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Bicycle parking choice behaviour at train stations

A case study in Delft, the Netherlands

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Abstract Due to the increasing use of the bicycle as access and egress mode to public transport hubs, bicycle parking facilities are being constructed and extended. The provision of appropriate infrastructure requires the understanding of the needs and preferences of the cyclists. In order to gain insights into the parking spot choices of the cyclists, we have collected data at a bicycle parking facility in Delft train station (the Netherlands). This dataset is used to estimate discrete choice models that distinguish between an uncongested (i.e. many empty spots) and a congested (i.e. almost full) state of the facility. The findings reveal that cyclists want to park close to the exit of the parking facility which promotes the design in tiers. At the same time, they want to exert minimal effort, which calls for an easier mechanism to park in the top tier. Last but not least, providing real-time information signs is advisable, as it facilitates the parking spot choice as by reducing searching time.

1 Introduction

The interest in and use of bicycles is increasing in urban areas, also as access and egress mode for longer distance trips. The latter requires the provision of seamless connections to other modes. Bicycle parking facilities at train stations, for example,

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are of vital importance to guarantee this seamless connection. In order to provide appropriate bicycle parking infrastructure, it is important to understand and predict the bicycle flows and time spent in the facility. One of the main determinants of the underlying model is the parking spot choice behaviour of cyclists. To the best of the authors' knowledge, there is no study investigating this choice behaviour from the perspective of the cyclists. The contribution of this paper is, thus, to fill this gap and develop a corresponding choice model.

As a starting point, literature related to car parking choice has been consulted and transferability to bicycle parking choice is discussed. It has been found that car drivers tend to choose spots that are closer to their destination [3]. This effect is especially present for male drivers [5, 6]. The factor age is only significant when a parking fee is applicable [4]. [6] found a difference between parking behaviour during quiet and busy times. This difference has been observed to particularly affect the usage of real-time information signs that display the availability of spots. Drivers do not use the signs when they drive to their first preferred spot. When that is not available, they make use of the signs to find an available spot [2]. In another study, however, the information signs were found to be used and trusted by the drivers leading to time savings [1]. Even though the precise use of the information signs is inconclusive, it becomes clear that they do play a role in the parking choice.

By transferring these car-related findings to bicycles, we hypothesise that the bicycle parking choice follows the flow diagram of Fig. 1. A cyclists entering the parking facility needs to weigh two elements, namely the walking distance to the exit and the parking effort when there is an upper and a lower tier. Moreover, we hypothesise that the occupancy of the facility matters. In an uncongested parking facility, cyclists are free to park in their desired spot, while in a congested state (i.e., when the majority of the parking places is occupied), the availability of spots is also weighed in, by considering the real-time information (RTI) signs. Personal characteristics, such as age and gender, are also believed to play a role in this choice. Gender is expected to influence the importance of walking distance, while age affects the significance of parking effort. As we expect that the state of the parking facility affects the parking choice behaviour of cyclists, we develop two models, one for each state, using the random utility maximisation principle and discrete choice theory.

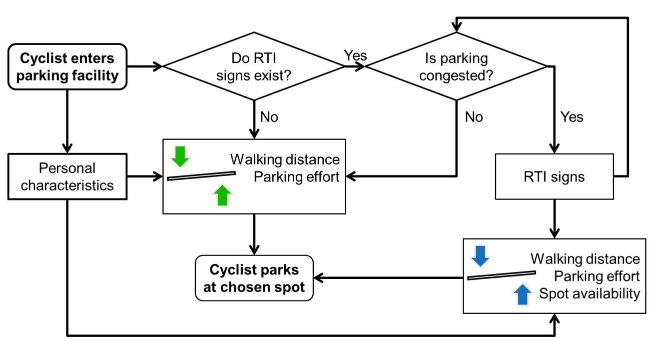

Fig. 1 Flow diagram of bicycle parking choice behaviour.

The paper is structured as follows. Sect. 2 describes the data collection of bicycle parking choices, which are used to estimate the behavioural models developed in Sect. 3. In Sec. 4 the results of the model estimation are presented and discussed, leading up to the conclusions in Sect. 5.

2 Data collection

The data collection took place at the central train station of Delft, the Netherlands. There are currently two underground bicycle parking facilities at this station, with a total of 7700 spots. Both have two tier parking spots and RTI signs. The second parking facility of about 2000 spots was chosen for the data collection, because the RTI signs show the spot availability per tier of each row, instead of per row which is the case in the first parking. The layout is sketched in Fig. 2, along with pictures taken inside the parking to show the RTI signs and the two tier design within a row.

Revealed and stated preference data were collected during the morning peak hours of two working days in December 2018. The revealed data consist of observations of the parking choices made by incoming cyclists and of recordings of the number of available spots as indicated by the RTI signs. In total, 1167 parking choices were observed over 13 rows with 2 tiers each. The RTI signs have an updating frequency of 1 min and the recordings were made with an interval of 5 min.

The stated preference data were collected by means of a survey, filled in by users of the parking facility. The questionnaire visualised four parking choice dilemmas, trading off the parking effort (top/bottom tier) and the distance to the parking exit (far/close). The respondents had to choose one alternative per case, which led to 460 stated choices. Moreover, the gender and age group (youngster, adult, elderly) were collected as personal characteristics in both datasets. The majority of the persons, however, belongs to the adult age group, which does not allow the further consideration of age as a factor affecting the bicycle parking choice.

3 Model estimation approach

The collected datasets cover aggregated spot choices, i.e., segments in the facility with similar characteristics containing multiple spots. These segments are discrete and finite and comprise the choice set. The estimation is based on the utility maximization principle as the decision rule. As previously explained, two parking choice models are developed, namely a congested and an uncongested model.

The observed (revealed) choices are used to estimate the congested choice model, since during the data collection the number of available spots was limited. Based on descriptive statistics, three attributes seem to have a statistically significant relation with the parking choice: (i) the tier, (ii) the walking distance to the parking exit and (iii) the availability indicated by the RTI signs.

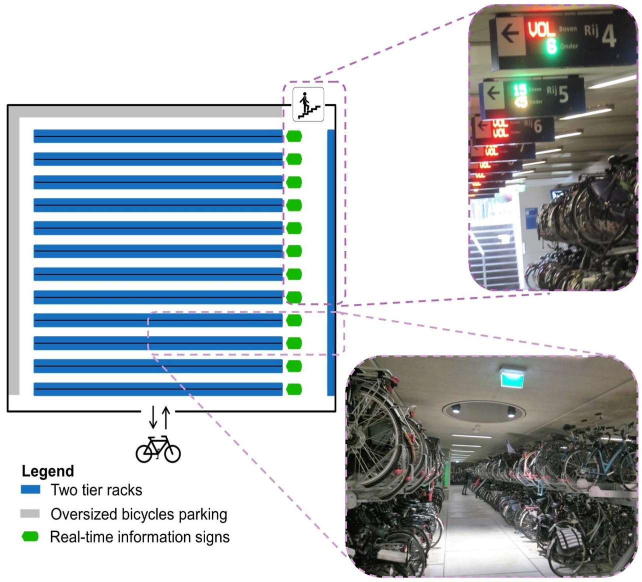

Fig. 2 Layout of observed bicycle parking facility in Delft train station, The Netherlands. The photos show the RTI signs and the arrangement of spots within a row in two tiers.

The tier of alternative i is coded as a dummy $D_{\mathrm{Top_i}}$ (top is 1, bottom is 0), while the walking distance from the middle of alternative i to the closest parking exit $WalkDist_i$ is a continuous variable. Both attributes are hypothesised to be influenced by the gender (M for males and F for females). Therefore, four interaction terms are considered in the utility function.

With respect to the availability signs, the information is captured in two attributes. The first represents the colouring scheme of the sign (see Fig. 2), which is red when the tier of a row is full, orange when there are less than 5 spots available and green otherwise. The hypothesis is that cyclists would opt to go towards a choice alternative that has a green sign and, therefore, the dummy D_{Green_i} is created (green is 1, not green is 0). Moreover, if cyclists upon entering would inspect all the signs, they are considered more likely to choose an alternative that has a higher availability compared to the others. The dummy D_{HAV_i} takes the value 1 when the availability of alternative i is greater than the average of all alternatives, and otherwise it is 0.

The utility function for alternative i of the congested model is:

$$\begin{aligned} V_{\mathrm{congested}_i} = (\beta_{\mathrm{TopF}} \cdot F + \beta_{\mathrm{TopM}} \cdot M) \cdot D_{\mathrm{Top}_i} + \beta_{\mathrm{Green}} \cdot D_{\mathrm{Green}_i} + \\ (\beta_{\mathrm{WalkF}} \cdot F + \beta_{\mathrm{WalkM}} \cdot M) \cdot WalkDist_i + \beta_{\mathrm{HAV}} \cdot D_{\mathrm{HAV}_i} \end{aligned} \tag{1}$$

The estimation of the uncongested choice model is based on the survey (stated choices). The attributes of this model are the two parking spot properties that were traded off in the survey. The tier attribute is similar to the congested model, including the two interaction terms with the gender. The distance to the parking exit in this case is a dummy D_{Close_i}, indicating whether alternative i is close to or far from the exit (close is 1, far is 0).

The utility function for an alternative i of the uncongested model is:

$$V_{\text{uncongested}_i} = \beta_{\text{Close}} \cdot D_{\text{Close}_i} + (\beta_{\text{TopF}} \cdot F + \beta_{\text{TopM}} \cdot M) \cdot D_{\text{Top}_i} \quad (2)$$

4 Results

The estimation results of the two models are summarised in Tab. 1. Negative parameter values correspond to a decrease in utility, while positive values indicate an increase. All considered attributes prove to be statistically significant, and hence they affect the parking behaviour choice.

The negative parameters for the top tier indicate that cyclists dislike parking in the top tier. Top tier spots are for both models four to five times less attractive for female cyclists compared to male cyclists.

Regarding the walking distance to the exit, cyclists prefer to minimise it by parking closer to the parking exit. In congestion, male cyclists penalise walking distance twice as much as female cyclists. This is in line with their lower disutility for top tier spots. It means that male cyclists prefer to park as close to the exit as possible, even if it requires greater parking effort, while female cyclists would rather walk further to find a spot in the bottom tier. The break-even point in this trade-off is 56.5 m for women, in comparison to 6.5 m for men.

With respect to the real-time information signs, a green indication increases the utility of that alternative. High availability also has a positive influence, though a bit more conservative. The reason might be that it is rather easy for incoming cyclists to check the colour of all signs, but comparing the actual numbers is more involved and they are less willing to perform the calculations. In any case, it is proven that the RTI signs are appreciated by cyclists when the parking is at a congested state and the effort to find a spot is higher because of the scarcity of spots.

Table 1 Model estimation results

Model ($\bar{\rho}^2$)	Coefficient name	Description	Value	Robust standard error	Robust t-test
Uncongested (0.16)	β_{TopF}	Top tier & Female	-1.38	0.18	-7.64
	β_{TopM}	Top tier & Male	-0.29	0.13	-2.19
	β_{Close}	Close to exit	0.91	0.16	5.68
Congested (0.10)	β_{TopF}	Top tier & Female	-2.26	0.14	-16.54
	β_{TopM}	Top tier & Male	-0.52	0.11	-4.81
	β_{WalkF}	Walking distance & Female	-0.04	0.01	-5.57
	β_{WalkM}	Walking distance & Male	-0.08	0.01	-2.19
	β_{Green}	Green number in RTI sign	1.05	0.14	7.58
	β_{HAV}	High availability	0.64	0.09	7.10

5 Conclusions

The present study investigated the bicycle parking choice behaviour at parking facilities present at public transport hubs. Data were collected at a bicycle parking facility in Delft, the Netherlands, and used to estimate two discrete choice models, which capture the different behaviour under a uncongested and a congested state of the facility.

The model estimation results reveal that cyclists prefer to park close to the exit of the parking facility to reduce their walking distance. At the same time, they dislike exerting effort when parking. This attitude is stronger for women, who would rather walk more than 50 m to find a spot in the bottom tier, while the corresponding threshold for men is lower than 10 m. The information signs were found to have a positive contribution to the utility function, especially with respect to the colouring scheme.

These insights have implications for the design guidelines of parking facilities. In order to reduce walking distances, the tier design is promoted as it decreases the size of the facility. However, this increases the parking effort, which is especially disliked by women and may call for the installation of an easier mechanism to park in the top tier in the rows furthest away from an exit of the facility. Last but not least, providing real-time information signs with colours for different occupancy levels is advisable, as it facilitates the parking spot choice by reducing the search time.

It is important to check the transferability of these findings before design guidelines can be developed. Future studies should also further investigate the effect of age, as it might have an influence on the parking effort.

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References

1. Axhausen, K.W., Polak, J., Boltze, M.: Effectiveness of parking guidance and information systems: Recent evidence from nottingham and frankfurt/main. Transport Studies Unit Oxford Uuniversity-publications-TSU-all series- (1993)
2. Axhausen, K.W., Polak, J.W., Boltze, M., Puzicha, J.: Effectiveness of the parking guidance information system in frankfurt am main. Traffic Engineering+ Control **35**(5), 304–9 (1994)
3. Bonsall, P., Palmer, I.: Modelling drivers' car parking behaviour using data from a travel choice simulator. Transportation Research Part C: Emerging Technologies **12**(5), 321–347 (2004)
4. Tsamboulas, D.A.: Parking fare thresholds: a policy tool. Transport Policy **8**(2), 115–124 (2001)
5. Vo, T.T.A., van Der Waerden, P., Wets, G.: Micro-simulation of car drivers' movements at parking lots. Procedia engineering **142**, 100–107 (2016)
6. van der Waerden, P., Borgers, A., Timmermans, H.: Travelers micro-behavior at parking lots-a model of parking choice behavior. In: Proceedings of the 82nd annual meeting of the transportation research board (2003)