone. It thus seems that public transport or the shared bicycle alone are sufficient for most journeys.

Of the 14 respondents who were asked why they did use the HTM-fiets in combination with the bus or tram, 3 respondents did not provide a reason, 3 respondents only mentioned a reason why they used the HTM-fiets (and not specifically the combination) and 8 respondents did provide one or multiple reasons. These reasons are shown in Table 21. The full answers are provided in Appendix 23. Since the number of respondents who answered these questions is very low, it is difficult to draw conclusions. However, it seems that there are people who have to transfer between tram lines, but take the HTM-fiets if the transfer time is too long. Also it seems that there are people who use the HTM-fiets to cycle to a different tram stop to take a better suitable tramline or avoid a detour. One respondent answered that he or she used the HTM-fiets to travel to the tram stop because the distance was too long for walking and bicycles are not always allowed on the tram. Furthermore, there are respondents who use the combination of the HTM-fiets and the bus or tram because it is convenient.

*Table 21 - Reasons why people use the HTM-fiets in combination with bus/tram*

| Answer category | Number of respondents |
|---|---|
| **1. Waiting time for next tram was too long** | 2 |
| **2. To cycle to a different stop** | 2 |
| **3. Convenience** | 2 |
| **4. Too far to walk to the tram stop and can't always take own bicycle onto the tram** | 1 |
| **5. Convenient that you can park in front of the door** | 1 |
| **6. Weather circumstances** | 1 |

**Overview of factors influencing the extent to which people use the combination**
The analysis of the trip factors and public transport factors showed that the trip length of combined trips is generally longer than of trips with the HTM-fiets that are not combined with the bus/tram. Also, combined trips more often have a trip purpose related to work/school than to leisure. Furthermore, combined trips are more often made from the edge of the city to the city centre and vice versa than within the city centre. Finally, it seemed that combined trips were more often made with the tram, which is a relatively high quality form of public transport, than with city buses. Based on this could cautiously be concluded that a longer trip length, a trip purpose related to work/school, a trip that is from the edge to the city centre or vice versa and a trip which include a ride with a relatively high quality form of public transport (tram instead of city bus), could increase the chance that a trip is made in combination with the bus/tram. However, due to the low number of described HTM-fiets rides in combination with the bus/tram, these results remain indicative. The analysis regarding the socio demographic factors and attitude/motivational factors showed that a lower education level, a high level of bus use and disagreeing that a drop zone close to home was an important reason to use the HTM-fiets, increases the relative odds that someone belongs to the group that sometimes to always uses the combination of HTM-fiets and bus/tram versus to the group that never uses this combination.

In addition, the respondents mentioned that they have used the combination mainly because the waiting time for the next tram was too long, to cycle to a different public transport stop to take a more suitable line, because it is too far to walk to the tram stop and because it is convenient. The main reasons why people do not use the combination are because it is not necessary, because they specifically use the HTM-fiets instead of the bus/tram, because they use the HTM-fiets at moments when the bus/tram is not available and because drop zones are not located in the right places to make the combination attractive. These are thus also factors that play a role in the extent to which people

use the shared bicycle in combination with the bus/tram. Besides, the experts confirmed that the locations of the drop zones could be an important reasons for why the combination is not often used as well as the fact that the distances in The Hague are relatively short.

Overall this section has provided an answer to the fourth sub-question 'Which factors determine to what extent the shared bicycle is used in combination with urban public transport?'.

## 6.4 Possible improvements in the integration of the HTM-fiets and bus/tram

Based on the survey results can be concluded that the HTM-fiets is currently more used as a substitute than as a complement to urban public transport in a ride from A to B. The results also indicate which factors have an influence on the extent to which people use the HTM-fiets in combination with urban public transport in a single ride. Making the combination more attractive could be focussed on the factors that appeared to have an influence on this. For example, since it seems like the combination is more often used for relatively large distances and from or towards the edge of the city, expanding the area in which the HTM-fiets is offered to other municipalities adjacent to The Hague, can facilitate the combination for longer trips and from or to more locations at the edge of the city. Furthermore, more possibilities could be created to travel from the stops of the higher quality public transport lines towards important destinations or from important origins in these areas to these stops, by adding more drop zones to facilitate first and last mile transportation by the HTM-fiets. Besides, a relatively frequent mentioned reason for not using the combination by the respondents was that the drop zones are not located in the right places to make the combination attractive. By expanding the area and adding more drop zones, the chance that more drop zones are located in the right places to facilitate the combined use of the HTM-fiets and bus/tram will likely also increase.

In addition to the survey, the expert meeting is used to gain more insight into whether there is value in a better integration between the HTM-fiets and urban public transport and how a better integration can be achieved (see Appendix 3 for a summary of the expert meeting). The experts mention that a measure to realise a better integration is providing more drop zones at locations that are not well accessible by public transport to increase the possibilities to use the HTM-fiets as first or last mile transportation both within The Hague and in municipalities adjacent to The Hague. This corresponds to the recommendations derived from the factors influencing the combined usage. However, the data-analysis showed that drop zones located in areas with weak public transport connections are one of the least used drop zone types. The reason why these drop zones are less used could be related to the lower population densities and lower number of facilities and thus visitors in these areas. However, adding more drop zones in these areas still improves the accessibility of the area and provides new travel opportunities that could increase the usage of the HTM-fiets in these areas. Secondly, it is mentioned that an integrated payment system could make using the combination more attractive. Currently the bus and tram have to be paid with the OV-chipkaart, while the HTM-fiets has to be paid with a smartphone application on which you have to deposit money. When people exit the bus/tram and see that there is a HTM-fiets available it should be easy to continue your journey with the HTM-fiets without having to download an application and deposit money. This is especially relevant for attracting new customers. Finally, it is mentioned that the combination can be promoted more by making the HTM-fiets visible in large trip planning application such as Google Maps. If people see that they can reach their destination faster by performing a part of the trip with the HTM-fiets they might consider using it sooner. This also increases the visibility of the HTM-fiets for potential new customers.

In conclusion, the following improvements could be made to realise a better integration:

- Adding more drop zones (especially at locations that are less accessible by public transport and around stops of high quality public transport lines)
- Expanding the area
- Realise an integrated payment system

- Include the HTM-fiets in (public transport) trip planning applications

However, the possibilities to change some of these aspects and improve the integration are limited by certain factors. First, the municipality has stated in the permit where drop zones can be located, which does not include a lot of locations that are not close to or at bus/tram stops. If the municipality would release this restriction there will be more possibilities to implement new drop zones at the right locations. Furthermore, an integrated payment system using the OV-chipkaart is difficult to realise for both technical and cost related reasons. This is because if you don't want the intervention of a person, a validator has to be placed on every bicycle to make it possible to use the OV-chipkaart for payments.

Although the above mentioned improvements can be made to realise a better integration between the HTM-fiets and urban public transport in a ride from A to B, it is not sure whether it is very valuable to focus on this, since the survey showed that the HTM-fiets is little used this way and because respondents indicate that it is often not necessary to use this combination. Therefore, it might be more valuable to ensure that the HTM-fiets and bus/tram together form one extensive and well-integrated public transport network than to assure a good integration of the HTM-fiets and the bus/tram in one ride from A to B, which is also mentioned in the expert meeting. To realise this the HTM-fiets could also be promoted as a form of public transport. If people want to travel by public transport they should view both the bus/tram and the HTM-fiets as an opportunity to travel by public transport. This way the HTM-fiets increases the possibilities for travelling with public transport, whether this is instead of the bus/tram because it better suits the needs of the traveller or in combination with the bus/tram. In combination could in this case also be at a more macro level, for example in cases where people use the bus or tram to travel to their work and take the HTM-fiets on the way back or to travel somewhere in their lunch break.

Most of the points of improvement mentioned above could also contribute to making one whole system of the HTM-fiets and bus/tram rather than two separate systems. For example, adding more drop zones, also in areas with weak public transport connections, can improve the accessibility of different areas and increases the travel possibilities of people. This way people might be more inclined to make use of the total system of HTM-fiets and bus/tram. Also realising an integrated payment system and including the HTM-fiets in (public transport) trip planning applications can contribute to realising one whole system of the HTM-fiets and bus/tram. Furthermore, the general smartphone application of HTM, which provides information regarding the bus and tram services, and the HTM-fiets application could be merged into one application. This way it will become more visible that the HTM-fiets also offers a form of public transport. In conclusion, instead of placing the focus on improving the combined journey of HTM-fiets and bus/tram in a single ride, the improvements should be focussed on creating one extensive and well-integrated public transport system that includes both the bus/tram and the HTM-fiets.

## 6.5 Overview

The survey results show that the HTM-fiets is not often used in combination with urban public transport in a ride from A to B. Only 9% of the respondents indicate that they use the HTM-fiets as often in combination with the bus/tram as not or more often in combination with the bus/tram than not in combination in a single ride. Of the other respondents who have indicated that they use the HTM-fiets more often not in combination with the bus/tram than in combination or never in combination in a single ride, 45% have used the HTM-fiets as substitute for the bus/tram. Based on this can be concluded that in this type of city, which is relatively small and with an extensive urban public transport network (12 tram lines and 8 bus lines), and with this BSP setup, which currently has a relatively low amount of drop zones (65) and bicycles (500) and of which a large share of the drop zones is located close to or at bus/tram stops, the shared bicycles are more used as substitute for urban public transport than as a complement in a single ride. Reasons mentioned by the respondents

and experts of why the shared bicycles are not often used in combination with urban public transport include that drop zones are not located in the right places, that distances in the city are too small to use the combination, that the shared bicycle alone is sufficient for most trips, that the public transport network is extensive enough to facilitate most trips and finally that people specifically use the HTM-fiets instead of public transport or when public transport is not available.

On the other hand, it seems that a longer trip length, a trip purpose related to work/school, a trip that is from the edge to the city centre or vice versa and a trip which include a ride with a relatively high quality form of public transport (meaning the tram instead of city buses), could increase the chance that a trip is made in combination with the bus/tram. However, due to the low number of described HTM-fiets rides in combination with the bus/tram, these results remain indicative. Furthermore, a lower education level, a high level of bus use and disagreeing that a drop zone close to home was an important reason to use the HTM-fiets, increases the relative odds that someone belongs to the group that sometimes to always uses the combination of HTM-fiets and bus/tram versus to the group that never uses this combination. Finally, people mention that they use the combination specifically to skip waiting time for the next bus/tram line, to cycle to a different and better suitable bus/tram line and because of convenience.

Although the HTM-fiets was originally also intended as first and last mile transportation, it thus seems that users of the HTM-fiets do not use the shared bicycle often for this purpose. Therefore, within the city of The Hague it might be more valuable to make sure the HTM-fiets and urban public transport together form one extensive public transport network than to assure a good integration of the HTM-fiets and the bus/tram in one ride from A to B. Some of the improvements that could realise a better integration in a single ride can also contribute to making one extensive and integrated public transport network of the HTM-fiets and bus/tram, rather than two separate networks. This includes adding more drop zones (especially in areas with weak public transport connections), realising an integrated payment system and making the HTM-fiets visible in large (public transport) trip planning applications. It has to be taken into account that some of these changes are dependent on the permit, costs and technical difficulties.

# 7. Conclusion, discussion and recommendations

Shared bicycles have been introduced in many cities worldwide in the past years. They provide new transport options, both as a separate mode and in combination with public transport. In case shared bicycles are used in combination with public transport the advantages of both modalities could be combined. Public transport can provide fast and accessible connections and the shared bicycle can provide flexible transport for the first and last mile. The combined usage of shared bicycles and public transport could provide an attractive and more sustainable alternative to private motorised vehicles. This research has examined the usage of a bicycle sharing program (BSP) within a mid-sized city located in a country with high cycling rates. It has specifically focussed on the combined usage of BSPs with urban public transport since limited research had been performed regarding this subject. The conclusion of this research is provided In section 7.1. Thereafter, the discussion is described in section 7.2. Finally, the recommendations for practice and the recommendations for further research based on this study are discussed in respectively section 7.3 and 7.4.

## 7.1 Conclusion

The objective of this research was to analyse the role of shared bicycles with respect to the urban public transport network in a mid-sized city with high cycling rates and to examine whether the shared bicycle is more a complement or substitute of the urban public transport network. Besides, it is examined if and how the integration between shared bicycles and urban public transport could be improved. To obtain the necessary insights a case study was used, which is the BSP called HTM-fiets located in The Hague (≈540.000 inhabitants), the Netherlands. Both a data-analysis of the operational trip data, a survey among the users of the HTM-fiets and an expert meeting were conducted to provide answers to the research questions. The results could be used to improve the shared bicycle concept and the integration with urban public transport to offer travellers attractive and sustainable transportation modes.

*General usage of the HTM-fiets*

From this study can first be concluded that the users of the HTM-fiets seem more often man than woman, most often have an age between 25 and 44 and are largely higher educated, which is comparable with users of other BSPs in both cities within the Netherlands and within other cities worldwide (Waes et al., 2018; Ma et al., 2020; Murphy & Usher, 2015). Furthermore, the users of the HTM-fiets more often own a bicycle in The Hague than not, whereas other studies found that people who do not own a bicycle are more likely to use BSPs (Bachand-Marleau et al., 2011). This difference is likely caused by the high level of bicycle ownership within the Netherlands. The non-users, who have made an account in the HTM-fiets application, but have not used the HTM-fiets (yet), overall have a higher age and lower education level compared to the users. This could indicate that while older and lower educated people show interest in the concept, it does not directly fit their transportation needs. It could also indicate that the system including the application might be too complicated, which keeps them from using the HTM-fiets.

Looking at the usage of the HTM-fiets, it can be concluded that the usage is relatively low compared to other BSPs worldwide. However, the usage depends on many factors such as the size of the BSP in terms of bicycles and drop zones, the tariff system of the BSP and also on characteristics of the city. Furthermore, based on the data-analysis can be concluded that the HTM-fiets is more often used during the summer months compared to the other months and is on average more often used on a weekend day compared to on a weekday. During the weekdays, no real rush-hour pattern is observed and during the weekend the usage is highest between 10AM and 2PM and also a peak can be observed between midnight and 1AM. The median duration of rides made with the HTM-fiets is 23 minutes, which means most rides are relatively short. Furthermore, 79% of the users have only used the HTM-fiets between 1 and 5 times, which means that the HTM-fiets is more used by occasional users than by frequent users. Based on these usage patterns it seemed as if the HTM-fiets is more used for occasional

leisure trips than for regular work or school related trips. This is confirmed by the results of the survey, which showed that indeed more people had used the HTM-fiets for leisure purposes during their last ride. This might be caused by the fact that people have a privately owned bicycle for regular trips or that other transportation means, such as public transport or the OV-fiets, are already sufficient to accommodate commuting trips.

Drop zones located close to facilities, in business areas and around public transport nodes, which are mainly located in the city centre, seem most used. By expanding the concept, for example to different municipalities, this could be important places to locate new drop zones. Drop zones located at the edges of the public transport network and at locations with a weak public transport connection are the least used drop zone types. This could be caused by the lower population densities in these areas and lower number of facilities, which results in a lower number of visitors. Furthermore, the data-analysis showed that the two large train station in The Hague (Den Haag Centraal and Station HS) are the most used drop zones. The survey showed that respectively 43% and 67% of the respondents who picked up or returned the HTM-fiets at Den Haag CS and Stations HS arrived or departed their by train. This indicates that the HTM-fiets is also used as first and last mile transportation of train rides.

The main points of improvement following from the survey and expert meeting that could increase the usage of the HTM-fiets include:

- Increasing the number of drop zones
- Expanding the area in which the HTM-fiets is offered
- Making the drop zones more visible and attractive
- Creating certainty that bicycles are available
- Offering a better bicycle

It has to be taken into account that the possibilities to add drop zones and expand the area partially depend on the permit issued by the municipality. Furthermore, although in this case a large share of the respondents specifically indicate that more drop zones would increase their usage, previous study have shown that adding more drop zones does not necessarily have a direct relationship with an increase of the total system usage in terms of trips per day per bicycle (De Chardon et al. 2017; Zhang et al. 2016). Therefore, this should be taken into account in deciding on the number of drop zones (and bicycles) to add to the concept. While most of these aspects are feasible to change, offering a better bicycle does not seem feasible in the short term due to the high investment it would take.

*Combined usage of shared bicycles and urban public transport*

Regarding the extent to which the HTM-fiets is used in combination with urban public transport can be concluded from the survey that the current setup of the HTM-fiets, within a mid-sized city with a relatively extensive urban public transport network, does not attract many people to use the combination of the shared bicycle and bus/tram in a single ride. Of all HTM-fiets users in the sample (156 respondents), 9% has indicated that they use the HTM-fiets as often in combination with the bus/tram as not or more often in combination in a single ride. Of the other respondents who have indicated that they use the HTM-fiets more often not in combination with the bus/tram than in combination or never in combination in a single ride, 45% have used the HTM-fiets as substitute for the bus/tram. In the current setup it thus seems that the HTM-fiets is more often used as substitute for the bus or tram than as a complement in a single ride. The main reasons why the combination of the HTM-fiets and urban public transport is not often used, which are mentioned by the survey respondents and participants of the expert meeting, include that it is not necessary for most rides, among others because distances in the city are not large enough, and that people specifically use the HTM-fiets instead of public transport because it is for example faster or cheaper. It also includes that people use the HTM-fiets at times (such as in the night) when public transport is less available and that drop zones are not located in the right places to facilitate the combination. On the other hand, the

majority (67%) of the non-users indicate that they expect to use the HTM-fiets in combination with the bus/tram, which does not correspond with the actual usage of the HTM-fiets by the users.

Due to the low number of described HTM-fiets rides in combination with the bus/tram, the results regarding the influence of the trip factors and public transport factors on the extent to which the HTM-fiets is used in combination with the bus/tram are indicative. However, it does seem as if a longer trip length, a trip purpose related to work/school, a trip that is from the edge to the city centre or vice versa and a trip which includes a ride with a relatively high quality form of public transport (tram instead of city buses), could increase the chance that a trip is made in combination with the bus/tram. Looking at the socio-demographic factors and attitude/motivational factors, the multinomial logistic regression analysis showed that a lower education level, a high level of bus use and disagreeing that a drop zone close to home was an important reason to use the HTM-fiets, increases the relative odds that someone belongs to the group that sometimes to always uses the combination of HTM-fiets and bus/tram versus to the group that never uses this combination. The other socio-demographic factors included in this study (age, gender, bicycle ownership, level of cycling and level of tram use), the attitude towards the bicycle and public transport in general and the other reasons for using the HTM-fiets did not have a significant influence on the relative odds of sometimes to always using the combination versus never.

This thesis aims to answer the main research question:

*"To what extent do urban public transport and bicycle sharing programs complement each other and how can the integration of these systems be improved from a user and operator perspective?"*

It can be concluded that in this specific case study the shared bicycle does not complement urban public transport to a large extent in a single ride from A to B. In the case chosen the shared bicycle seems more used as a substitute for urban public transport. Based on the data-analysis, survey results and expert meeting it is concluded that it is probably more valuable to focus on integrating the shared bicycle with urban public transport as a whole than to assure a good integration of the shared bicycle and the bus/tram in a single ride from A to B.

To realise the integrated public transport shared bicycle system, the shared bicycle could be marketed as a form of public transport, next to the bus and tram network. Depending on the needs of the traveller and the circumstances, such as the availability of these transport modes throughout the day, the traveller can then decide which mode or combination of modes suits best. The improvements that are identified in this study to realise a better integration between the shared bicycle and bus/tram in a single ride, could largely also contribute to creating one extensive public transport network of the shared bicycle, bus and tram. This includes:

- Adding more drop zones and specifically in areas that are less accessible by bus/tram
- Realising an integrated payment system
- Making the HTM-fiets visible in large (public transport) trip planning applications

Although the data-analysis showed that drop zones that are currently located in areas with weak public transport connections are among the least used drop zones, adding more drop zones in these areas still improves the accessibility of these areas and increases the number of transport option. Therefore, adding more drop zones in these areas might be important to be able to link the people who live in these areas to the network. From the operator perspective this might initially result in higher costs. However, in case it results in a higher usage of the shared bicycle, bus and tram combined, it will also become beneficial for the operator. As mentioned before, it has to be taken into account that in case of the HTM-fiets the number of drop zones and locations where drop zones can be offered are partially dependent on the permit issued by the municipality. Realising an integrated payment system and making the shared bicycle visible in large public transport trip planning application can contribute to

positioning the shared bicycle as a form of public transport. However, this could be difficult to realise for technical and cost related reasons.

Overall, focussing on creating one extensive and well-integrated public transport network consisting of the shared bicycle, bus and tram, will be valuable for travellers since it increases their accessibility and number of transportation options. These modalities might then also become a more attractive alternative for private motorised vehicles. In case this results in a decrease of the usage of private motorised vehicles it will also be beneficial for the environment and accessibility of the city.

## 7.2 Discussion

A commonly mentioned limitation of using a case study is that scientific generalisation could be difficult (Zainal, 2007; Yin, 1984). Also in this study it is difficult to determine whether it is possible to generalise the results to other cities and BSPs. Looking at previous research performed regarding the usage of BSPs, it seems that this usage depends on multiple factors which include the setup of the BSP in terms of bicycles and stations, the size and density of the city, the size and density of the public transport network and the type of inhabitants. Taking this into account, it is likely that within cities of about the same size, where distances in general are relatively short, and where most areas of the city are also well accessible by public transport, shared bicycles will not often be used as a complement to the urban public transport network consisting of bus and tram in a single trip. However, in cities where distances are in general larger and where certain areas are less accessible by public transport, the results are likely to be different, as for example have been found for Minneapolis-Saint Paul (Shaheen et al., 2013). It is important to mention that also the setup of this BSP where most drop zones are located close to bus/tram stops might have had an impact on the results. If more drop zones were located in areas where public transport is less accessible, the results might have been different. In cities with comparable characteristics and BSPs, it is probably also more valuable to focus on creating one extensive and well-integrated public transport system in the city including shared bicycles, than to improve the integration of shared bicycles and urban public transport in a single ride to stimulate the combined usage.

Furthermore, not all factors that might have influenced the extent to which the shared bicycle is used in combination with the bus/tram could be included in the research. This is partially because the survey could not become too long and it was not desired that too many questions were asked regarding personal details of respondents. Also, it appeared that most socio-demographic factors and attitude/motivational factors that were included in this study did not have a significant influence. It might had been more relevant if also other factors were included in the study, such as whether people live in the city centre, at the edge of the city or do not live in The Hague and whether someone is visiting the city as a tourist. However, also other type of factors such as the size, density and network design of the public transport network might have had an influence on the extent to which the shared bicycle is used in combination with public transport. Since this study focussed on the user perspective by conducting a survey, these type of factors related to the characteristics of the public transport network were not examined. Furthermore, while this study could identify that the factors education level, level of bus use and the extent to which a drop zone close by home was an important reason for using the shared bicycle had a significant influence on the extent to which people use the shared bicycle in combination with the bus/tram, it could not be determined with certainty based on this study why these factors have a significant influence on this. To gain more insight in this, interviews or a focus group with respondents could have been held.

Since only 14 respondents described their last ride with the shared bicycle in combination with the bus/tram in a single ride of which 8 respondents described this correctly, it is difficult to draw conclusions regarding the trip characteristics and public transport characteristics, which is an important limitation of this study. A higher response rate of the survey could have led to a higher

amount of people who made 'sometimes to always' use of the combination of the shared bicycle and bus/tram, which would have resulted in a larger amount of trips described in combination. Also, it would have been ideal if the public transport smartcard data (OV-chipkaart) of a person could have been linked to their usage of the shared bicycle. In that case it could be determined more accurately how often and for which type of ride rides people use the shared bicycle in combination with the bus/tram. However, due to restrictions regarding the data this was not possible within this research.

Another limitation of this study is that it could not be determined with certainty if the sample was representative for the population (everyone who have made an account in the HTM-fiets application), since no user characteristics of the population were known. Therefore, certain groups of people may have been overrepresented, which could have influenced the results. Finally, it cannot be stated with certainty that all respondents understood the questions in the survey correctly. Based on the description of the last ride of people who were supposed to describe their last ride with the HTM-fiets in combination with the bus/tram in a ride from A to B, it appeared that some people described a trip in which they used public transport to go somewhere and returned with the shared bicycle. An incorrect interpretation of a question could also have happened with closed questions in the survey. In that case it could not be checked if everyone understood the question correctly.

## 7.3 Recommendations for practice

Based on this study, several recommendations can be made for practice. First, this study showed which groups of people mainly make use of the HTM-fiets and which do not. This can be considered when promoting the HTM-fiets and trying to attract new customers. Promotion can be both targeted at the group which is known to make use of the shared bicycles (relatively young, high educated men), but can also be targeted at groups that currently might be less aware of the possibilities to travel by HTM-fiets. Furthermore, this study showed that drop zones located close to facilities, in business areas and near nodes/junctions of public transport, generate the largest demand. When increasing the amount of drop zones or expanding the program to different areas or municipalities, this will be important locations to place new drop zones. The usage around the edge of the public transport network and thus mainly at the edge of the city, still has to be stimulated. The HTM-fiets could be made a more attractive transportation mode in these areas by locating more drop zones in these areas, which increases the chance that a drop zone is located close by people's home and it also increases the number of destinations to travel to. This corresponds with the most important point of improvement resulting from this study, which is related to the amount and location of drop zones. Besides adding more drop zones at the edge of the public transport network, also adding more drop zones in general to increase the density of drop zones around the city could increase the usage of the HTM-fiets, since a large share of the respondents indicate that more drop zones is an important aspect that would increase their usage.

Furthermore, it is recommended to focus on creating one extensive and well-integrated urban public transport network in the city of The Hague, which consists of the bus, tram and shared bicycle. Due to the low number of people who use the HTM-fiets and bus/tram in combination in a single ride and the reasons mentioned to not use the HTM-fiets this way, it is less valuable to focus on stimulating this. To be able to realise this extensive public transport network it is recommended to add more drop zones to increase the density of the total network and increase the accessibility in different areas, to merge the applications of the HTM-fiets and the general HTM application and to make the HTM-fiets visible in other (public transport) trip planning applications. While realising an integrated payment system could also contribute to integrate the HTM-fiets network and bus/tram network, this is difficult for both technical and cost related reasons.

These findings could also be taken into account when introducing a new BSP in general to a city with similar characteristics. In the planning stage, when it is determined where to locate drop zones and

how the system works in terms of payment and application, the focus can already be placed on creating one extensive public transport system and on the marketing of the shared bicycle as a form of public transport. Drop zones could be placed in locations with high demand, but also in places around the city that are less accessible by (higher quality forms of) public transport to increase the size and density of the entire network and with that improve the accessibility within the city. By offering the same payment method for public transport and the shared bicycle and having one central application which includes (trip planning) information regarding all forms of public transport and at the same time can be used to rent a shared bicycle, the shared bicycle becomes more visible as a form of public transport and it will become easier to switch between using these different types of public transport (including the shared bicycle).

## 7.4 Recommendations for further research

This research had a focus on finding out from a user perspective to what extent they use the shared bicycle in combination with urban public transport, identified factors that had an influence on this and identified improvements that could be made in the bicycle sharing program and in the integration with the urban public transport network. However, there are several aspects regarding this subject that could not be concluded based on this research. Therefore, multiple recommendations for further research are provided.

This study has found whether the shared bicycle functions more as a complement or substitute to urban public transport for a specific city type and BSP. Also, several other studies researched the relation between shared bicycles and public transport in different cities, which led to different results regarding whether shared bicycles seem to function more as a complement or as a substitute of public transport. It seems that this depends among others on the characteristics of the city, the public transport network and the BSP, which makes it difficult to determine in which cases the shared bicycle functions more as a complement or as a substitute. It is recommended to perform more research between different city types and BSPs to examine which of these characteristics determine specifically how the shared bicycle is used in relation to the public transport network. In case a new BSP is planned for a city, this information can then be used to determine how to position the BSP.

This study also showed that changes regarding the drop zones, including realising more drop zones, expanding the area, locate them at places with weak public transport and making the drop zones more visible and attractive, could have a positive influence on the usage of the HTM-fiets and the combined usage with urban public transport. Recently, but after the period over which the data-analysis is performed and the survey is conducted, the HTM-fiets concept is expanded to a municipality adjacent to The Hague called Zoetermeer. In Zoetermeer the concept differs from The Hague on different aspects, including that there are more destination oriented drop zones that are located in places with weak or no public transport connections and signs are placed at drop zones to make them more visible. Also, in The Hague itself hundred drop zones are added to the BSP. It is recommended to research after a certain period of time, whether the concept in Zoetermeer is used differently, especially whether the combined usage of shared bicycles and urban public transport shows different patterns, and if the usage in The Hague itself has changed. This way it can be determined what the impact is of these type of measures on the total usage and combined usage of shared bicycles and public transport. This information could then be used in decisions regarding further development of the BSP and also for the introduction of new BSPs in other locations.

Furthermore, this study showed that while users of the HTM-fiets did not often use the shared bicycle in combination with the bus/tram, the majority of people who had not used the HTM-fiets (yet), but did make an account in the application, expected to use the HTM-fiets in combination with the bus/tram in case they were going to use the HTM-fiets. It is not clear what causes this difference between the expected usage and actual usage. Therefore, it is recommended to examine the reasons

why the expected usage and actual usage differ from each other by performing a focus group or interview with both users and non-users. The reasons that causes people to not use the combination, while they initially expected to use this, can be used to identify improvements to realise more possibilities for combined usage.

Finally, as mentioned before, this study focussed on people who had downloaded the HTM-fiets application. The points of improvement following from this study are thus based on the opinion of people who already know the concept of the BSP. However, this might not correspond to the improvements that are necessary to attract new customers, which have not downloaded the application yet. Therefore, it is recommended to perform a study regarding the points of improvements from the perspective of people who have no experience with the BSP concept. As a result improvements in BSPs can increase both the usage of existing users and also attract new users.

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# Appendix

## Appendix 1: Emails Survey

Figure 28 shows the first email send to all people who have made an account in the HTM-fiets application containing links to the survey (sent on 20-2-20). Figure 29 shows the reminder email (sent on 4-3-20)

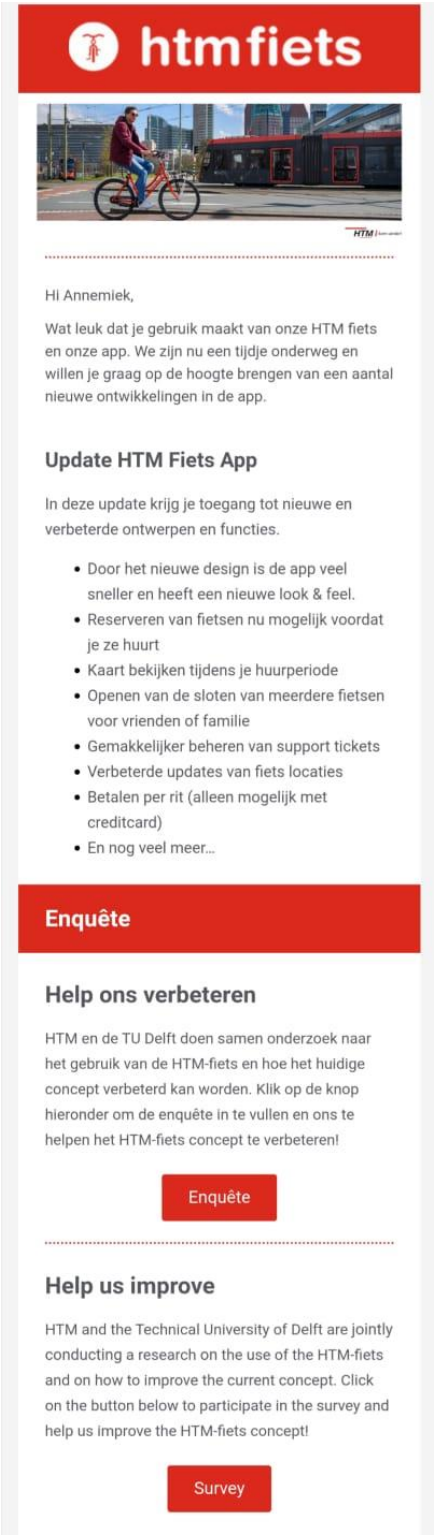



*Figure 28 - First email containing survey*

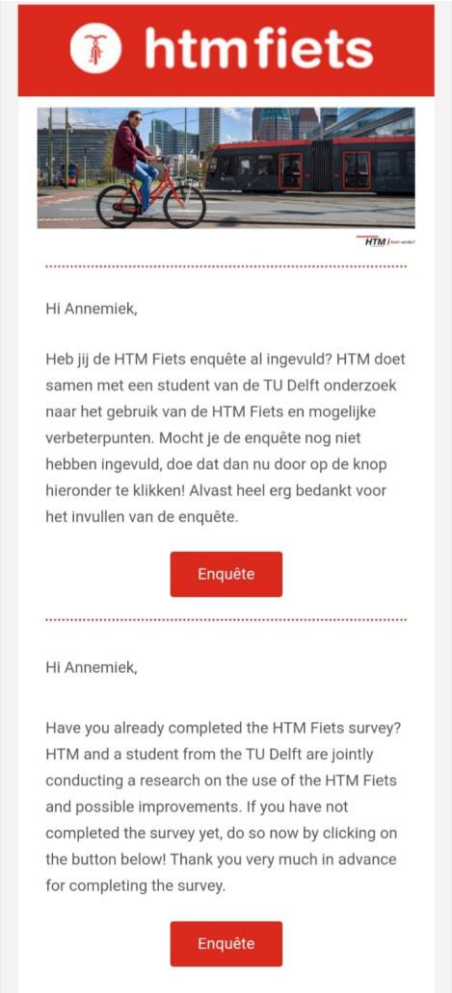



*Figure 29 - Reminder email containing survey*

## Appendix 2: Final survey design

**Survey HTM-fiets**

---

Dear participant,

This survey is part of my graduation research to complete the Master program Transport, Infrastructure and Logistics at the Technical University of Delft in cooperation with HTM. The aim of this research is to gain insight in the use of the HTM-fiets (the shared bicycle of the company HTM).

This survey consists of three parts. In the first part some questions with respect to personal details will be asked. The second part is about your usage of the HTM-fiets. Finally, the third part is about your motivation for using the HTM-fiets and your usage of the bicycle and public transport in general.

Your participation in this survey is completely voluntary and you can stop it at any time. No traceable personal data will be collected and your answers will be stored anonymously.

The survey takes approximately 10 to 15 minutes.

If a question is marked with a little red star (*), this means that this question must be answered in order to continue with the survey.

Thank you for your participation!

Annemiek van Marsbergen
If you have any questions regarding the survey, please contact:

Als u de Nederlandse versie wilt kunt rechtsboven aan deze pagina klikken op de knop waar “English” staat en selecteert u “Nederlands”.

---

**Part 1**
In this part of the survey some questions with respect to personal details will be asked.

1) What is your age?*
_____

2) What is your gender?*
( ) Man
( ) Woman
( ) Other
( ) I'd rather not say

3) What is your highest completed level of education?*
( ) Primary education
( ) Pre-vocational education
( ) Secondary education and pre-university education
( ) Higher education (Bachelor's, Master's degree)
( ) Other, namely:: _____
( ) I'd rather not say

4) Do you own a bicycle in The Hague?*
( ) Yes
( ) No

5) Do you work for the company HTM?*
( ) Yes
( ) No

---

**Part 1**

Logic: Show/hide trigger exists.
6) On average, how often have you used the HTM-fiets yourself since the introduction in May 2019?*
( ) 4-7 days a week
( ) 1-3 days a week
( ) 1-3 days a month
( ) Less than 1 day a month
( ) Not once
( ) Other, namely:: _____

*Page exit logic: New Skip/Disqualify IF: #6 Question "On average, how often have you used the HTM-fiets yourself since the introduction in May 2019?" is one of the following answers ("4-7 days a week","1-3 days a week","1-3 days a month","Less than 1 day a month","Other, namely:") THEN: Jump to page 5 - Part 1*

---

**Part 2**

7) Why did you download the app of the HTM-fiets?*
_____

8) Are you still planning to use the HTM-fiets in the future?*
( ) Definitely yes ( ) Probably yes ( ) Maybe ( ) Probably not ( ) Definitely not

*Logic: Hidden unless: #8 Question "Are you still planning to use the HTM-fiets in the future?" is one of the following answers ("Definitely yes","Probably yes","Maybe")*
9) If you are going to use the HTM-fiets, do you expect to use it in combination with the bus or tram in a single journey from A to B?
*Line 3 and 4 of the RandstadRail are also included in the tram category.**
( ) I expect to use the HTM-fiets in combination with the bus or tram
( ) I don't expect to use the HTM-fiets in combination with the bus or tram

10) Indicate to what extent you agree with the statements below.
*(Drop zones are the locations where you can pick-up and return the HTM-fiets)*

I would start using the HTM-fiets if.. *

| | Strongly disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| the price is lower | ( ) | ( ) | ( ) | ( ) | ( ) |
| there are more drop zones | ( ) | ( ) | ( ) | ( ) | ( ) |
| there is a drop zone closer to my home | ( ) | ( ) | ( ) | ( ) | ( ) |
| there are drop zones closer to my destinations | ( ) | ( ) | ( ) | ( ) | ( ) |
| the bicycle is more comfortable | ( ) | ( ) | ( ) | ( ) | ( ) |
| the app works better | ( ) | ( ) | ( ) | ( ) | ( ) |
| there is certainty that a bicycle is available | ( ) | ( ) | ( ) | ( ) | ( ) |
| there are less broken bicycles | ( ) | ( ) | ( ) | ( ) | ( ) |

Logic: Hidden unless: Question "the app works better" is one of the following answers ("Agree","Strongly Agree")

11) What could be improved about the HTM-fiets app?

_____

12) Are there any other changes that would make you start using the HTM-fiets?

_____

13) Have you ever used shared bicycles or shared scooters from other providers in the Netherlands?*

| | Never | Sometimes | Regularly |
|---|---|---|---|
| Free-floating shared bicycles (like Mobike) | ( ) | ( ) | ( ) |
| Shared bicycles with drop zones (like GoAbout) | ( ) | ( ) | ( ) |
| The OV-fiets | ( ) | ( ) | ( ) |
| Shared scooters (like Felyx) | ( ) | ( ) | ( ) |

Page exit logic: New Skip/DisqualifyIF: #6 Question "On average, how often have you used the HTM-fiets yourself since the introduction in May 2019?" is one of the following answers ("Not once")
THEN: Jump to page 14 - Part 3

---

**Part 1**

*Logic: Show/hide trigger exists. Hidden unless: #6 Question "On average, how often have you used the HTM-fiets yourself since the introduction in May 2019?" is one of the following answers ("4-7 days a week","1-3 days a week","1-3 days a month","Less than 1 day a month","Other, namely:")*

14) How often do you use the HTM-fiets in combination with the bus or tram in The Hague in a single journey from A to B?
*Line 3 and 4 of the RandstadRail are also included in the tram category.*
*

( ) Never ( ) Usually not ( ) A bit more often not in combination ( ) As often in combination as not ( ) A bit more often in combination ( ) Usually ( ) Always

---

**Part 2 (describe HTM-fiets trip)**

*Logic: Hidden unless: #14 Question "How often do you use the HTM-fiets in combination with the bus or tram in The Hague in a single journey from A to B?*
*Line 3 and 4 of the RandstadRail are also included in the tram category.*
*" is one of the following answers ("Never","Usually not","A bit more often not in combination")*

Read the following instructions carefully:
In this part of the survey you will be asked if you can describe a specific trip with the HTM-fiets. To answer the following questions, consider the last trip where you used the HTM-fiets not in combination with the bus/tram* in The Hague. This means you will describe a single trip from A to B. All questions in this part will be about this trip.

**Line 3 and 4 of the RandstadRail are also included in the tram category*.

*Logic: Hidden unless: #14 Question "How often do you use the HTM-fiets in combination with the bus or tram in The Hague in a single journey from A to B?*
*Line 3 and 4 of the RandstadRail are also included in the tram category.*
*" is one of the following answers ("As often in combination as not","A bit more often in combination","Usually","Always")*

Read the following instructions carefully:
In this part of the survey you will be asked if you can describe a specific trip with the HTM-fiets. To answer the following questions, consider the last trip where you used the HTM-fiets in combination with the bus/tram* in The Hague. This means you will describe a single trip from A to B. All questions in this part will be about this trip.

**Line 3 and 4 of the RandstadRail are also included in the tram category.*

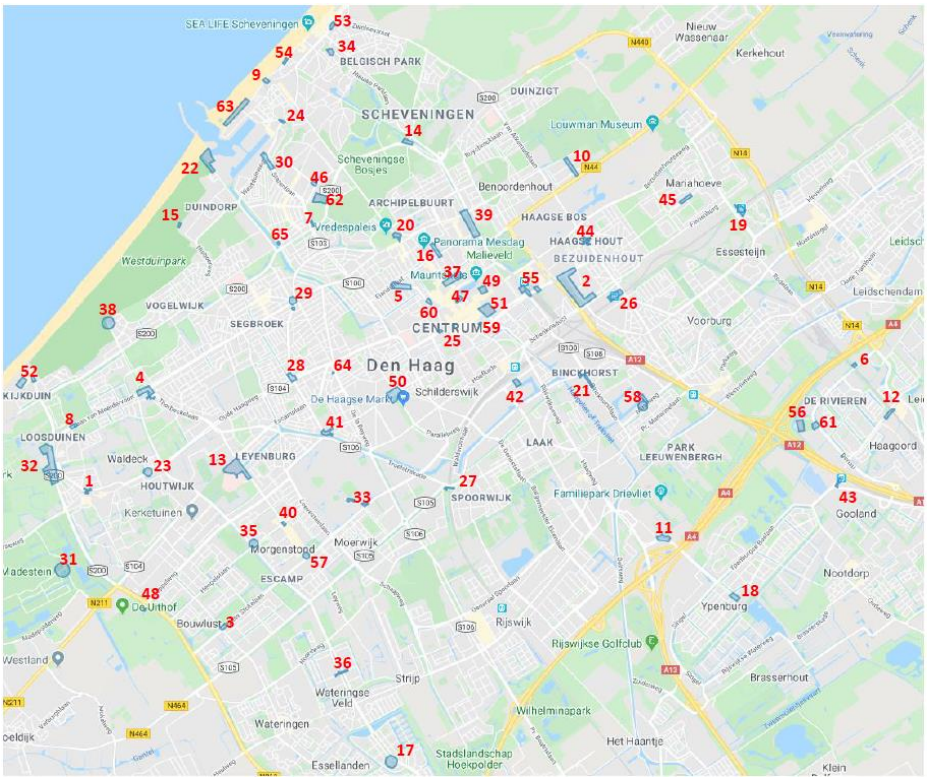
15) On what date did this last trip with the HTM-fiets take place?
*You can find this date in the HTM-fiets app under 'my trip history'. If you don't know the date and don't have access to the app you can select the second option and give an indication of the day/month this trip took place. **
( ) Date (dd/mm/yyyy):: _____*
( ) Indication day/month (e.g. monday/December):
_____*

16) Between which times did this last ride that you made with the HTM-fiets take place?*
( ) 06:00 - 09:00
( ) 09:00 - 16:00
( ) 16:00 - 19:00
( ) 19:00 - 00:00
( ) 00:00 - 06:00
( ) I don't know

---

**Part 2 (describe HTM-fiets trip)**

Drop zones are the locations where you can pick-up and return the HTM-fiets. On the map below all drop zones of the HTM-fiets are indicated with a number. Below the map you will find a list with the corresponding names of these drop zones. For the next question, please enter the numbers of the drop zones where you have picked up and returned the HTM-fiets.




1. Arnold Spoelplein
2. Beatrixkwartier
3. Beresteinlaan
4. De Savornin Lohmanplein
5. Elandstraat
6. Forepark
7. Gemeentemuseum/Museon
8. Heliotrooplaan
9. Strandweg 2
10. Laan van Clingendael
11. Laan van 's-Gravenmade
12. Leidschenveen
13. Leyenburg
14. Madurodam
15. Markenseplein
16. Mauritskade
17. Parijsplein
18. Plesmanlaan
19. Station Mariahoeve
20. Vredespaleis
21. Wegastraat
22. Zuiderstrandtheater
23. Buitentuinen
24. Duinstraat
25. Grote Markt
26. Laan van NOI
27. Station Moerwijk
28. Valkenboslaan
29. Valkenbosplein
30. Van Boetzelaerlaan
31. Vroondaal
32. Westduin
33. Zuiderpark
34. Circustheater
35. Zweeloostraat
36. Hoge Veld
37. Kneuterdijk
38. Laan van Poot
39. Javabrug/Dr. Kuyperstraat
40. Leyweg
41. Soestdijkseplein
42. Station HS
43. Station Ypenburg
44. Theresiastraat
45. Vlamenburg
46. World Forum
47. Buitenhof
48. De Uithof
49. Plein
50. Hobbemaplein
51. Kalvermarkt-Stadhuis
52. Kijkduin
53. Kurhaus
54. Strandweg 3
55. Den Haag Centraal
56. ADO stadion
57. Leyweg
58. Saturnusstraat/Maanweg
59. Bezemstraat/Jacobstraat
60. Torenstraat
61. Donau
62. OPCW
63. Strandweg 1
64. Lunterenstraat
65. Houtrust

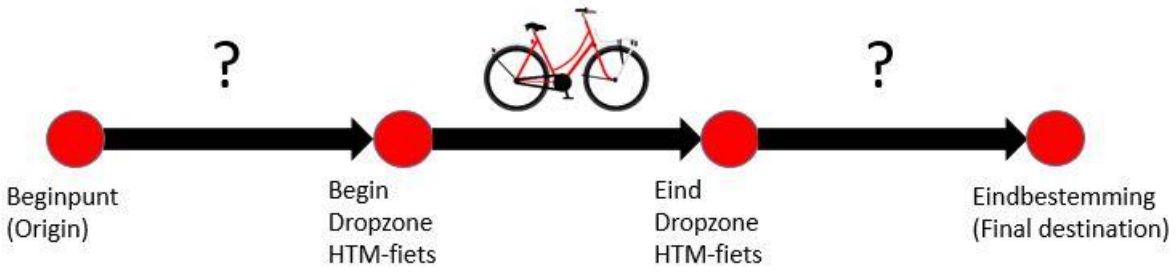
17) From which to which drop zone did you cycle during this last trip with the HTM-fiets?
*On the map above, all drop zones of the HTM-fiets are indicated with a number. Please enter the number of your start drop zone and end drop zone in the boxes below. If you don't know it anymore, please enter a zero ('0').*
*

Start drop zone: _____
End drop zone: _____

*Page exit logic: New Skip/DisqualifyIF: #14 Question "How often do you use the HTM-fiets in combination with the bus or tram in The Hague in a single journey from A to B?*
*Line 3 and 4 of the RandstadRail are also included in the tram category.*
*" is one of the following answers ("As often in combination as not","A bit more often in combination","Usually","Always") THEN: Jump to* *page 9 - Part 2 (describe HTM-fiets trip)*

---

**Part 2 (describe HTM-fiets trip)**




18) How did you get to the drop zone from where you picked-up the HTM-fiets at the beginning of your trip?*
( ) On foot
( ) By metro line E
( ) By train
( ) By car
( ) Other, namely:: _____

*Logic: Hidden unless: #18 Question "How did you get to the drop zone from where you picked-up the HTM-fiets at the beginning of your trip?" is one of the following answers ("On foot","By car","Other, namely:")*
19) What were approximately the time and the distance travelled to get to this drop zone from the starting point of your trip?
*If you can't make an estimation, please enter a zero ('0').**
The time (in minutes) was approximately::
_____
The distance (in metres) was approximately::
_____

*Logic: Hidden unless: #18 Question "How did you get to the drop zone from where you picked-up the HTM-fiets at the beginning of your trip?" is one of the following answers ("By train")*
20) At which train station did you board the train at the start of your train journey?*
_____

*Logic: Hidden unless: #18 Question "How did you get to the drop zone from where you picked-up the HTM-fiets at the beginning of your trip?" is one of the following answers ("By metro line E")*
21) At which metro station did you board the metro at the start of your metro ride?*
_____

22) How did you travel to your final destination from the drop zone where you returned the HTM-fiets?*
( ) On foot
( ) By metro line E
( ) By train
( ) By car
( ) Other, namely:: _____

*Logic: Hidden unless: #22 Question "How did you travel to your final destination from the drop zone where you returned the HTM-fiets?" is one of the following answers ("On foot","By car","Other, namely:")*
23) What were approximately the time and the distance travelled to get from this drop zone to your final destination?
*If you can't make an estimation, please enter a zero ('0').**
The time (in minutes) was approximately::
_____
The distance (in metres) was approximately::
_____

*Logic: Hidden unless: #22 Question "How did you travel to your final destination from the drop zone where you returned the HTM-fiets?" is one of the following answers ("By train")*
24) At which train station did you disembark at the end of your train journey?*
_____

*Logic: Hidden unless: #22 Question "How did you travel to your final destination from the drop zone where you returned the HTM-fiets?" is one of the following answers ("By metro line E")*
25) At which metro station did you disembark at the end of your metro ride?*
_____

26) How would you describe this last trip with the HTM-fiets?
*Examples of activities are working, going to school, visiting a restaurant, etc.*
*
( ) From home towards an activity
( ) From an activity towards home
( ) From an activity towards another activity
( ) Other, namely:: _____

27) What was the main reason for you to make this trip?
*If you are assessing a trip home, choose the purpose of your trip on the other way.*
*
( ) From/towards my job
( ) From/towards school, study, internship
( ) Business trip, visiting a congress etc.
( ) Shopping
( ) Visiting family, friends
( ) Visiting a restaurant or bar
( ) Trip to the beach, museum, cinema, etc.
( ) Sport club or other leisure activity
( ) Recreational cycling/sightseeing
( ) Other, namely:: _____

28) If the HTM-fiets and other shared bicycles had not been available, how would you have made the part of this trip that you now covered with the HTM-fiets? *
( ) On foot
( ) With my own bicycle
( ) By the OV-fiets
( ) With my own scooter/moped
( ) By shared scooter/moped
( ) By bus
( ) By tram
( ) By metro
( ) By train
( ) By car
( ) I would not have made this entire trip
( ) I would have made this entire trip with other means of transportation
( ) Other, namely:: _____

*Logic: Hidden unless: #28 Question "If the HTM-fiets and other shared bicycles had not been available, how would you have made the part of this trip that you now covered with the HTM-fiets? " is one of the following answers ("I would have made this entire trip with other means of transportation")*
29) Which different means of transportation would you have used for this trip?
*U can select multiple means of transportation.*
*
[ ] Walking
[ ] My own bicycle
[ ] OV-fiets
[ ] My own scooter/moped
[ ] Shared scooter/moped
[ ] Bus
[ ] Tram
[ ] Metro
[ ] Train
[ ] Car
[ ] Other, namely:: _____

30) What are reasons for you not to use the HTM-fiets in combination with the bus or tram?
_____

*Page exit logic: New Skip/DisqualifyIF: #14 Question "How often do you use the HTM-fiets in combination with the bus or tram in The Hague in a single journey from A to B?*
*Line 3 and 4 of the RandstadRail are also included in the tram category.*
*" is one of the following answers ("Never","Usually not","A bit more often not in combination")*
*THEN: Jump to page 13 - Part 3*

---

**Part 2 (describe HTM-fiets trip)**

31) Which statement corresponds to this last trip with the HTM-fiets?*
( ) I first travelled by bus/tram, and then used the HTM-fiets
( ) I first used the HTM-fiets, and then travelled by bus/tram

32) What type of public transport did you use in The Hague in combination with this last ride on the HTM-fiets?
*Select all means of transportation that you used.*
*
[ ] Bus
[ ] Tram

*Logic: Show/hide trigger exists. Hidden unless: #32 Question "What type of public transport did you use in The Hague in combination with this last ride on the HTM-fiets?*
*Select all means of transportation that you used.*
*" is one of the following answers ("Bus")*
33) Which bus line(s) did you travel with?
*If you made a transfer between several bus lines, you can select all these bus lines below.**
[ ] Line 20
[ ] Line 21
[ ] Line 22
[ ] Line 23
[ ] Line 24
[ ] Line 25
[ ] Line 26
[ ] Line 27
[ ] Line 28
[ ] Line 29
[ ] Line N1
[ ] Line N2
[ ] Line N3
[ ] Line N4
[ ] Line N5
[ ] Line N6
[ ] A bus line from EBS, Arriva or Connexxion

*Logic: Show/hide trigger exists. Hidden unless: #32 Question "What type of public transport did you use in The Hague in combination with this last ride on the HTM-fiets?*
*Select all means of transportation that you used.*
*" is one of the following answers ("Tram")*
34) Which tram line(s) did you travel with?
*If you have made a transfer between several tram lines, you can select all these tram lines below.*
*
[ ] Line 1
[ ] Line 2
[ ] Line 3
[ ] Line 4
[ ] Line 6
[ ] Line 9
[ ] Line 11
[ ] Line 12
[ ] Line 15
[ ] Line 16
[ ] Line 17
[ ] Line 19

*Logic: Hidden unless: #33 Question "Which bus line(s) did you travel with?"is one of the following answers ("Line 20")*
35) At which stop did you get on and off line 20?*

*Logic: Hidden unless: #33 Question "Which bus line(s) did you travel with?" is one of the following answers ("Line 21")*
36) At which stop did you get on and off line 21?*

*Logic: Hidden unless: #33 Question "Which bus line(s) did you travel with?" is one of the following answers ("Line 22")*
37) At which stop did you get on and off line 22?*

*Logic: Hidden unless: #33 Question "Which bus line(s) did you travel with?" is one of the following answers ("Line 23")*
38) At which stop did you get on and off line 23?*

*Logic: Hidden unless: #33 Question "Which bus line(s) did you travel with?" is one of the following answers ("Line 24")*
39) At which stop did you get on and off line 24?*

*Logic: Hidden unless: #33 Question "Which bus line(s) did you travel with?" is one of the following answers ("Line 25")*
40) At which stop did you get on and off line 25?*

*Logic: Hidden unless: #33 Question "Which bus line(s) did you travel with." is one of the following answers ("Line 26")*
41) At which stop did you get on and off line 26?*

*Logic: Hidden unless: #33 Question "Which bus line(s) did you travel with?" is one of the following answers ("Line 27")*
42) At which stop did you get on and off line 27?*

*Logic: Hidden unless: #33 Question "Which bus line(s) did you travel with?" is one of the following answers ("Line 28")*
43) At which stop did you get on and off line 28?*

*Logic: Hidden unless: #33 Question "Which bus line(s) did you travel with?" is one of the following answers ("Line 29")*
44) At which stop did you get on and off line 29?*

*Logic: Hidden unless: #33 Question "Which bus line(s) did you travel with?" is one of the following answers ("Line N1")*
45) At which stop did you get on and off line N1?*

*Logic: Hidden unless: #33 Question "Which bus line(s) did you travel with?" is one of the following answers ("Line N2")*
46) At which stop did you get on and off line N2?*

*Logic: Hidden unless: #33 Question "Which bus line(s) did you travel with?" is one of the following answers ("Line N3")*
47) At which stop did you get on and off line N3?*

*Logic: Hidden unless: #33 Question "Which bus line(s) did you travel with?" is one of the following answers ("Line N4")*
48) At which stop did you get on and off line N4?*

*Logic: Hidden unless: #33 Question "Which bus line(s) did you travel with?" is one of the following answers ("Line N5")*
49) At which stop did you get on and off line N5?*

*Logic: Hidden unless: #33 Question "Which bus line(s) did you travel with?" is one of the following answers ("Line N6")*
50) At which stop did you get on and off line N6?*

*Logic: Hidden unless: #34 Question "Which tram line(s) did you travel with?" is one of the following answers ("Line 1")*
51) At which stop did you get on and off line 1?*

*Logic: Hidden unless: #34 Question "Which tram line(s) did you travel with? " is one of the following answers ("Line 2")*
52) At which stop did you get on and off line 2? *

*Logic: Hidden unless: #34 Question "Which tram line(s) did you travel with?" is one of the following answers ("Line 3")*
53) At which stop did you get on and off line 3?*

*Logic: Hidden unless: #34 Question "Which tram line(s) did you travel with?" is one of the following answers ("Line 4")*
54) At which stop did you get on and off line 4?*

*Logic: Hidden unless: #34 Question "Which tram line(s) did you travel with?" is one of the following answers ("Line 6")*
55) At which stop did you get on and off line 6?*

*Logic: Hidden unless: #34 Question "Which tram line(s) did you travel with?" is one of the following answers ("Line 9")*
56) At which stop did you get on and off line 9?*

*Logic: Hidden unless: #34 Question "Which tram line(s) did you travel with?" is one of the following answers ("Line 11")*
57) At which stop did you get on and off line 11?*

*Logic: Hidden unless: #34 Question "Which tram line(s) did you travel with?" is one of the following answers ("Line 12")*
58) At which stop did you get on and off line 12?*

*Logic: Hidden unless: #34 Question "Which tram line(s) did you travel with?" is one of the following answers ("Line 15")*
59) At which stop did you get on and off line 15?*

*Logic: Hidden unless: #34 Question "Which tram line(s) did you travel with?" is one of the following answers ("Line 16")*
60) At which stop did you get on and off line 16?*

*Logic: Hidden unless: #34 Question "Which tram line(s) did you travel with?" is one of the following answers ("Line 17")*
61) At which stop did you get on and off line 17?*

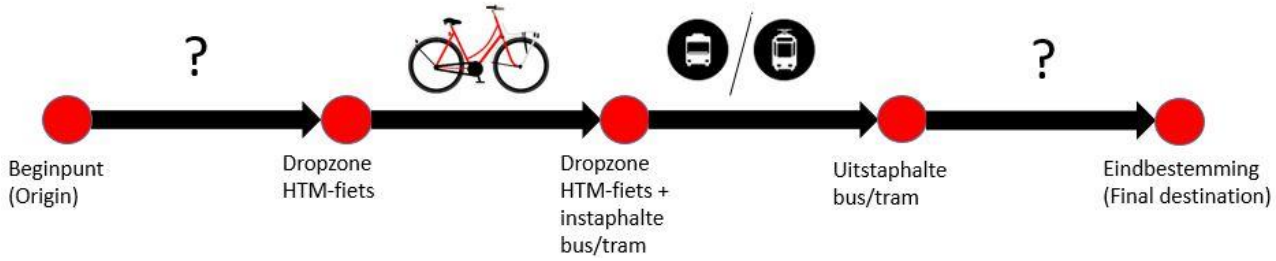
*Logic: Hidden unless: #34 Question "Which tram line(s) did you travel with?" is one of the following answers ("Line 19")*
62) At which stop did you get on and off line 19?*

*Logic: Hidden unless: #33 Question "Which bus line(s) did you travel with?" is one of the following answers ("A bus line from EBS, Arriva or Connexxion")*
63) At which stop did you get on and off during your trip with the bus of EBS, Arriva or Connexxion?
Boarding stop: _____
Exit stop: _____

---

**Part 2 (describe HTM-fiets trip)**

*Logic: Hidden unless: #31 Question "Which statement corresponds to this last trip with the HTM-fiets?" is one of the following answers ("I first used the HTM-fiets, and then travelled by bus/tram")*




*Logic: Hidden unless: #31 Question "Which statement corresponds to this last trip with the HTM-fiets?" is one of the following answers ("I first used the HTM-fiets, and then travelled by bus/tram")*
64) How did you get to the drop zone where you picked-up the HTM-fiets at the beginning of your trip?*
( ) On foot
( ) By car
( ) Other, namely:: _____

*Logic: Hidden unless: #31 Question "Which statement corresponds to this last trip with the HTM-fiets?" is one of the following answers ("I first used the HTM-fiets, and then travelled by bus/tram")*
65) What were approximately the time and the distance travelled to get to this drop zone from the starting point of your trip?
*If you can't make an estimation, please enter a zero ('0').**
The time (in minutes) was approximately::
_____
The distance (in metres) was approximately::
_____

*Logic: Hidden unless: #31 Question "Which statement corresponds to this last trip with the HTM-fiets?" is one of the following answers ("I first used the HTM-fiets, and then travelled by bus/tram")*
66) How did you travel to your final destination from the (last) bus/tram stop?*
( ) On foot
( ) With my own bicycle
( ) By scooter/moped

( ) By metro line E
( ) By train
( ) By car
( ) Other, namely:: _____

*Logic: Hidden unless: (#31 Question "Which statement corresponds to this last trip with the HTM-fiets?" is one of the following answers ("I first used the HTM-fiets, and then travelled by bus/tram") AND #66 Question "How did you travel to your final destination from the (last) bus/tram stop?" is one of the following answers ("On foot","With my own bicycle","By scooter/moped","By car","Other, namely:"))*
67) What were approximately the time and the distance travelled to get from this bus/tram stop to your final destination?
*If you can't make an estimation, please enter a zero ('0').**
The time (in minutes) was approximately::
_____
The distance (in metres) was approximately::
_____

*Logic: Hidden unless: (#31 Question "Which statement corresponds to this last trip with the HTM-fiets?" is one of the following answers ("I first used the HTM-fiets, and then travelled by bus/tram") AND #66 Question "How did you travel to your final destination from the (last) bus/tram stop?" is one of the following answers ("By train"))*
68) At which train station did you disembark at the end of your train journey?*
_____

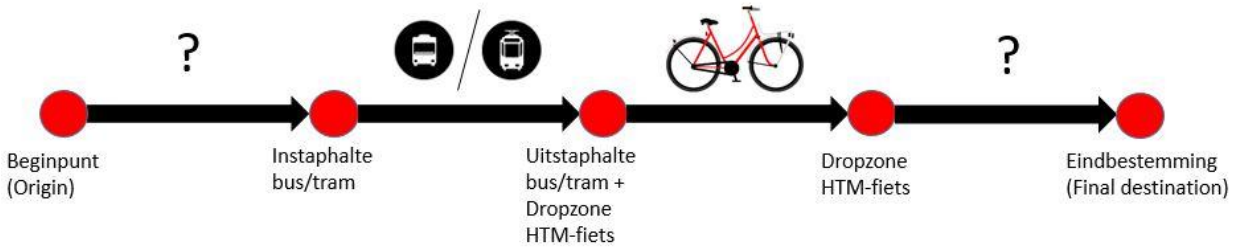
*Logic: Hidden unless: (#31 Question "Which statement corresponds to this last trip with the HTM-fiets?" is one of the following answers ("I first used the HTM-fiets, and then travelled by bus/tram") AND #66 Question "How did you travel to your final destination from the (last) bus/tram stop?" is one of the following answers ("By metro line E"))*
69) At which metro station did you disembark at the end of your metro ride?*
_____

*Page exit logic: New Skip/DisqualifyIF: (#31 Question "Which statement corresponds to this last trip with the HTM-fiets?" is one of the following answers ("I first used the HTM-fiets, and then travelled by bus/tram") AND #32 Question "What type of public transport did you use in The Hague in combination with this last ride on the HTM-fiets?*
*Select all means of transportation that you used.*
*" is not one of the following answers ("De trein/metro")) THEN: Jump to page 12 - Part 2 (describe HTM-fiets trip)*

---

**Part 2 (describe HTM-fiets trip)**

*Logic: Hidden unless: #31 Question "Which statement corresponds to this last trip with the HTM-fiets?" is one of the following answers ("I first travelled by bus/tram, and then used the HTM-fiets")*




*Logic: Hidden unless: #31 Question "Which statement corresponds to this last trip with the HTM-fiets?" is one of the following answers ("I first travelled by bus/tram, and then used the HTM-fiets")*
70) How did you get to the (first) bus/tram stop at the beginning of your trip?*
( ) On foot
( ) With my own bicycle
( ) By scooter/moped
( ) By metro line E
( ) By train
( ) By car
( ) Other, namely:: _____

*Logic: Hidden unless: (#31 Question "Which statement corresponds to this last trip with the HTM-fiets?" is one of the following answers ("I first travelled by bus/tram, and then used the HTM-fiets") AND #70 Question "How did you get to the (first) bus/tram stop at the beginning of your trip?" is one of the following answers ("On foot","With my own bicycle","By scooter/moped","By car","Other, namely:"))*
71) What were approximately the time and the distance travelled to get to this bus/tram stop from the starting point of your trip?
*If you can't make an estimation, please enter a zero ('0').**
The time (in minutes) was approximately::
_____
The distance (in metres) was approximately::
_____

*Logic: Hidden unless: (#31 Question "Which statement corresponds to this last trip with the HTM-fiets?" is one of the following answers ("I first travelled by bus/tram, and then used the HTM-fiets") AND #70 Question "How did you get to the (first) bus/tram stop at the beginning of your trip?" is one of the following answers ("By train"))*
72) At which train station did you board the train at the start of your train journey?*
_____

*Logic: Hidden unless: (#31 Question "Which statement corresponds to this last trip with the HTM-fiets?" is one of the following answers ("I first travelled by bus/tram, and then used the HTM-fiets") AND #70 Question "How did you get to the (first) bus/tram stop at the beginning of your trip?" is one of the following answers ("By metro line E"))*
73) At which metro station did you board the metro at the start of your metro ride?*
_____

*Logic: Hidden unless: #31 Question "Which statement corresponds to this last trip with the HTM-fiets?" is one of the following answers ("I first travelled by bus/tram, and then used the HTM-fiets")*
74) How did you travel to your final destination from the drop zone where you returned the HTM-fiets?*
( ) On foot

( ) By car
( ) Other, namely:: _____

*Logic: Hidden unless: #31 Question "Which statement corresponds to this last trip with the HTM-fiets?" is one of the following answers ("I first travelled by bus/tram, and then used the HTM-fiets")*
75) What were approximately the time and the distance travelled to get from this drop zone to your final destination?
*If you can't make an estimation, please enter a zero ('0').**
The time (in minutes) was approximately::
_____
The distance (in metres) was approximately::
_____

*Page exit logic: New Skip/DisqualifyIF: (#31 Question "Which statement corresponds to this last trip with the HTM-fiets?" is one of the following answers ("I first travelled by bus/tram, and then used the HTM-fiets") AND #32 Question "What type of public transport did you use in The Hague in combination with this last ride on the HTM-fiets?*
*Select all means of transportation that you used.*
*" is not one of the following answers ("De trein/metro")) THEN: Jump to page 12 - Part 2 (describe HTM-fiets trip)*

---

**Part 2 (describe HTM-fiets trip)**

76) How would you describe this last trip with the HTM-fiets?
*Examples of activities are working, going to school, visiting a restaurant, etc.**
( ) From home towards an activity
( ) From an activity towards home
( ) From an activity towards another activity
( ) Other, namely:: _____

77) What was the main reason for you to make this trip?
*If you are assessing a trip home, choose the purpose of your trip on the other way.**
( ) From/towards my job
( ) From/towards school, study, internship
( ) Business trip, visiting a congress etc.
( ) Shopping
( ) Visiting family, friends
( ) Visiting a restaurant or bar
( ) Trip to the beach, museum, cinema, etc.
( ) Sport club or other leisure activity
( ) Recreational cycling/sightseeing
( ) Other, namely:: _____

78) If the HTM-fiets and other shared bicycles had not been available, how would you have made the part of this trip that you now covered with the HTM-fiets? *
( ) On foot
( ) With my own bicycle
( ) By OV-fiets
( ) With my own scooter/moped
( ) By shared scooter/moped
( ) By bus

( ) By tram
( ) By metro
( ) By train
( ) By car
( ) I would not have made this entire trip
( ) I would have made this entire trip with other means of transportation
( ) Other, namely:: _____

*Logic: Hidden unless: #78 Question "If the HTM-fiets and other shared bicycles had not been available, how would you have made the part of this trip that you now covered with the HTM-fiets? " is one of the following answers ("I would have made this entire trip with other means of transportation")*
79) Which different means of transportation would you have used for this trip?
*U can select multiple means of transportation.* *
[ ] Walking
[ ] My own bicycle
[ ] OV-fiets
[ ] My own scooter/moped
[ ] Shared scooter/moped
[ ] Bus
[ ] Tram
[ ] Metro
[ ] Train
[ ] Car
[ ] Other, namely:: _____

80) What are reasons for you to use the HTM-fiets in combination with the bus or tram?
_____

*Page exit logic: New Skip/DisqualifyIF: #14 Question "How often do you use the HTM-fiets in combination with the bus or tram in The Hague in a single journey from A to B?*
*Line 3 and 4 of the RandstadRail are also included in the tram category.*
*" is one of the following answers ("Always") THEN: Jump to* *page 13 - Part 3*

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**Part 3**

In this last part of the survey questions will be asked with respect to your reasons for using the HTM-fiets and about your bicycle and public transport use in general.

81) Indicate to what extent you agree with the statements below.

An important reason for me to start using the HTM-fiets is that... *

| | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| using the HTM-fiets is fast | ( ) | ( ) | ( ) | ( ) | ( ) |

| | | | | | |
|---|---|---|---|---|---|
| using the HTM-fiets is relaxing and fun | ( ) | ( ) | ( ) | ( ) | ( ) |
| using the HTM-fiets is environmetally friendly | ( ) | ( ) | ( ) | ( ) | ( ) |
| using the HTM-fiets is healthy | ( ) | ( ) | ( ) | ( ) | ( ) |
| using the HTM-fiets is cheap | ( ) | ( ) | ( ) | ( ) | ( ) |
| using the HTM-fiets is safe | ( ) | ( ) | ( ) | ( ) | ( ) |
| using the HTM-fiets is flexible | ( ) | ( ) | ( ) | ( ) | ( ) |
| the HTM-fiets is reliable | ( ) | ( ) | ( ) | ( ) | ( ) |
| the HTM-fiets is comforTable | ( ) | ( ) | ( ) | ( ) | ( ) |
| the HTM-fiets and the app are easy to use | ( ) | ( ) | ( ) | ( ) | ( ) |
| there is a dropzone close to my home | ( ) | ( ) | ( ) | ( ) | ( ) |

82) Are there any other reasons why you started using the HTM-fiets?

_____

83) Indicate to what extent you agree with the statements below.

I would make more frequent use of the HTM-fiets if...*

| | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| the price is lower | ( ) | ( ) | ( ) | ( ) | ( ) |
| there are more drop zones | ( ) | ( ) | ( ) | ( ) | ( ) |
| there is a drop zone closer to my home | ( ) | ( ) | ( ) | ( ) | ( ) |
| there are drop zones closer to my destinations | ( ) | ( ) | ( ) | ( ) | ( ) |
| the bicycle is more comforTable | ( ) | ( ) | ( ) | ( ) | ( ) |
| the app works better | ( ) | ( ) | ( ) | ( ) | ( ) |
| there is certainty that a bicycle is available | ( ) | ( ) | ( ) | ( ) | ( ) |
| there are less broken bicycles | ( ) | ( ) | ( ) | ( ) | ( ) |

*Logic: Hidden unless: Question "the app works better" is one of the following answers ("Agree","Strongly agree")*

84) What could be improved about the HTM-fiets app?

_____

85) Are there any other changes that would make you use the HTM-fiets more?

_____

86) Have you ever used shared bicycles or shared scooters from other providers in the Netherlands? *

| | Never | Sometimes | Regularly |
|---|---|---|---|
| Free-floating shared bicycles (like Mobike) | ( ) | ( ) | ( ) |
| Shared bicycles with drop zones (like GoAbout) | ( ) | ( ) | ( ) |
| The OV-fiets | ( ) | ( ) | ( ) |
| Shared scooters (like Felyx) | ( ) | ( ) | ( ) |

**Part 3**

87) Indicate to what extent you agree with the statements below.*

| | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|---|---|---|---|---|---|
| I like riding a bicycle | ( ) | ( ) | ( ) | ( ) | ( ) |
| I like travelling with public transport | ( ) | ( ) | ( ) | ( ) | ( ) |

88) How often do you cycle on average?
*This question concerns cycling in general and not specifically with the HTM-fiets* *

( ) 4-7 days a week
( ) 1-3 days a week
( ) 1-3 days a month
( ) 6-11 days a year
( ) Less than 5 days a year
( ) Never

89) How often do you travel by tram on average?*
( ) 4-7 days a week
( ) 1-3 days a week
( ) 1-3 days a month
( ) 6-11 days a year
( ) Less than 5 days a year
( ) Never

90) How often do you travel by bus on average?*
( ) 4-7 days a week
( ) 1-3 days a week
( ) 1-3 days a month

( ) 6-11 days a year
( ) Less than 5 days a year
( ) Never

---

91) Do you have any questions or comments about this survey or are there any other things you would like to share?

_____

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**This is the end of the survey.**

Thank you for participating in this study!

If you have any comments or questions regarding this survey, you can reach me via:

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## Appendix 3: Summary expert meeting

- confidential -

## Appendix 4. Assumptions multinomial logistic regression

1. The dependent variable is measured at the nominal level:
The dependent variable is the extent to which people have used the HTM-fiets in combination with the bus or tram. Respondents could provide an answer on a seven point scale, but based on the answers it is decided to group the answers together in three different groups. The final groups can be seen as categorical and thus the dependent variable is measured at the nominal level and this assumption is met.

2. There are one or more independent variables that are nominal, ordinal or continuous:
In total three different independent variables are taken into account in this regression analysis, which are education level, level of bus use and the extent to which a drop zone close by was an important reason to start using the HTM-fiets. All these variables have an ordinal measurement level and therefore this assumption is met.

3. The observations should be independent and the dependent variable has mutually exclusive and exhaustive categories:
All observations represent one respondent and there are no multiple observations of the same respondent. The observations are thus independent of each other. The dependent variable originally had as answer categories 'never', 'usually not', 'a bit more often not in combination', 'as often in combination as not', 'a bit more often in combination', 'usually' and 'always'. These categories are mutually exclusive and exhaustive and thus this assumption is met.

4. There is no multicollinearity:
With this assumptions is meant that the independent variables should not be highly correlated to each other. Since the independent variables have an ordinal measurement level, the Spearman rank correlation coefficient is used to test if these variables have a high correlation to each other. The correlation is considered high when the correlation coefficient has a value greater than 0.8. As can be seen in Table 22 none of the independent variables have a correlation greater than 0.8 to each other and therefore this assumption is met.

*Table 22 - Results correlation independent variables*

| Independent variables | Correlation coefficient |
|---|---|
| **Education level – level of bus use** | -0.178 (p=0.006) |
| **Education level – DZ close by** | -0.124 (p=0.127) |
| **Level of bus use – DZ close by** | 0.080 (p=0.321 |

5. The relationship between any continuous independent variable and the logit transformation of the dependent variable is linear:
There are no continuous independent variables included in this analysis and therefore this assumption is met.

6. There are no outliers, high leverage values or highly influential points:
Since all variables are of nominal/ordinal level and the answer categories are grouped there are no outliers, high leverage values or highly influential points and therefore this assumption is met.

## Appendix 5: Usage per drop zone

- confidential -

## Appendix 6: Drop zones with a high usage during summer

- confidential -

## Appendix 7: Drop zones with a high and low usage during the weekend

- confidential -

## Appendix 8: Number of total rides per time period per day

- confidential -

## Appendix 9: Drop zones with a high usage between 3PM and 5PM on weekdays

- confidential -

## Appendix 10: Rides between 12AM and 6AM (night time)

- confidential -

## Appendix 11: Shortage/surplus at drop zones

- confidential -

## Appendix 12: Number of drop zones classified as a certain type

Table 23 shows the total number of drop zones that is classified as a certain drop zone type.

*Table 23 - Number of drop zones per drop zone type*

| Drop zone type | Number of drop zones |
|---|---|
| **Recreation** | 34 |
| **Business** | 19 |
| **Residential area** | 26 |
| **Facility** | 28 |
| **Node/junction** | 29 |
| **Edge network** | 19 |
| **Weak PT** | 11 |
| **Cross connection** | 30 |

## Appendix 13: Analysis of drop zones with weak public transport

- confidential -

## Appendix 14: Difference socio-demographics between users and non-users

For each socio-demographic variable a Chi-square independence test is performed to determine if there is a significant difference between users and non-users with respect to these socio-demographics in the sample. Table 24 shows the results of these Chi-square tests.

*Table 24 - Results Chi-square tests of socio-demographic factors with 'users/non- users'*

| Factor | Pearson Chi-Square value | df | Asymp. Sig. |
|---|---|---|---|
| **Age** | 17.542 | 3 | 0.001 |
| **Education level** | 11.877 | 2 | 0.003 |
| **Gender** | 0.746 | 1 | 0.400 |
| **Bicycle ownership** | 0.544 | 1 | 0.461 |
| **HTM employee** | 0.408 | 1 | 0.523 |

## Appendix 15: Difference HTM employees and non-HTM employees survey

To test if employees of HTM use the HTM-fiets different than people who are not employed by HTM it is examined for two aspects if there is a difference between these two groups. These are the frequency of using the HTM-fiets and the extent to which they use the HTM-fiets in combination with the bus/tram. These aspects are tested since employees of HTM might have a different opinion regarding the HTM-fiets and the bus/tram since they work for the company that offers these services.

Since only 16 of the 245 respondents are employees of HTM the assumptions to perform a Chi-square test (not more than 20% of the cells can have an expected frequency lower than 5) cannot be met. However, the crosstabs still give an indication of whether the employees provided similar answers as the non-employees. In Table 25 can be seen that the distribution within the frequencies of use shows a similar pattern for employees and non-employees, except that there are no HTM employees who conducted the survey that have used the HTM-fiets very frequently (category 4 and 5). Since the deviation is not large it is concluded that HTM employees don't use the HTM-fiets with a completely different frequency than non-HTM employees.

*Table 25 - Frequency of use HTM-fiets of non-HTM employees and HTM employees*

**Frequency of use * Employee HTM Crosstabulation**

| | | | Employee HTM | | |
|---|---|---|---|---|---|
| | | | No | Yes | Total |
| Frequency of use | Never | Count | 82 | 7 | 89 |
| | | % within Employee HTM | 37,3% | 43,8% | 37,7% |
| | Less than 1 day per month | Count | 100 | 8 | 108 |
| | | % within Employee HTM | 45,5% | 50,0% | 45,8% |
| | 1-3 days per month | Count | 29 | 1 | 30 |
| | | % within Employee HTM | 13,2% | 6,3% | 12,7% |
| | 1-3 days per week | Count | 7 | 0 | 7 |
| | | % within Employee HTM | 3,2% | 0,0% | 3,0% |
| | 4-7 days per week | Count | 2 | 0 | 2 |
| | | % within Employee HTM | 0,9% | 0,0% | 0,8% |
| Total | | Count | 220 | 16 | 236 |
| | | % within Employee HTM | 100,0% | 100,0% | 100,0% |

In Table 26 can be seen that the distribution within the extent to which the respondents have used the HTM-fiets in combination with the bus or tram only differs in the fact that there are no HTM employees that conducted the survey who used the HTM-fiets sometimes to always in combination with the bus/tram. However, this does not seem a significant difference and therefore is concluded that the extent to which the HTM-fiets is used in combination with the bus/tram is not completely different between HTM employees and non-HTM employees.

*Table 26 - Extent combination HTM-fiets and bus/tram use of non-HTM employees and HTM employees*

**Extent combi usage * Employee HTM Crosstabulation**

| | | | Employee HTM | | |
|---|---|---|---|---|---|
| | | | No | Yes | Total |
| Extent combi usage | Never | Count | 68 | 4 | 72 |
| | | % within Employee HTM | 46,3% | 44,4% | 46,2% |
| | Usually not | Count | 53 | 5 | 58 |
| | | % within Employee HTM | 36,1% | 55,6% | 37,2% |
| | Sometimes to always | Count | 26 | 0 | 26 |
| | | % within Employee HTM | 17,7% | 0,0% | 16,7% |
| Total | | Count | 147 | 9 | 156 |
| | | % within Employee HTM | 100,0% | 100,0% | 100,0% |

## Appendix 16: Open question reasons for downloading the HTM-fiets app

- confidential -

## Appendix 17: Trip purpose per time period

Table 27 shows the number of rides with a certain trip purpose per time period based on the description of the last rides by the survey respondents.

*Table 27 - Number of rides with a certain trip purpose per time period*

| | 00:00 - 06:00 | 06:00 - 09:00 | 09:00 - 16:00 | 16:00 - 19:00 | 19:00 - 00:00 |
|---|---|---|---|---|---|
| **To/from work** | 2 | 7 | 13 | 10 | 6 |
| **To/from school** | | 1 | 3 | 4 | |
| **Business** | | 1 | 1 | 1 | |
| **Shopping** | | | 2 | 3 | 1 |
| **Family/friends** | 5 | 1 | 4 | 3 | 6 |
| **Restaurant/bar** | 10 | 1 | 1 | 3 | 2 |
| **Beach/museum etc** | 4 | 2 | 12 | 4 | 4 |
| **(Sports) Club** | 1 | | 2 | 2 | |
| **Sightseeing** | | | 11 | 5 | |
| **Total** | 22 | 13 | 49 | 35 | 19 |

## Appendix 18: Open question points of improvement users

- confidential -

## Appendix 19: Open question points of improvement non-users

- confidential -

## Appendix 20: Original and grouped answer categories of factors in the survey

Within the factors extent to which people use the HTM-fiets in combination with the bus/tram, age, education level, attitude towards cycling and public transport, level of cycling, level of tram use, level of bus use and the motivations of people to use the HTM-fiets, certain answer categories are grouped together. This is done to meet the requirements of the Chi-square independence test and for performing the multinomial logistic regression analysis. The original answer categories and the grouped answer categories are presented in Table 28.

*Table 28 - Original and grouped answer categories of factors in the survey*

| Factor | Original answer categories | Grouped answer categories |
|---|---|---|
| **Extent to which people use the HTM-fiets in combination with the bus/tram** | - never<br>- usually not<br>- a bit more often not in combination<br>- as often in combination as not<br>- a bit more often in combination<br>- usually<br>- always | - never<br>- usually not<br>- sometimes to always |
| **Age** | - younger than 25 years<br>- 25 – 44 years<br>- 45 – 64 years<br>- 65 years and older | - younger than 25 years<br>- 25 – 44 years<br>- 45 years and older |
| **Education level** | - Primary education<br>- practical vocational education<br>- secondary education<br>- higher education | - Lower and secondary education<br>- Higher education |
| **Attitude towards cycling/public transport (statements)** | - completely disagree<br>- disagree<br>- neutral<br>- agree<br>- completely agree | - disagree and neutral<br>- agree |
| **Level of cycling/tram use/bus use** | - never<br>- less than 5 days/year<br>- 6-11 days/year<br>- 1-3 days/month<br>- 1-3 days/week<br>- 4-7 days/week | - infrequent (never till 1-3 times/month)<br>- frequent (1-7 days/week) |
| **Motivations to use the HTM-fiets (statements)** | - completely disagree<br>- disagree<br>- neutral<br>- agree<br>- completely agree | - disagree and neutral<br>- agree |

## Appendix 21: Results Chi-Square tests of all factors with extent combined usage

In this appendix the results of the Chi-square independence test, which are performed to identify which factors had an influence on the extent to which the HTM-fiets is used in combination with bus/tram, are presented. In case the asymptotic significance is below 0.05 it can be concluded that the factor is significantly different for the extent to which people use the HTM-fiets in combination with bus/tram and thus has an influence on this. For example, education level is almost significant, which means there is a difference in the extent to which lower educated people use the HTM-fiets in combination with bus/tram and the extent to which higher educated people use the HTM-fiets in combination with bus/tram. None of the factors show a significance smaller than 0.05.

*Table 29 - Results Chi-square tests of all factors with 'extent to which people use the HTM-fiets in combination with bus/tram'*

| Factor | Pearson Chi-Square value | df | Asymp. Sig. |
|---|---|---|---|
| **Age** | 4.462 | 4 | 0.347 |
| **Gender** | 3.170 | 2 | 0.205 |
| **Education level** | 5.884 | 2 | 0.053 |
| **Bicycle ownership** | 0.523 | 2 | 0.770 |
| **Level of cycling** | 0.668 | 2 | 0.716 |
| **Level of bus use** | 5.239 | 2 | 0.073 |
| **Level of tram use** | 3.218 | 2 | 0.200 |
| **Attitude cycling** | 3.285 | 2 | 0.194 |
| **Attitude PT** | 0.267 | 2 | 0.875 |
| **Fast** | 0.123 | 2 | 0.941 |
| **Relaxing and fun** | 0.350 | 2 | 0.840 |
| **Environmentally friendly** | 1.531 | 2 | 0.465 |
| **Healthy** | 0.897 | 2 | 0.639 |
| **Cheap** | 1.889 | 2 | 0.389 |
| **Safe** | 0.717 | 2 | 0.699 |
| **Flexible** | 0.368 | 2 | 0.832 |
| **Reliable** | 0.776 | 2 | 0.678 |
| **Comfortable** | 0.482 | 2 | 0.786 |
| **Easy** | 0.302 | 2 | 0.860 |
| **Drop zone close by home** | 4.317 | 2 | 0.116 |

Education level, level of bus use and a drop zone close by home as reason to use the HTM-fiets have a significance smaller than 0.05. The crosstabs (presented in Table 30, Table 31 and Table 32) show per category within these factors which percentage ‘never’, ‘usually not’ or ‘sometimes to always’ use the combination of HTM-fiets and bus/tram.

*Table 30 - Crosstab education level and extent to which people use the HTM-fiets in combination with bus/tram*

**Education level * Extent combi usage Crosstabulation**

| | | | Extent combi usage | | | |
|---|---|---|---|---|---|---|
| | | | Never | Usually not | Sometimes to always | Total |
| Education | low/secondary | Count | 13 | 9 | 10 | 32 |
| | | % within Education3 | 40,6% | 28,1% | 31,3% | 100,0% |
| | higher | Count | 59 | 46 | 16 | 121 |
| | | % within Education3 | 48,8% | 38,0% | 13,2% | 100,0% |
| Total | | Count | 72 | 55 | 26 | 153 |
| | | % within Education3 | 47,1% | 35,9% | 17,0% | 100,0% |

*Table 31 - Crosstab level of bus use and extent to which people use the HTM-fiets in combination with bus/tram*

**Level bus use * Extent combi usage Crosstabulation**

| | | | Extent combi usage | | | |
|---|---|---|---|---|---|---|
| | | | Never | Usually not | Sometimes to always | Total |
| Level bus use | low | Count | 58 | 43 | 15 | 116 |
| | | % within Levelbus3 | 50,0% | 37,1% | 12,9% | 100,0% |
| | high | Count | 14 | 15 | 11 | 40 |
| | | % within Levelbus3 | 35,0% | 37,5% | 27,5% | 100,0% |
| Total | | Count | 72 | 58 | 26 | 156 |
| | | % within Levelbus3 | 46,2% | 37,2% | 16,7% | 100,0% |

*Table 32 - Crosstab DZ close by home and extent to which people use the HTM-fiets in combination with bus/tram*

**DZ close by home * Extent combi usage Crosstabulation**

| | | | Extent combi usage | | | |
|---|---|---|---|---|---|---|
| | | | Never | Usually not | Sometimes to always | Total |
| DZ close by home as important resons to use HTM-fiets | Disagree | Count | 28 | 29 | 16 | 73 |
| | | % within DZinbuurt3 | 38,4% | 39,7% | 21,9% | 100,0% |
| | Agree | Count | 44 | 29 | 10 | 83 |
| | | % within DZinbuurt3 | 53,0% | 34,9% | 12,0% | 100,0% |
| Total | | Count | 72 | 58 | 26 | 156 |
| | | % within DZinbuurt3 | 46,2% | 37,2% | 16,7% | 100,0% |

## Appendix 22: Model fit multinomial logistic regression model

The model fitting information (Table 33) and goodness-of-fit (Table 34) indicate how well the model fits the data. Table 33 shows that the likelihood ratio test has a Chi-Square value of 15.078 and a p-value of 0.020. This means that the final modal significantly predicts the dependent variable better than the Intercept Only model. Furthermore, Table 34 shows that the Pearson Chi-Square statistic is not significant which means that the model fits the data well.

*Table 33 - Model Fitting Information logistic regression model*

| | **Model Fitting criteria** | **Likelihood Ratio Tests** | | |
|---|---|---|---|---|
| **Model** | **-2 log Likelihood** | **Chi-Square** | **df** | **Sig.** |
| **Intercept Only** | 69.893 | | | |
| **Final** | 54.814 | 15.078 | 6 | 0.020 |

*Table 34 - Goodness-of-Fit logistic regression model*

| | **Chi-Square** | **df** | **Sig.** |
|---|---|---|---|
| **Pearson** | 12.629 | 8 | 0.125 |

## Appendix 23: Open question reasons to use the HTM-fiets (not) in combination

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