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Exploring the role of bicycle sharing programs in relation to urban transit

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ABSTRACT

In this study a unique bicycle sharing program (BSP) is studied: a BSP initiated by an urban transit provider (buses and trams). The idea is that the combined use of BSPs and buses and trams could increase the catchment area of urban transit alone, therefore offering a more competitive alternative for the car. However, in the scientific literature hardly any knowledge is available regarding to what extent, by whom and how this bicycle – urban transit combination is used. This study explores the so-called 'HTM-fiets' programme in The Hague, the Netherlands, operated by urban transit operator HTM. Within the case, data was collected through a survey among the users of this program. The results indicate that, in this case, only 9% of the respondents use HTM-fiets in combination with urban transit. Of bike users who use HTM-fiets as a stand-alone mobility option (i.e. without combining it with transit), 46% have used the HTM-bike as substitute for bus and tram. Our results imply that the transit provider of 'HTM-fiets' faces difficult policy choices. The large degree of substitution may negatively influence their business case. However, a large degree of substitution is at the same time not a problem per se for them, because this substitution may alleviate crowding problems in transit and 'HTM-fiets' can be seen as an extra service by them offered to people in the Hague to ensure better accessibility of the city. The main lesson would be to focus on an integrated design of BSP and public transport in case a complementary system is aimed for, since our case shows clearly that without an integrated design especially substitution will take place from urban transit to the bicycle.

1. Introduction

Cities worldwide become more populated, hence the pressure on existing mobility systems increases. Since a large share of trips is made using cars, this often leads to high levels of congestion and pollution in cities (Banister, 2008). To keep cities 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 much attention is the bicycle, which is flexible, low-cost and if replaced for the car, able to reduce traffic congestion and pollution (Handy et al., 2014**)**. If the bicycle and transit are integrated (used complementary), the benefits of both could be combined (Kager et al., 2016, Brand et al., 2017). Transit could provide fast and accessible connections and the bicycle could provide flexible transport for the first and last mile (Shelat et al., 2018, van Mil et al., 2020). 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 (DeMaio, 2009; Larsen, 2013; Li et al., 2018; van Waes et al., 2018, Van Waes et al., 2018).

Faghih-Imani and Eluru (2015) found that metro and regional train stations were often chosen as destination by users of the BSP in Chicago, which could indicate that that these two modalities have been used complementary. Also, Leth et al. (2017) found that the BSP in Vienna strengthened the relation with transit by comparing travel times of shared bicycle routes with travel times of alternative transit routes. On the other hand, 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, suggesting that the bicycle served as substitute. While these studies examine different aspects of the relationship between BSPs and transit, they can generally only make assumptions on the extent to which shared bicycles are used as a

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complement or substitute to transit. Besides, these studies mostly focussed on the combination with metro or regional rail.

This paper aims to bridge this gap by investigating how BSPs are used in a unique BSP program ('HTM-fiets') which specifically aims for the combined use of shared bicycle and buses and trams (from now on referred to as 'urban transit'). We are interested in questions such as: how are the shared bicycles used? Are they used complementary to the urban transit modes, as substitute, or both? And can we understand why this is the case? Also, we will briefly touch upon the implications of our results for the combined BSP and transit provider. The BSP that is used in this study is the 'HTM-fiets', which operates in the Hague, the Netherlands. The Netherlands has a long tradition of cycling and has the highest rate of bicycle use in the world (Heinen et al., 2013). 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 transit, which includes bus, tram and metro (Martens, 2007; Ton et al., 2020).

The remainder of this paper is structured as follows. Section 2 discusses the scientific literature on BSPs in relation to urban transit. Section 3 describes the methodology applied in this paper. Section 4 discusses the results and we put this single case study in a broader context here. Finally, Section 5 concludes this paper and provides recommendations.

2. The role of BSPs in urban transit

The introduction of BSPs has generally been matched with a modal shift, albeit that the extent to which this happens varies largely per BSP. This section explores literature on how BSPs worldwide have impacted (urban) transit (2.1) and investigates how much is known about whether BSPs serve as complementary to transit or as a substitute (2.2).

2.1. The relationship between BSPs and transit

The relationship between BSPs and transit has been studied widely, mostly with a focus on train or metro. Shaheen et al. (2013) conducted a survey among users of BSPs in four cities in North America (Toronto, Montreal, Washington DC, and the Twin Cities). The effect of the BSPs on transit usage varied, as some people increased their usage whereas others decreased usage. In all, except the Twin Cities, an overall reduction of bus and rail usage was observed. In the Twin cities, an increase in rail usage was found and only a slight reduction in bus usage. The Twin Cities have a less extensive transit network, which means that the BSP might have provided improved access and egress possibilities to transit. Furthermore, this could be due to population density, which is much lower compared to the other cities. Martin & Shaheen (2014) found that the effect of a BSP on transit depends on where people live. People who live in the suburbs were more likely to increase their bus and rail usage as a result of their use of shared bicycles, whereas people who live in high urban areas use transit less after the introduction of BSPs. Most likely, this can be attributed to BSPs providing new opportunities for the first and last mile connection to transit in suburbs, whereas BSPs provide a faster, more flexible alternative to transit in high urban areas, especially for short distance trips. This corresponds to a study from Ma et al. (2015), who found that the demand for BSPs in the suburbs of Washington DC was very large. Besides, they found that an increase in shared bicycle trips with 10% would generate an increase in transit ridership of 2.8%. Ma et al. (2015) also found that transit stations of Metrorail were important origins and destinations for trips made by shared bicycle. Faghih-Imani and Eluru (2015) studied destination preferences of BSP 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. However, occasional users often chose other destinations, potentially due to more leisure-related trip purposes.

Besides the actual modal shift that occurs after introduction of BSPs, several studies have investigated the potential impact of BSPs on transit, being complementary or substituting, through travel time comparison (Jäppinen et al., 2013; Leth et al., 2017). Jäppinen et al. (2013) found that if the combination of BSP and transit is used in Helsinki, the transit travel times could be reduced by>10%, which is around 6 min per trip. The biggest reduction in travel time is found in the more remote regions, with longer access distances to transit stations. Furthermore, in downtown Helsinki it is more likely that BSPs replace (part of) the transit trips, since this will often be a faster alternative. Leth et al. (2017) found that BSPs would serve as complementary to transit instead of substituting trips in Vienna. Furthermore, they state that regions with poor transit cross-connections could be suitable for BSPs since people use BSPs to avoid transit trips that require a transfer. From this research they could however not conclude that people actually used the shared bicycle as a supplement of transit since this was only an estimation based on travel time.

2.2. Modal shift as a result of introducing BSPs?

Several studies have investigated for which mode the BSP was used as an alternative on an urban level (Bachand-Marleau et al., 2012; Fishman et al., 2014; Midgley, 2011; Murphy and Usher, 2015; van Gerrevink, 2019). One of the reasons for implementing a BSP in a city is to promote the use of sustainable modes of transport and reduce the use of cars. Table 1 provides an overview of the modal shift towards BSPs (excluding all other potential effects on mode use).

The shift from car to BSP varies from 1% to 21% for different systems in different cities. Even though a reduction in car use is achieved, BSPs generally attract people from other sustainable modes such as transit, walking, and the privately-owned bicycle as well. Especially in Delft, a very small percentage of the shared bicycle users would have used the car if the shared bicycle was not available (van Gerrevink, 2019). However, the authors did observe a growth of train trips due to the introduction of Mobikes, that could imply an indirect competition to the car. The modal shift towards a BSP also depends on the current modal split in a city (Fishman et al., 2013). If only a small number of trips within a city is made by car and/or a mature cycling culture already exists, it is not likely that a large share of the BSP trips is replacing the car, which is the case for Delft. A large share of the BSP trips (23% to 51%) replaces transit trips, indicating that the BSP offers a more attractive alternative than transit. In these cases, the BSP serves as substitute for transit. These studies have not specified whether it entails urban transit or regional transit. The studies in Montreal (Bachand-Marleau et al., 2012) and Lyon (Midgley, 2011) also investigated to what extent the BSPs generate new trips. It appeared that respectively 3% and 2% of the shared bicycle users in these cities would not have

Table 1
Modal shift towards the BSP system (Bachand-Marleau et al., 2012; Fishman et al., 2014; Midgley, 2011; Murphy and Usher, 2015; van Gerrevink, 2019).

BSP	Car	Taxi	Transit	Walking	Bicycle	New trip
BIXI (Montreal, Canada)	2%	8%	34%	25%	28%	3%
Dublin bikes (Dublin, Ireland)	13%	–	23%	31%	32%	–
Velo'v (Lyon, France)	7%	–	50%	37%	4%	2%
Bicing (Barcelona, Spain)	10%	–	51%	26%	6%	–
Mobike (Delft, Netherlands)	1%	–	25%	33%	30%	–
Nice Ride (Minnesota, USA)*	19%	–	–	–	–	–
MBS (Melbourne, Australia)*	21%	–	–	–	–	–
CityCycle (Brisbane, Australia)*	19%	–	–	–	–	–

* Only data about car trips replacements reported (Fishman et al., 2014).

made a trip if the shared bicycle was not available.

Ma et al. (2020) performed a detailed study on the use of different transportation modes by Mobike users in Delft (in the Netherlands) after the introduction of the BSP. They found that the largest share of the users decreased their usage of the bus and tram (40%), private bicycle (35%), and walking (35%). However, for some users (16%) the bus/tram use increased after introduction of the BSP. They state that this is because the BSP is used as first- and last- mile transportation to bus/tram stops. The use of a BSP means that one has to be less concerned about parking, compared to private bicycles, which are very common in Delft.

Concluding, BSPs seem to act as a substitute for transit. These studies did not focus on programs where the transit provider specifically introduces a BSP in order to combine the shared bicycle and transit mode.

3. Methodology

This section discusses the methodology for investigating to what extent BSPs and urban transit are used complementary. The case study, which is HTM-fiets in The Hague, Netherlands is introduced in section 3.1. Data on the use of HTM-fiets in relation to urban transit is collected through a survey, which is discussed in section 3.2. The method used to analyse the data is described in section 3.3.

3.1. Case study: HTM-fiets (The Hague, Netherlands)

HTM-fiets was selected as a case study specifically because of the unique opportunity to analyse real-world data and to analyse preferences of actual users of a bike-urban transit concept. In doing so, we could answer our research questions based on revealed data. A disadvantage of an in-depth single case study like this is a potential lack of generalisability. In section 4 we will discuss to what extent our results can be generalised.

HTM-fiets is located in the city of The Hague. This city is located in the western part of The Netherlands and is the third largest city of the country (+/- 500.000 inhabitants). Trips within the city are mostly made by bicycle and car (respectively 22% and 42%). Transit is used less for commuting (15%) (KiM, 2019) . The transit network of The Hague (operated by HTM) consists of 12 tram lines (including two light rail lines), and 8 bus lines, resulting in a dense urban transit network. The high use of bicycles in the city might influence the usage of the BSP and the modal shift that is resulting from the introduction of the BSP. HTM-fiets is operated by HTM, the transit operator of The Hague.

Several providers of shared mobility participated in a pilot program set up by the municipality. HTM introduced their program in May 2019, simultaneous with the launch of two other BSPs (Mobike and Go About). In this research, we only analyse HTM-fiets. Mobike and Go About serve other areas, such as specific suburbs. HTM-fiets BSP consists of 500 bicycles and around 60 drop zones (near transit stops) where the bicycles can be picked-up or returned (see Fig. 1. HTM-fiets is a one-way, docked system that works with geofenced areas that can be used to get or park a bicycle. The pilot prescribes that each operator can deploy a maximum of 500 bicycles at the start of the pilot. Using HTM-fiets costs one euro per 30 min and has a maximum daily tariff of five euros. HTM-fiets can be paused, but then the payment will continue. HTM states on the website their goal with this program: '*The 'HTM-fiets continues where trams and buses stop. This means that the first or last mile of the journey can be covered by bicycle, so that you can get to your destination quickly and easily. The great advantage of the HTM-fiets is that it can be picked up at one location and returned at another*' (HTM, 2020).

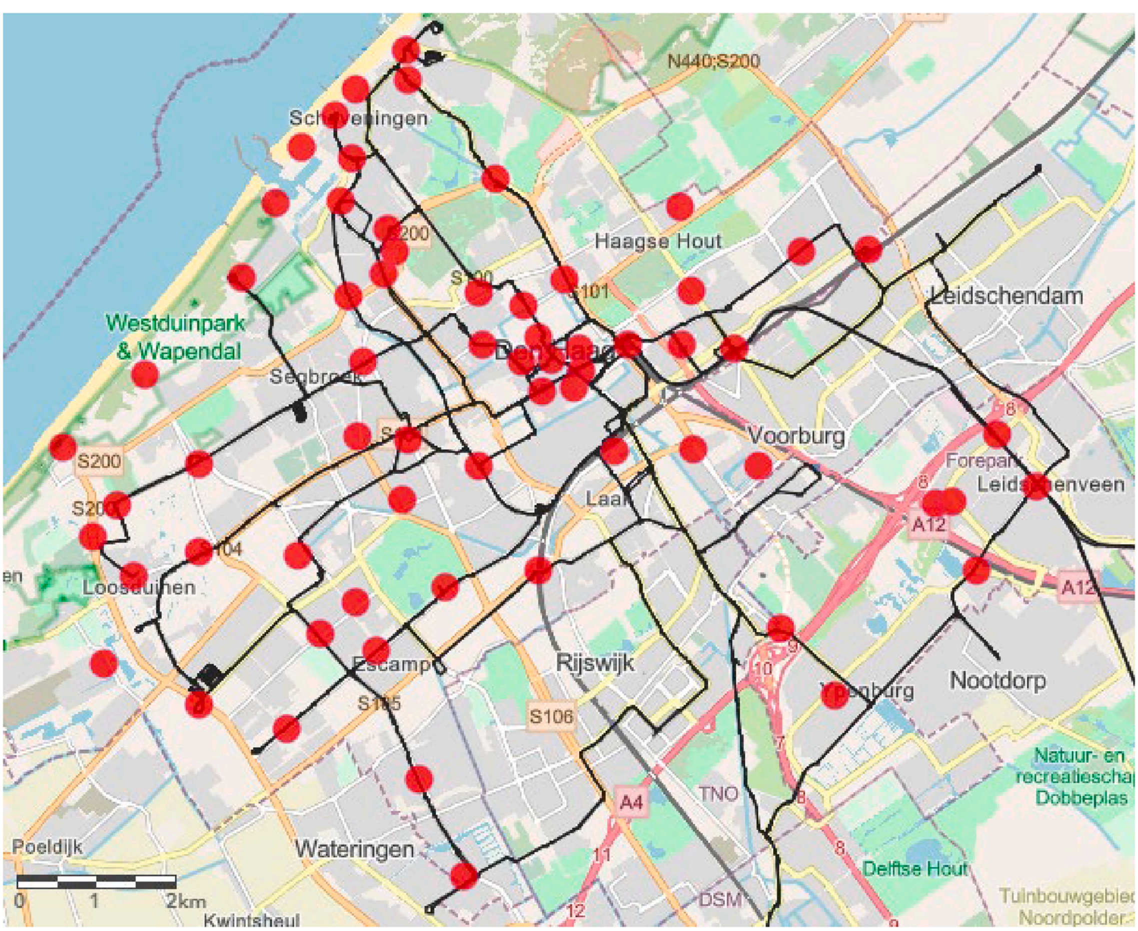

Fig. 1. Drop zones of HTM-fiets.

3.2. Data collection

A survey was conducted among the individuals who have created an account in HTM-fiets application. This application is used to unlock/lock bicycles and deals with payment. The survey was distributed online via a link in an email. This is a very time-efficient way to reach many people, data is automatically stored, and the respondents can complete the survey at a convenient time and place (Evans and Mathur, 2005). The survey was distributed in February 2020 (pre-COVID19) among all installers of the app. A total of 245 people responded and fully completed the survey (3% response rate), only 156 people have used HTM-fiets and are included in this study. There is no clear explanation for the low response rate. We speculate that relatively many people have installed the app (for 'just in case'), but do not actually use HTM-fiets. However, the number of responses is sufficient to answer our research questions. More details will be provided in Section 4.1.

Fig. 2 provides an overview of the survey design. The survey consists of three parts. First, all respondents were asked to answer questions regarding socio-demographics (age, gender, education, and bicycle ownership (specifically in The Hague)). Furthermore, a question about the frequency of use of HTM-fiets was included. The respondents who had used HTM-fiets at least once were directed to different follow-up questions than the respondents who had not used HTM-fiets. More details of the survey can be found in van Marsbergen (2020).

The second part focused on the extent to which HTM-fiets was used in combination with transit. This question was answered on a 7-point scale ranging from "never" to "always" to obtain a detailed answer. In case the respondents largely used 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 HTM-fiets in combination with the bus/tram in a single ride. If they largely used HTM-fiets alone (answers 1 to 3 on the scale), they were asked to describe their last ride made with HTM-fiets alone. The description of the last trip by the respondents includes the origin and destination drop zone, departure time, the used bus/tram lines and the main trip purpose. Next to the last ride, this part also included questions that focus on identification of the (potential) modal shift as a result of the introduction of the BSP. Respondents had to indicate which mode of transportation they would have used for the part of the trip for which they now used HTM-fiets, in case HTM-fiets (and other shared bicycles) would not have been available. Thereafter, respondents were asked through an open question why they used or did not use HTM-fiets in combination with the bus/tram.

In the third and final part of the survey, all respondents were asked which improvements of the concept would increase their use of the BSP. To gain detailed insight in this aspect a 5-point Likert scale was used. The respondents were given several statements regarding different types of improvements that might increase their usage of HTM-fiets and could answer to what level they agreed with the statements (1 being

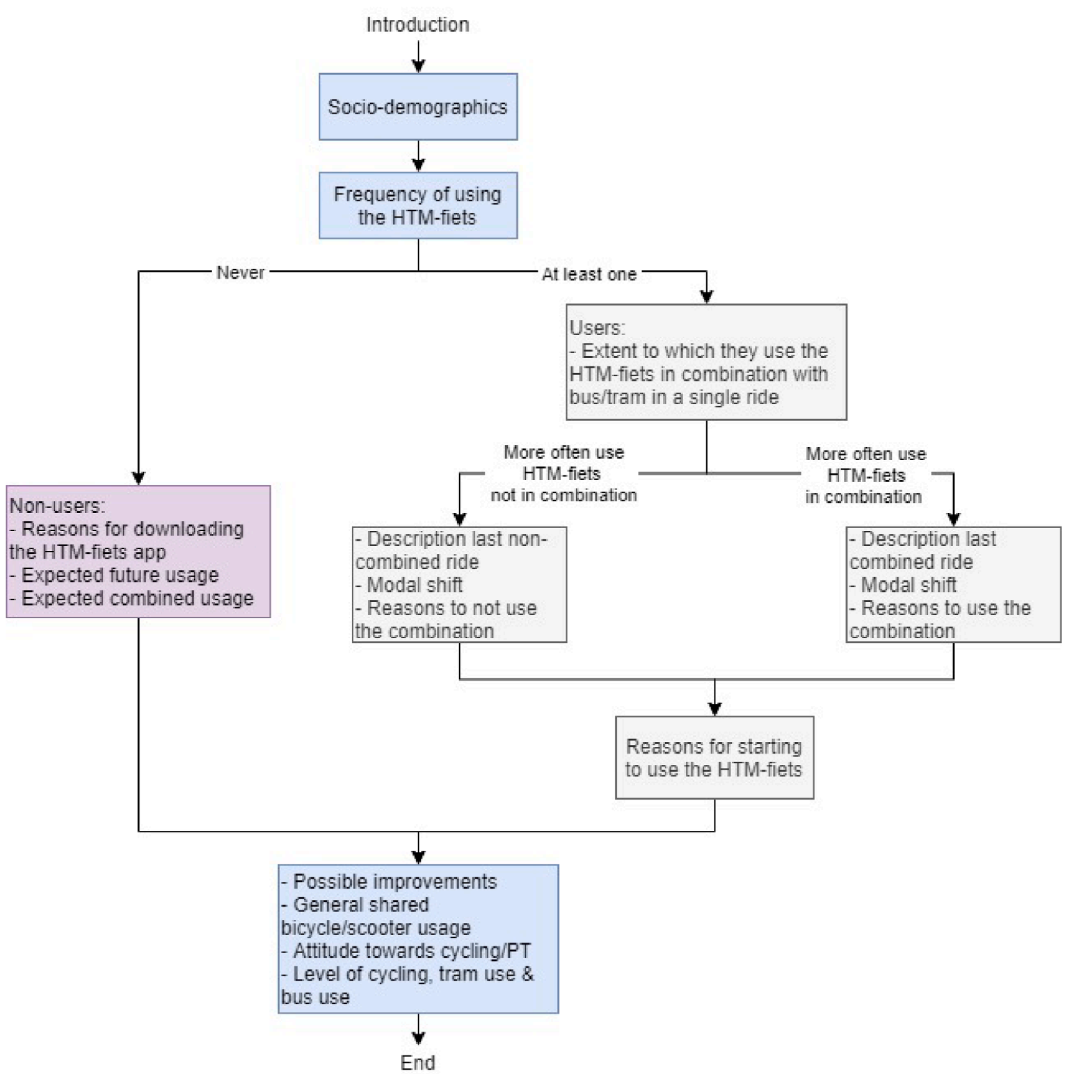

Fig. 2. Overview of Survey design.

completely disagree and 5 being completely agree). Finally, the respondents were asked about their general level of cycling and level of bus use and tram use and their attitudes towards these modes.

3.3. Data analysis methodology

The extent to which people use the combined BSP and transit mode was investigated through various methods. First, the trip factors and transit factors (trip length, trip purpose, origin and destination location of a trip and the quality of transit lines) were evaluated qualitatively, based on the descriptions of all last rides made with HTM-fiets in combination with the bus/tram. Furthermore, we analysed which transit mode is most often used in combination with HTM-fiets. 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 transit and reasons for using HTM-fiets), we tested whether these factors are significantly different for the extent to which people use HTM-fiets in combination with urban transit, using the Chi-square independence test (Field, 2009). The measurement level of the dependent variable (the extent to which people use HTM-fiets in combination with urban transit) is categorical. A multinomial logistic regression analysis was carried out to identify relevant explanatory variables (Field, 2009). We chose MNL because our dependent variable consists of three items ('sometimes to always', 'never' and 'hardly ever') that cannot be ordered in a meaningful way. We did not consider more advanced logit model such as mixed logit as we assume that we do not violate the two basic MNL assumptions in our choice situation (to what extent do people use HTM bike?), namely independence of irrelevant alternatives and no correlation over repeated choices. The independent variables that are significantly different according to the Chi-square test were included in this analysis. Through an open question we asked people about the reasons why they (not) use HTM-fiets in combination with bus/tram. All the answers were analysed and in case similar answers were provided these were grouped together in one answer category.

4. Results

This section describes the use of HTM-fiets based on the results of the survey conducted among the users of HTM-fiets. First, section 4.1 provides more information on HTM-fiets users and how they use the system. Section 4.2 describes the role of the BSP in relation to transit and other modes. Finally, the factors that influence the extent to which HTM-fiets is used in combination with the bus/tram are discussed in section 4.3.

4.1. HTM-fiets: Users and usage

The total sample consists of 245 respondents. Only 156 people have used the HTM-fiets and are included in this analysis. The other 89 respondents did download the app but did not use the HTM-fiets (yet).

Table 2
Distribution of socio-demographics for users.

Variable	Category	Share
Age	< 25 years	18.6%
	25 – 44 years	52.6%
	45 – 64 years	25.6%
	65 and older	3.2%
Education level	Lower education	3.2%
	Secondary education	17.3%
	Higher education	77.6%
	Other/I'd rather not say	1.9%
Gender	Female	31.4%
	Male	66.7%
	Other/I'd rather not say	1.9%
Bicycle ownership in The Hague	Yes	65.4%
	No	34.6%

Table 2 shows the distribution of socio-demographics of the users of HTM-fiets. HTM-fiets users are more often male (67%), most often aged between 25 and 44 (53%) and are largely higher educated (78%), which is comparable with users of other BSPs in the Netherlands and worldwide (Ma et al., 2020; Murphy and Usher, 2015; Van Waes et al., 2018, Van Waes et al., 2018). Furthermore, 65% of the users of HTM-fiets 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., 2012). This difference is likely caused by the high level of bicycle ownership in the Netherlands and the fact that your own bicycle is usually located at home and is therefore not present everywhere you go.

HTM-fiets users were asked about their level of cycling, tram use and bus use and attitudes towards cycling and transit. Fig. 2 shows that 75% of the users of HTM-fiets cycle at least once a week and 47% cycles>4 days a week. This corresponds with other studies that found that high usage of the bicycle in general was positively associated with becoming a member of a BSP (Bachand-Marleau et al., 2012; Fishman et al., 2015). Furthermore, 53% uses the tram on a regular basis (at least once per week) and 26% uses the bus at least once per week. Consequently, most HTM-fiets users are more frequent cyclists and less frequent transit users. 88% of HTM-fiets users (completely) agreed with the statement that they like travelling by bicycle. HTM-fiets users are in general people who like to cycle. The attitude towards travelling by transit is a little less positive, but still 53% of HTM-fiets users (completely) agreed to the statement that they like travelling by transit, whereas 17% dislikes travelling by transit.

Based on the descriptions of the last ride made using HTM-fiets, we found that 53% of the described rides took place in the winter months (December – March), while 22% took place in spring/summer (April – August) and 20% in autumn (September – November). The other 6% of the respondents could not recall when their last ride took place. Trips were mainly made for leisure (53.8%) and commuting to work or school (31.4%). The first trip purpose reflects occasional trips, whereas the latter reflects more regular use. Of the described rides made in the winter, 60% had a leisure purpose and 33% commuted, whereas the described rides made in summer had a leisure purpose in 50% of the cases and 35% commuted. It thus seems that there is not a large difference in trip purpose between these periods. 88% is an occasional user (<3x per month), of which 33% used HTM-fiets for commuting and 57% for leisure. Only 5.7% is frequent user (>1x per week), 56% of these respondents used HTM-fiets for commuting and 44% for leisure. Consequently, the frequent user uses the HTM-fiets more often for commuting purposes compared to the occasional user. Furthermore, most leisure rides 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. Commuting trips seem not only concentrated in the morning and evening peak but are more distributed throughout the whole day.

Fig. 3 shows the usage of all drop zones for the last described ride. We chose to ask respondents for their last ride because we considered that this was easier for them to fill in than to ask them for their most used drop zone, for example. Some people may use different drop zones and for them it would not be possible to answer clearly which zone they used most. Drop zones located close to facilities, in business areas and around large transit nodes, which are mainly located in the city centre, show a higher use. Drop zones located at the edges of the transit network and at locations with a weak transit 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 main train stations in The Hague, Den Haag Centraal and Station Hollands Spoor. The survey shows that respectively 43% and 67% of the respondents who picked up or returned HTM-fiets at Den Haag CS and Stations HS arrived or departed by train. This indicates that HTM-fiets is also used as first and last mile transportation of train trips (Fig. 4).

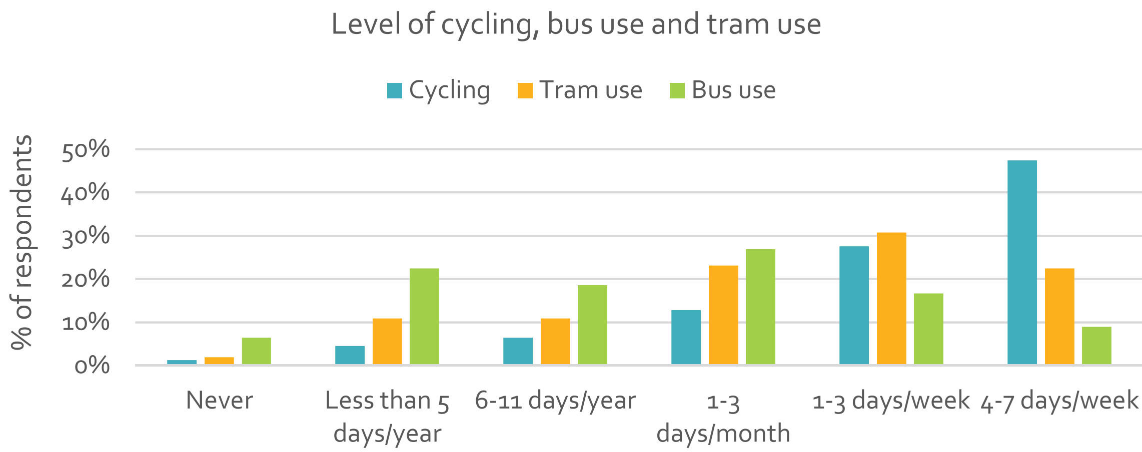

Fig. 3. Frequency of cycling, tram use and bus use of HTM-fiets users.

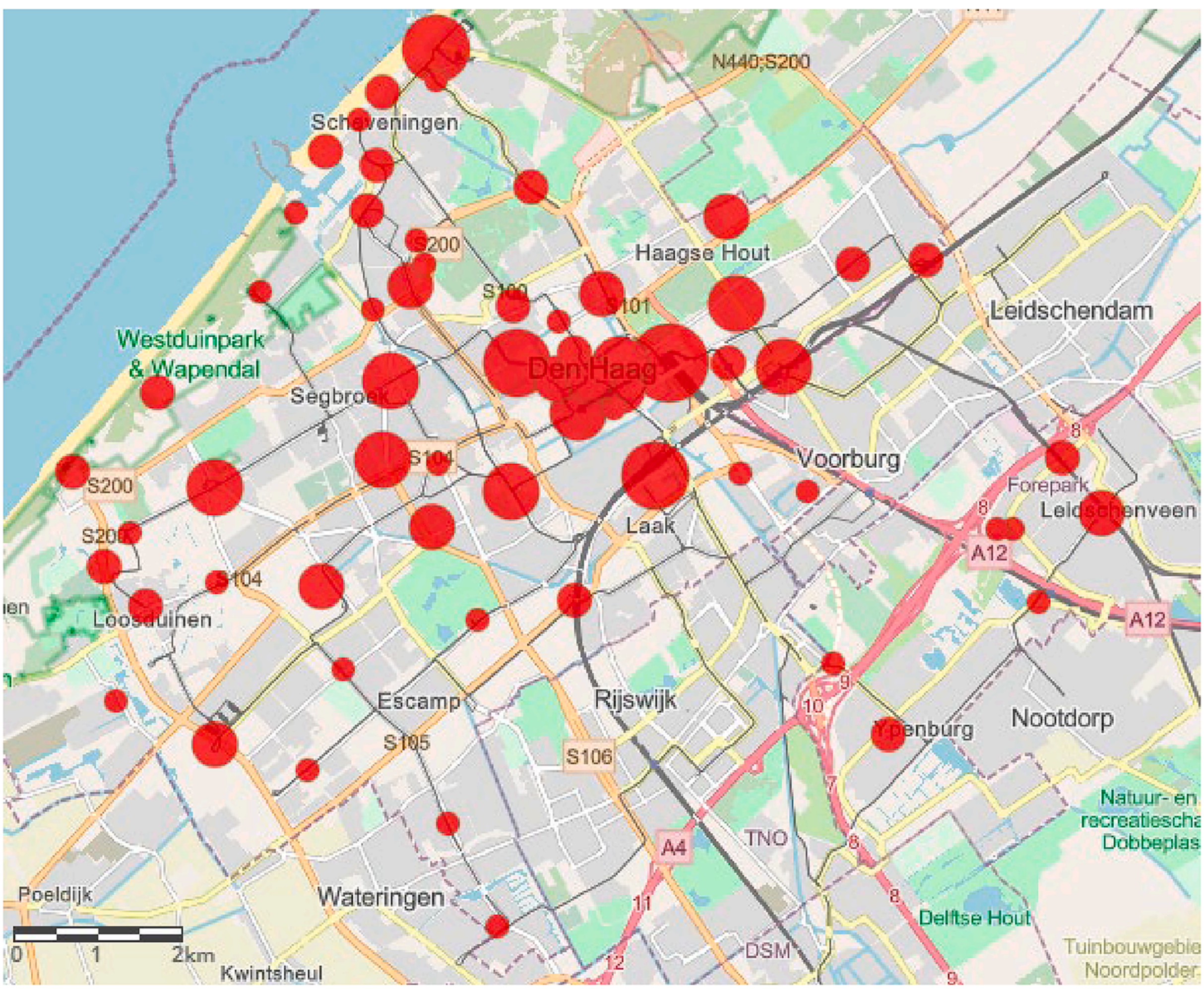

Fig. 4. Usage per drop zone expressed in circles varying in size depending on the amount of usage for the last described ride.

4.2. HTM-fiets and urban transit

The majority of HTM-fiets users (83.3%) do not (or usually not) use HTM-fiets in combination with urban transit in a single trip (Fig. 5). Those people use HTM-fiets for the entire trip. Only 9% of the respondents use HTM-fiets in combination with urban transit (varying from 'around half of the trips' to 'always'). Consequently, the current setup of the BSP concept does not attract many people to use it in combination with the bus or tram, thus HTM-fiets is not often used as a complement to urban transit within a single journey from A to B. Interestingly, this contrasts with the expectation of potential users, of which 67% expects to use HTM-fiets in combination with the bus/tram. It thus seems that there is a difference between how people expect to use HTM-fiets and how they actually use it. What causes this difference cannot be derived from the survey results. However, as a potential user, HTM-fiets might be a promising first or last mile solution, but if you

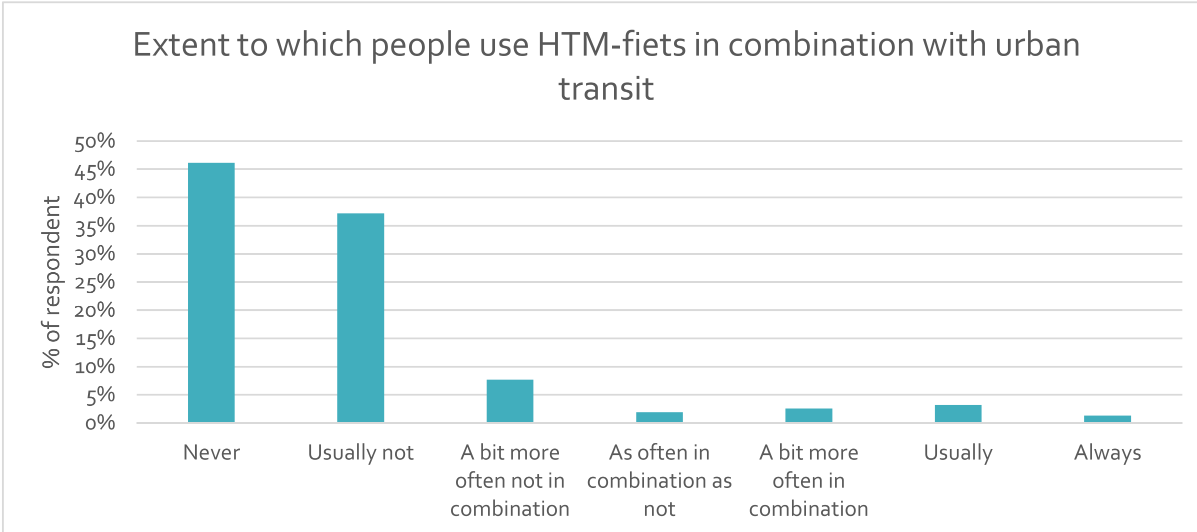

Fig. 5. Extent to which people use HTM-fiets in combination with urban transit (n = 156).

actually start using 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 (Bachand-Marleau et al., 2012).

Based on the extent to which people use the combination of HTM-fiets and bus/tram, respondents either described their last ride with HTM-fiets or their last ride with HTM-fiets in combination with urban transit. This resulted in 8 respondents describing their last combined ride and 142 respondents their last ride using the BSP only. Fig. 6 shows for each mode the share of respondents that would have used that specific mode if HTM-fiets was not available. The total percentage of HTM-fiets users that have used HTM-fiets instead of transit (tram, bus and train) is 47% (Fig. 6 top). 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 transit to the shared bicycle (Bachand-Marleau et al., 2012; Midgley, 2011; Murphy and Usher, 2015; van Gerrevink, 2019). Consequently, the substitution rate in The Hague is in line with other studies. For the trips that are made in combination with urban transit (but note, N is only 8) most HTM-fiets users would have changed to a complete urban transit trip (50%) in case the HTM-fiets was not available (Fig. 6 bottom). bottom bottom)

More than half of the respondents indicated to use HTM-fiets instead of non-transit modes. Even though 65% of the respondents have a privately-owned bicycle in The Hague, only 6% would use their own bicycle for the part of their trip for which they used HTM-fiets. 10% of the respondents would have used the car or taxi/Uber if 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; Midgley, 2011; Murphy and Usher, 2015; van Gerrevink, 2019). The percentage of people who have switched from the car in The Hague is comparable with Dublin and Barcelona, but higher than in the other three cities. In The Hague, like in other cities, the BSP ensures a small decrease in car use, but it mainly attracts users from other sustainable modes. Furthermore, 10% of the respondents would not have made the trip in case HTM-fiets was not available. This means that HTM-fiets also generates new rides that otherwise would not have been made.

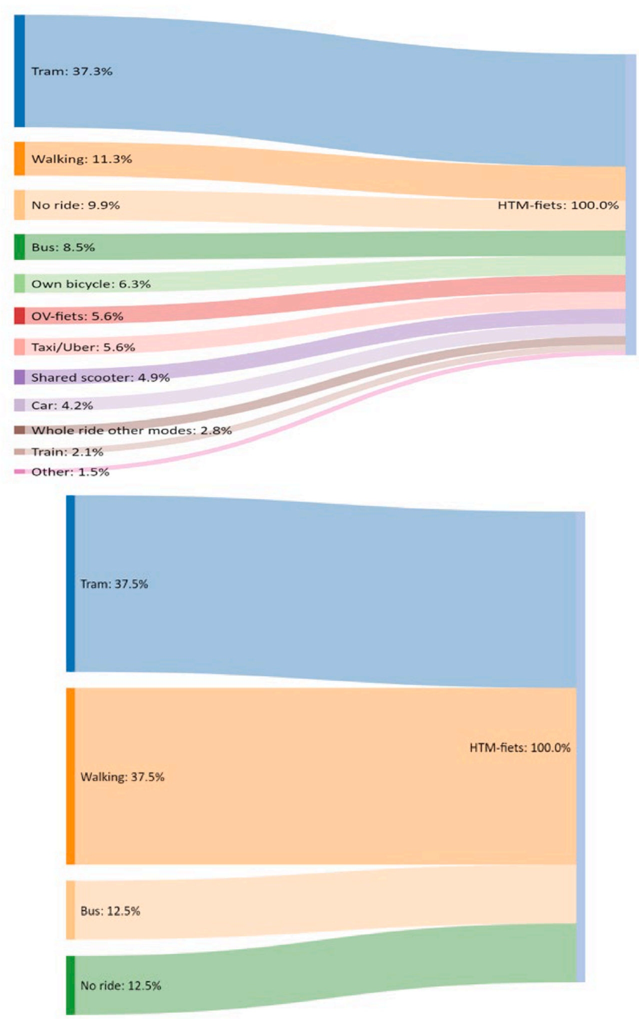

Fig. 6. Mode used if HTM-fiets was not availableup: HTM-fiets for entire ride (n = 142) and down: HTM-fiets in combination with urban transit (n = 8).

4.3. Why use HTM-fiets as standalone or in combination with urban transit?

This section discusses the influence of various factors on the extent to which people use HTM-fiets standalone or in combination with urban transit. We explore reasons for not using HTM-fiets in combination with urban transit. In addition, we tested age and several interaction factors in our logistic regression models.

Of the 14 respondents who indicated to use the combined mode more often than the BSP alone, six had a faulty description of the entire ride in the survey (due to not understanding the question and not matching drop zones and transit stops). So, we only have eight combined rides in our sample. The total trip length of each combined trip was determined based on the shortest distance via bicycle paths between the start and end location of each combined trip, which includes both the HTM-fiets ride and the bus/tram ride. It thus represents the shortest distance that would have been travelled if the entire ride had been made by bicycle without detours. The average trip length of the combined trips is 6.1 km. The trip lengths of HTM-fiets only rides have a lower average trip length of 4.1 km. This suggests that combined rides generally have a longer trip length compared to HTM-fiets only rides. However, given our small sample size we cannot state this with certainty. Our sample (n = 8) is also too small to draw conclusions regarding the question if the combination was more often used from the edges of the city or for commuting, as the literature suggests (Martin and Shaheen, 2014; Faghih-Imani and Eluru, 2015).

A Chi-square independence test is used to test if the socio-demographic and attitudinal factors are significantly different in the extent to which people use HTM-fiets in combination with urban transit or not. The seven categories of the extent to which HTM-fiets is used in combination are reduced to three categories: 'never' (n = 72), 'usually not' (n = 58) and 'sometimes to always' (n = 26). None of the socio-demographic and attitude factors are significantly different on a 5% confidence interval for the extent to which the combination is used. However, education level (Chi2(1) = 5.884, p = 0.053), level of bus use (Chi2(1) = 5.239, p = 0.073), and reason for using HTM-fiets is 'drop zone close to home' (Chi2(1) = 4.317, p = 0.116) are significant on the 15% confidence interval; these are included in the multinomial logistic regression.

Our final multinomial logistic regression model (containing most significant parameters of all the ones we tested) has a Pearson Chi-Square statistic, which is significant (Chi2 = 27.431, p = 0.017), which means that the model fits the data better than the intercept only model. Furthermore, the model has a Nagelkerke R-square of 0.191, thus explaining about 19% of the variability in the data. We chose to show the Nagelkerke pseudo-R-square here because of communicative reasons, as this pseudo-R-square scales from 0 to 1 just like the R^2 in linear regression that it tries to approximate. Table 3 shows the results of the model. The reference category for this model is the category 'sometimes to always'. All variables presented are significant on the 10% confidence level. The model shows that someone with high education has a higher probability to use BSP standalone compared to someone with low education. Furthermore, people who have a low level of bus usage have higher odds of never (or hardly ever) using the combination of HTM-fiets and bus/tram. Also, age is a significant explaining factor. Younger and middle-aged people (<45) show higher odds to use HTM-fiets stand alone in our model. Finally, the odds of never (or nearly ever) using the combination HTM-fiets and urban transit is lower for a person that disagrees with or is neutral about the necessity of having a drop zone close to home (this factor is moderated by age). In other words, these persons seem to mind about drop zones locations in their choice of using eventually HTM -fiets in combination with urban transit.

In addition, respondents who use HTM-fiets more often not in combination (142 respondents) were asked what their reasons were for not using the combination. Table 4 shows the most provided answers, where most people said it was not necessary to use the combination because HTM-fiets was sufficient for the entire trip. This suggests that they can travel in a convenient way by bicycle alone. Furthermore, a lot of people specifically use HTM-fiets instead of the bus/tram (substitute), where some explained that this is because the BSP is faster/cheaper or that they have less access/egress time from the train with HTM-fiets compared to

Table 3
Results of Multinomial Logistic Regression (n = 156).

	Variables	Beta	Std. Error	Wald	Df	Sig.	Exp(B)
Never	Intercept	−0.099	0.737	0.018	1	0.893	
	Education [low]	−1.364	0.648	4.426	1	0.035	0.256
	Education [high]	0			0		
	Level of bus use [low]	1.447	0.581	6.194	1	0.013	4.25
	Level of bus use [high]	0			0		
	Age (<25)	2.525	1.314	3.691	1	0.055	12.468
	Age (25–44)	1.833	0.078	4.363	1	0.037	6.254
	Age (+45)	0					
	Drop zone close to home [disagree/ neutral] * Age (<25)	−3.273	1.651	3.928	1	0.047	0.038
	Drop zone close to home [disagree/ neutral] * Age (25–44)	−2.46	1.206	4.159	1	0.041	0.085
	Drop zone close to home [disagree/ neutral] * Age (>45)	0					
	Drop zone close to home [agree] * Age (<25)	0					
	Drop zone close to home [agree] * Age (25–44)	0					
	Drop zone close to home [agree]*Age (>45)	0					
Hardly ever	Intercept	−0.747	0.821	0.828	1	0.363	
	Education [low]	−1.76	0.712	6.104	1	0.013	0.172
	Education [high]	0					
	Level of bus use [low]	1.072	0.588	3.32	1	0.068	2.921
	Level of bus use [high]	0					
	Age (<25)	3.664	1.38	7.05	1	0.008	38.999
	Age (25–44)	2.422	0.959	6.378	0	0.012	11.263
	Age (+45)	0					
	Drop zone close to home [disagree/ neutral] * Age (<25)	−3.666	1.685	4.72	1	0.03	0.026
	Drop zone close to home [disagree/ neutral] * Age (25–44)	−2.744	1.282	4.579	1	0.032	0.064
	Drop zone close to home [disagree/ neutral] * Age (>45)	0					
	Drop zone close to home [agree] * Age (25–44)	0					
		0					

(continued on next page)

Table 3 (*continued*)

Variables	Beta	Std. Error	Wald	Df	Sig.	Exp(B)
Drop zone close to home [agree] * Age (<25)						
Drop zone close to home [agree] * Age (25–44)	0					

Table 4
Reasons why people don't use HTM-fiets in combination.

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

with urban transit. 11 respondents mentioned they use HTM-fiets when the bus or tram is not available, e.g. during the night or in case of disruptions in the transit service. Furthermore, the location of drop zones is mentioned, because drop zones are mostly located at transit stops. This means that if people want to use HTM-fiets to travel from the bus/tram stop to their destination, they often cannot return the bicycle at their destination. In that case the bicycle can only be paused. This might still be interesting if they have a short meeting, but if they want to stay at their destination for a longer period, they pay the daily rate, which reduces the attractiveness of the system.

5. Conclusion and recommendations

This paper presents the findings of an investigation to the extent to which a bicycle sharing program (BSPs) is used in combination with urban transit or as a self-standing mode. For this study, the users of HTM-fiets, a BSP located in The Hague, Netherlands, were invited to participate in a survey that aimed to explore the use of HTM-fiets in relation to urban transit. We found that HTM-fiets users are often male, aged between 25 and 44, and highly educated, which is comparable with users of other BSPs elsewhere (Ma et al., 2020; Murphy and Usher, 2015; Van Waes et al., 2018, Van Waes et al., 2018). Furthermore, they often own 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., 2012). This difference is likely caused by the high level of bicycle ownership within the Netherlands (and The Hague).

Our main conclusion is that the BSP (HTM-fiets) is generally not used complementary to urban transit but as a substitute. Of all HTM-fiets users in the sample (156 respondents), only 9% has indicated that they use the HTM-fiets in combination for at least half of their trips. Of those who use HTM-fiets alone, 46% have used it as substitute for bus and 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. We are aware that this conclusion is based on a relatively small share of the BSP users in The Hague. Hence, we are not sure whether the use behaviour we find in our sample represents the use behaviour of the whole population of BSP users. However, we think that our conclusions still hold in case we had a larger sample, however the exact extent to which they hold is uncertain. The main reasons why the combination of the HTM-fiets and urban transit is not often used, include that it is not necessary for most rides, among others because distances in the city are relatively short, and that people specifically use the HTM-fiets instead of transit 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 transit is less available and that drop zones are not located in the right places to facilitate the combination. The survey also shows that the most frequent used pick-points are the two main regional and national train stations, where 43%-67% of the respondents who picked up or returned an HTM-fiets, arrived or departed by train.

Our model showed that a higher education level, a low level of bus use, young age and agreeing 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 never or nearly ever use the combination.

Our results imply that the provider of 'HTM-fiets' (also the transit provider in this case) faces difficult choices because the combined use of bicycle –transit (for which the provider aimed) is low. On one hand, this large substitution impact may negatively influence their business case. On the other hand, a large substitution impact may also help them alleviate crowding problems in transit (which can be positive for their business case) and they can view 'HTM-fiets' as an extra service offered to increase accessibility of the city. Additionally, our results imply that there are several design options (e.g., implementing specific drop zones, using geo-fencing, aiming at better integration with the bus and tram network, and focusing on the coverage gaps). Or implementing lower bicycle tariffs for long distance commuters) to turn 'HTM-fiets' and urban transit into a more complementary system. However, more research is needed into the effect of these design options on the business case of BSP and urban transit. More details on this full study can be found in van Marsbergen (2020).

We argue that our results are especially applicable to other Dutch cities (roughly > 150,000 inhabitants) because cycling culture, city size, transit systems are more or less comparable. For these kinds of cities (and their transit provider) the lessons learned in this study can be used when implementing a similar system. For other countries, the findings should be interpreted with more care because of different city characteristics, cycling culture, transit network, and BSPs. The main lesson would be to focus on integrated planning of BSP and public transport in case a complementary system is aimed for. After all, our case shows clearly that just adding a BSP next to an existing urban transit service will not result in a complementary system per se. Consequently, for these cities it would be interesting to survey users of BSPs in similar situations to gain more evidence on how BSPs is used in relation to urban transit. This research focused on individual trips, however it would be interesting and useful for the business case to investigate the total mobility pattern of individuals, to see which position BSP's and urban transit could take on that macro level. A comparison with BSPs that are operated in completely different circumstances, would also provide interesting follow-up research, since this can show in which cases BSPs help increasing the strength of the bicycle-transit combination as a way to make cities better accessible.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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