Attractiveness of public transport systems in a metropolitan setting - DTU Orbit
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Attractiveness of public transport systems in a metropolitan setting

Attractive public transport systems are essential for ensuring mobility in metropolitan areas as urbanisation continues to put pressure on the increasingly congested transport networks. It is therefore important to design attractive public transport systems which appeal to not only captive, but also choice users if public transport is to accomplish its share of transport growth. This requires a system that meets the expectations of the travellers in terms of providing a competitive and timely service, which is traditionally associated with expensive metro systems. However, cost-effective systems such as Bus Rapid Transit (BRT) and Light Rail Transit (LRT) have become increasingly popular alternatives for relieving congestion and creating attractive public transport in mediumized cities or corridors where metro networks are financially infeasible. The objective of this PhD study is to create a better understanding of the determinants of attractiveness of public transport systems in an urban setting. Due to the width of the topic, this thesis includes six individual contributions, which seek to analyse public transport from different perspectives. However, all studies focus on how to ensure attractive public transport systems as perceived by both passengers at the individual level and for society at an overall level. This includes comparisons across the main public transport modes, namely BRT, LRT and metro or heavy rail systems, to contribute with insights on possible differences, which is especially important when considering the large differences in construction costs. The analyses performed as part of this thesis can be divided into three research areas within the overall theme, namely i) public transport operations, ii) effects of implementing the systems on a larger scale, and iii) the main determinants of travel satisfaction. The first part contains a two-fold analysis of specific aspects related to public transport operations. The first study analyses on-street public transport systems, i.e. BRT and LRT, with the objective of evaluating design elements and implementation. These systems comprise many design elements ranging from infrastructure elements, e.g. partly segregated bus lanes or fully segregated busways, to Advanced Public Transport Systems (APTS) elements, e.g. pre-board fare collection, signal prioritisation, and holding strategies. Due to the large flexibility in implementing these systems effects can vary widely across systems. This thesis proposes to evaluate such systems using a combined mesoscopic simulation model and large-scale public transport assignment model. This allows for analysing in detail the effects of individual service elements while similarly evaluating the effects in the entire transport network. The results from a case study suggest synergy effects when implementing BRT and LRT as coherent systems including both segregated infrastructure and APTS elements, hence highlighting the importance of thorough planning. Another important part of public transport operations is to minimise waiting times for passengers which is the topic of the second study. While much research has focused on minimising waiting times at transfers this study proposes a general framework for modelling and evaluating passengers’ first waiting time when accessing the public transport system. In these cases passengers have the possibility to time their arrival at the station based on the timetable, hence passengers will either arrive randomly or nonrandomly. This study proposes to model this arrival behaviour explicitly by a mixture distribution consisting of two components, namely a uniform distribution and a beta distribution. The framework is validated using a large-scale Automated Fare Collection (AFC) system from the Greater Copenhagen Area, which showed that a large share of passengers arrive timely even at short headways, i.e. 5 minutes. These results highlight the importance of providing accurate and updated timetables to passengers allowing them to minimise their waiting time, which is perceived as more onerous than other time components. The importance of this finding is further emphasised when considering that public transport operators are using frequency-based timetables, which can be seen as less attractive for passengers if headway times are longer than 5 minutes. The general framework can be easily adopted in transport models, thereby ensuring more accurate estimations of passenger effects when evaluating changes to operations.

The second part focus on aggregate effects of public transport systems in terms of traffic impacts, strategic effects and ridership attraction with specific focus on the differences between public transport modes. The findings of a literature review of 86 systems showed that less expensive BRT systems can obtain large effects in terms of travel time reductions resulting in significant changes to mode choice as car users move to public transport. However, the effects vary notably due to differences in system design and dependent on local conditions, e.g. the relative attractiveness of the systems as compared to the rest of the transport system. In terms of strategic effects the review observed similarly large increases to property values after implementing BRT systems as after implementing its rail-based counterparts, LRT and metro. However, effects varied notably across systems, hence highlighting the influence of local conditions. In summary, the attractiveness and effects of new public transport systems were independent of mode as effects were more related to the general improvement. However, for highcapacity BRT systems it is a larger challenge to avoid negative externalities while still ensuring attractive station environments within dense urban areas. In terms of ridership attraction, a regression analysis estimating public transport network ridership across 48 European cities found significant influence from service coverage and urban density. The analysis specifically revealed four underlying factors in the dataset. Ridership was positively associated with the coverage of metro, suburban, and light rail networks, employment and population density, and network connectivity including transfer possibilities. On the other hand, ridership was negatively associated with economic inequality in terms of unemployment, GDP per capita, car ownership and GINI coefficient.

The third part includes two studies on travel satisfaction with specific focus on the influence of psychological beliefs rather than solely focusing on service characteristics. This thesis contributes to extending previous research by analysing the psychological factors such as attitudes and norms, and specifically, whether the travel mode contribute to satisfying the needs of the travellers. This was analysed through two analyses using structural equation modelling of satisfaction survey data. The first study deployed a large-scale passenger satisfaction survey from six participating European cities. The results were consistent across all cities in highlighting three important factors influencing travel satisfaction, namely i) accessibility measures, e.g. travel speed, reliability and service frequency; ii) reasonable fares in terms of perceived value
of the system, and iii) norms in terms of perceived societal and environmental importance of public transport. Hence, this suggests that passengers not only prioritise traditional travel characteristics, but also consider other aspects when evaluating travel alternatives.

The second study extended previous research by proposing a general framework for representing the relationship between travel satisfaction and mode choice incorporating the Theory of Planned Behaviour and the ERG theory of human needs. This unifying framework allows for measuring and evaluating the sense of well-being rather than solely focusing on service characteristics. This included four sets of factors, namely i) existence needs, i.e. functional needs such as travel time and costs, ii) relatedness needs including social norms, iii) growth needs including attitudes and self-concepts, and iv) travel difficulties related to each transport mode, e.g. too far distance to nearest public transport stop and congestion or parking problems for car users. Using a tailor-made survey distributed in the multimodal Greater Copenhagen Area, the results confirmed that travel mode use frequency was related to overall travel satisfaction through a cyclical process while being subject to satisfaction of needs and travel difficulties. Specifically, the results suggested the importance of higher-order growth needs of selfefficacy and positive self-concepts in addition to functional needs. For public transport travel satisfaction and travel use frequency was mainly motivated by functional difficulties with other modes. In summary, this PhD study has contributed to research within public transport planning covering topics related to public transport operations, impacts of implementation, and determinants of travel satisfaction. This includes important implications for policy and practice as findings suggest the importance of ensuring coherent planning of public transport systems in order to obtain optimal results for passengers and society. Specifically, the results from this thesis show that significant improvements can be created with less expensive BRT systems if ensuring thorough planning and implementation. Finally, while the findings of this thesis confirm previous studies in highlighting the importance of traditional service characteristics, it also suggests a strong link between travel satisfaction, travel use frequency and psychological beliefs in terms of attitudes and social norms. Hence, it could be relevant for public transport to focus on addressing other needs of the travellers than pure transport, e.g. focusing on the environmental and social aspects as findings suggest are important for many travellers.

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