Behavioural models for cycling - Case studies of the Copenhagen Region. - DTU Orbit
(06/12/2018)

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Bicycle transport has traditionally been underrepresented in traffic models, because historically the main focus has been on modelling more resource-intensive investments in motor traffic roads and public transport. In order to decrease road congestion and to reduce the related health and societal problems, there is a growing interest in promoting more sustainable transport systems, with a particular emphasis on the bicycle as a sustainable transport alternative. Consequently, the objective of this PhD study is to expand the knowledge about travellers' choices of the bicycle as a mean of transport above other alternatives, as well as to create knowledge on the interaction between infrastructure and cyclists' route choices. In this study, the focus is on the traditional approaches to mode choice modelling, where the focus is on all transport modes, as well as the modelling of cyclists' route choices. The study focuses on identifying which conditions can: (i) promote bicycle use, with an emphasis on everyday cycling; (ii) influence the shift from motorised private transport to a more sustainable transport alternative; and (iii) find methods that make cycling more attractive, e.g., improving accessibility. The private car is the most dominant mode of transportation in cities throughout the world, even for short trips where it could easily be replaced by more sustainable transport options, such as bicycles. Like the car, a bicycle provides flexibility when travelling. It also cost much less and, in some cases, is even a faster and more efficient choice of transport, especially in highly congested areas. While the car might be a more popular alternative, especially in suburban or rural areas where activities are dispersed over large distances, short trips appear more receptive to a decrease in the use of the car. In this PhD study, the mode choice behaviour when travelling short distances was analysed, in the Copenhagen Region, in order to identify factors that affect the travellers' choices. Mixed logit models were estimated, in order to capture taste variations and differentiate travel time parameters across modes, on a dataset including trip information and socioeconomic variables for 7,958 individuals and 10,982 trip chains with five available alternative modes (i.e., walking, cycling, car driver, car passenger, and public transport). The results showed that travellers' have heterogeneous preferences regarding the travel time of nonmotorised modes, and more homogeneous preferences regarding the travel time of motorised modes. The results also showed that mode choice behaviour in short distance travelling is related to travellers' personal characteristics (i.e., gender, occupation, income, and having a public transport monthly pass) and their household characteristics (i.e., number of cars and family composition). Finally, the results showed that mode choice is also related to the trip characteristics (i.e., hilliness, temperature, trip purpose, urban characteristics, and parking availability). Lastly, the results showed that cyclists have a heterogeneous preference towards temperature and hilliness, meaning that some cyclists do not mind hilly areas or lower temperatures, while others do. In order to encourage the shift from private cars to more sustainable transport alternatives, decision-makers need to address specific population groups for specific trip purposes and focus on factors that are able to make cycling more attractive. The results suggested that further investigation of heterogeneity might uncover whether different population groups exhibit different preference structures. In previous literature on short trips, the focus has mainly been on mode choice models to uncover the determinants of choice between car and sustainable transport alternatives. Generally, the focus has been more on the characteristics of the alternatives and less on the socio-economic characteristics of the travellers, while considering the population to have homogeneous preferences and the same probability of shifting mode, regardless of their characteristics. However, this assumption appears rather unrealistic. In this thesis, in the first study on travel behaviour when travelling short distances, it was concluded that the choice between transport alternatives is not only related to the level-of-service characteristics of the alternatives, but also to a large extent the socio-economic characteristics of the travellers. Based on that study, a more suitable methodological approach was adopted, namely a latent class choice model, to identify lifestyle groups and to understand how lifestyle affects mode choice decisions when travelling short distances. The model allows linking observable characteristics of the individual with the probability of them having chosen a certain lifestyle and then the probability of individuals, with that specific lifestyle, choosing a specific transport mode for short distances. Short trip chains in the Copenhagen Region were investigated, on a data sample with 10,982 observations with five available alternative modes (i.e., walking, cycling, car driver, car passenger, and public transport). The results highlight the importance of investigating the heterogeneity of the population, when analysing the potential for switching from the car to sustainable travel modes. The results showed that the population is split into four lifestyle groups: auto-oriented, bicycle-oriented, public transport-oriented, and public transport-averse. This population split is according to several characteristics (i.e., gender, age, family composition, number of cars, income, occupation, and residence location). Each lifestyle group has a heterogeneous perception of travel time, where the rates of substitution between alternative transport modes were extremely different. In addition, each lifestyle group weighs the dispreferences for public transport transfers differently, has a different perception of weather conditions on active travel modes, and selects a transport mode depending on the trip purpose. When thinking about measures to increase the attractiveness of sustainable transport options in short distance travelling, decision-makers should: (i) propose traditional or creative solutions to encourage car-oriented individuals out of their cars; (ii) direct public transport-averse individuals with policies that make the car unattractive; and (iii) hinder the attractiveness of cars in the future for bicycle- and walk-oriented individuals. When thinking about bicycle infrastructure improvements, the reduction of cycling travel time has little effect on car-oriented individuals, unless the time savings are very high, and bicycle-oriented individuals will only modify their routes as they already consider bicycles the fastest choice. Efforts to increase the use of public transport, with the aim of improving the sustainability of cities, usually focus on the service of the public transport system itself, while the accessibility to and from the public transport network receives less attention. This PhD study contributes to the existing literature by investigating the choice of access and egress modes to and from train stations in the Copenhagen Region. This study adopted a mixed logit model that distinguished between the preference structure at the home-end and activity-end for travellers who have chosen trains as their main transport mode. The model accounted for the heterogeneity in the travellers' preferences and alternative mode perceptions, while investigating the effect of policy variables such as car parking availability, park & ride opportunities, bicycle parking availability and type, and the possibility of carrying bicycles.
on trains. The choices between five alternative transport modes was analysed (i.e., walking, cycling, being a car driver, being a car passenger, and riding a bus) for 2,921 observations of trips at the home-end of journeys, and 3,658 trips at the activity-end of journeys. The results showed that the choice of access and egress mode is affected by travel time and trip characteristics (i.e., travelling with someone or in the city centre), as well as underlining the relevance of bicycle parking and the possibility of carrying bicycles on trains to the choice of cycling to the train station. Most importantly, the results showed that travellers’ have heterogeneous preferences with regard to travel time and perception of the alternatives, as well as their preference structure relates more to their socio-economic characteristics (i.e., gender, season ticket, occupation and trip purpose, along with the number of cars and other motorists in the household) than the trip characteristics. The study successfully identified factors that can contribute to the sustainability of the travel choices after selecting a train as the main transport mode, e.g., by improving bicycle parking availability at train stations, but focusing on specific population groups might also contribute further, especially when considering travellers’ occupation and trip purpose. Bicycle route choice models provide measures to search for factors that make cycling more attractive. In this study, the findings from the model estimates depend on the observation of actual route choices and the generation of realistic alternatives. While collecting data on actual route choices has greatly profited from enhancements in GPS device technology, the post-processing of such large data is still difficult. In this study, a fully automatic postprocessing procedure was proposed and applied to extract relevant information for further analysis. It makes it possible to process raw individual-based GPS data, with no additional information required from the respondent, by combining fuzzy logic- and GIS-based methods. By applying this method it is possible to automatically identify trips, trip-stages, and the most probable transport mode used on each trip-stage. The method was validated on a dataset consisting of raw individual-based GPS logs, collected from 183 respondents living in the Greater Copenhagen area, with a total of 427 trip legs, thereof 113 bicycle trip legs. The method was validated through the application of a control-questionnaire. The study showed that using the proposed method: (i) correctly linked 82% of the reported trip legs to corresponding trip legs, (ii) avoided classifying non-trips such as scatter around activities as trip legs, (iii) correctly identified the transport mode for more than 90% of the trip legs, and was robust through the specification of the model parameters and thresholds. The results document that using the proposed method enabled the possibility of using individual-based GPS units to collect travel surveys in large-scale multi-modal networks. The literature on the generation of alternative route sets has mainly focused on the implementation of path generation methods for cars or public transport, which are normally generated on a simplified network. Only few studies have focused on bicycle route choice sets, which require a highly detailed network. In this study, the efficiency of choice set generation methods was analysed by their ability to generate relevant and heterogeneous bicycle routes in a high-resolution network by using different evaluation methods, such as replicating the observed routes while also generating realistic alternatives that take into account taste heterogeneity across cyclists. Three choice set generation methods for bicycle route choice were examined: A doubly stochastic generation function, a breadth first search on link elimination, and a branch & bound algorithm. The dataset used to evaluate the methods consisted of 778 bicycle trips traced by GPS and carried out by 139 persons. In addition, the extension of cost functions was proposed with bicycle-oriented factors not limited to distance and time, but also other factors considered relevant to cyclists, i.e., scenic routes, dedicated cycle lanes, and road types. The results showed that both the doubly stochastic generation function and the breadth first search on link elimination generated realistic routes, while the first produced more heterogeneous routes and the latter outperformed in computation cost. The two methods revealed similar performances in terms of coverage, i.e., almost 64% and 68%, respectively. The branch & bound method had lower coverage compared to the other two methods, as it reproduced approximately 40% of the observed routes. As to be expected, shorter routes resulted in a very good coverage for all methods, where there are typically (much) less possible alternative routes, while longer routes exhibited larger differences across algorithms, with the doubly stochastic generation function performing best. The results also indicated the heterogeneous and complex preference structure for cyclists when considering routes, thus emphasising the importance of realistic and heterogeneous alternative route sets for model estimation. Based on the above data, cyclists’ route choices were analysed by estimating a path-size logit model, accounting for similarities between the alternative routes. A large sample of GPS observations was estimated, comprised of 3,363 bicycle trip legs. The logit-rank of the pathsize variable was significant and positive, thus correctly accounts for route overlap. The results showed that cyclists are sensitive to the effects of distance, cycling the wrong way, hilliness, different bicycle facility types, bicycle bridges, surface type, intersection type (i.e., cyclists prefer roundabouts over other crossing types), the number of motorised traffic lanes, and crossing water/sea on motorised traffic bridges. Whereas motorised traffic type, speed limit, annual average daily traffic (AADT), time dependent traffic volumes, and accident patterns had no statistically significant effect on cyclists’ route choices. Most importantly, the results showed that cyclists appear to place relatively high value on different land-use conditions along the routes, that is, dispreference for high residential area and/or town centre and industrial areas, a willingness to take detours to cycle in recreational areas or parks when they are on both sides of the path, but avoidance of these detours when such areas are on one side of the path. Previous model estimates showed that the parameters describing paths along a scenic area and in forests did not have a significant effect on cyclists’ route choices. The results also showed that personal characteristics influence the route choice (i.e., gender and type of cyclist), that there were differences in route choice preferences depending on the time of day and whether it was weekday or weekend, and also different weather conditions (i.e., temperature, rain, and sunshine). The route choice model can be used to forecast future travel behaviour. However, the interaction between the bicycle route choice model and the mode choice models needs to be investigated. By focusing on the interaction between infrastructure and route choice of cyclists, it is possible to contribute to the understanding of which factors influence cyclists’ route choices. The work conducted in the PhD study contributes to the current literature on bicycle transport by investigating the choice of the bicycle as a transport alternative and cyclists’ route choices. Problems related to the modelling of cyclists’ route choices were successfully solved, i.e., by collecting actual route choices using individual-based GPS units, postprocessing the raw GPS data in order to get usable information on observed bicycle routes, and effectively generating realistic alternatives in a high resolution network. It was possible to analyse travel behaviour on extensive revealed preference data and the study
showed that it is possible to estimate quite advanced models on an elaborate set of variables and utility functions. The findings showed that it is important to take into consideration the heterogeneity of individuals and that decision-makers should focus on specific individuals or groups within the population when thinking about measures to increase the appeal of sustainable travel options. The findings also showed the importance of well-built bicycle facilities and the importance of choosing the location of such facilities carefully.

**General information**
State: Published
Organisations: Department of Transport, Traffic modelling and planning
Contributors: Halldórsdóttir, K., Nielsen, O. A., Prato, C. G.
Number of pages: 325
Publication date: 2015

**Publication information**
Publisher: Technical University of Denmark, Transport
Original language: English
Electronic versions:
Katrin_PhD_FINAL.pdf