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Effects of perception on public bike-and-ride: A survey under complex, multifactor mode-choice scenarios

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ABSTRACT

Bicycles are an environmentally-friendly, energy-saving mode of transportation. Public bike-and-ride is a term used to describe the use of public bicycles combined with transit as a means of transportation. A new stated preference (SP) design scheme based on the factors respondents felt were most important was proposed to augment the traditional SP design under complex multi-factor and multi-level situations. iPads were used to automatically administer the survey under each design scheme and collect the choice behavior data for public bike-and-ride. The concept of perceived psychological distance was further proposed and used to estimate Logit models. Comparative analysis of these models shows for the traditional SP design scheme, some factors, including perceived psychological distance, have reduced statistically significant effects on public bike-and-ride choice relative to the new SP design scheme. This indicates that in scenarios with complex decisions, the decision-makers would reduce their consideration of some factors and simplify their decision process making the new SP survey design scheme more suitable to analyze their choice behavior in those cases. Model analysis showed that perceived psychological distance for each traveler is the most critical factor during the decision process for travel behavior analysis. Finally, sensitivity analysis was conducted to determine which factors in the new survey design were important to increase the share of public bike-and-ride users. Practical findings for promoting public bike-and-ride use are presented in addition to theoretical references for improving the traditional survey methods.

1. Introduction

With the rapid development of urban economies and the growth of car ownership, traffic congestion is becoming increasingly prominent in metropolitan areas while air quality is getting worse. As a result, it is important to promote the sustainable development of urban transportation systems to address these issues. As an energy-saving and environment-friendly traffic mode, public bicycles, or "bike share" systems have been successfully applied in many cities such as London, Washington D.C., and Hangzhou. The implementation of public bicycle systems can promote low carbon travel, improve the operational efficiency of urban transport and reduce both pollution and traffic congestion.

As of December 2014, the subway operating mileage in Beijing was over 527 km and the daily passenger volume has exceeded ten million passengers. As an environmentally-friendly access mode for subways, public bicycle systems increase

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the accessibility and attractiveness of public transit. In 2012, Beijing officially launched a trial operation of public bicycle system. Forty-thousand public bicycles have been deployed as of December 31, 2014. As part of the "One Hundred Congestion Mitigation Projects" initiative by the Chinese government in 2015, ten-thousand public bicycles will be added to cover the central business districts and residential districts within about 3 km of subway lines. However, the public bicycle system in Beijing is still not perfect due to the low density of rental stations and the inconvenience of borrowing and returning bicycles in some areas. Moreover, the riding environment for cyclists in most areas isn't cyclist-friendly due to mixed traffic flow, limited space and air pollution. Thus, the utilization of some public bicycle rental stations is not high enough.

As an integrated multi-modal travel choice, public bike-and-ride, defined as the combined use of public bicycles and the subway, can effectively improve the usage of public bicycle system. There are many factors affecting the choice behavior of travelers for public bike-and-ride such as travel environment, mode-related factors and psychological factors. The effective acquisition and analysis method of travelers' behavioral data for public bike-and-ride, especially the effect of psychological factors, under multi-factor and multi-level decision scenarios still needs to be explored in depth. The research results will help to identify key factors that can increase the share of public bike-and-ride and provide insight into the behavioral mechanism.

2. Literature review

Several researchers have discussed the applications of public bicycle systems and the traffic policies that may encourage the use of the system. Martens (2004) discussed the use of bike-and-ride in Netherlands, Germany and United Kingdom (UK) with widely differing bicycle cultures and infrastructure. Midgley (2009) and Shaheen, Guzman, and Zhang (2010) reviewed the bike share systems in several European cities which often operate as part of the city's public transport system. In terms of traffic policies related to the bicycle system, Martens (2007) proposed a country-wide program to secure bicycle parking at train stations and the introduction of flexible rental bicycles to facilitate the combined use of bicycles and buses. Pucher, Dill, and Handy (2010) found that integrated policies including infrastructure provisions, supportive land use planning, and restrictions on car use are required to improve the use of bicycles. Meanwhile, Lumsdon and Tolley (2001) also discussed the national cycle strategy (NCS) in UK, finding that many local authorities needed to utilize a more robust cycling strategy to accomplish national targets for increased bicycle use.

In terms of study methodology, several studies have analyzed public bicycle choice behavior using a stated preference survey and disaggregate models. Taylor and Mahmassani (1996) conducted a stated preference survey to analyze the choice preferences of automobile only, park-and-ride, and bike-and-ride. A nested logit model was established to conclude that bike lanes and wide curb lanes are an incentive for experienced bicycle users to use bike-and-ride. Wardman, Tight, and Page (2007) built a multinomial logit model to analyze the propensity toward bicycles based on revealed preference and stated preference data. The model results show that a completely segregated bike path has the greatest impact on encouraging bicycle use. Campbell, Cherry, Ryerson, and Yang (2016) employed a stated preference survey and multinomial logit model to suggest that the bicycle choice for people in Beijing is strongly, negatively impacted by trip distance, temperature, precipitation, and poor air quality.

Some studies used social equilibrium models, mathematical network models and other similar methods to analyze the travelers' public bicycle choice behavior. Fukuda and Morichi (2007) used the social equilibrium equations to analyze the conformity effects of bicycle users on the choice of bicycle parking locations. Lin and Yang (2011) proposed a mathematical model to describe the bicycle network and routing choices. Sensitivity analysis was also performed to gain important factors affecting the system use such as the fixed cost of locating a bicycle station and the construction costs for a bicycle lane. Vogel, Greiser, and Mattfeld (2011) used a Geographical Business Intelligence process, which includes a cluster analysis, to gain insight into the complex bicycle activity patterns, based on the operational data from bicycle sharing system. Borgnat et al. (2011) analyzed the behaviors of shared bicycles users based on spatial–temporal data of bicyclists' movements.

Descriptive statistical analysis has been used to deal with public bike-and-ride related studies. Both Rietveld (2000) and Keijer and Rietveld (2000) proposed that bicycles are an attractive access mode for railways. Findings indicated that unavailable or insufficient parking facilities for bicycles are primary factors that affect the use of bicycles. Krizek and Stonebraker (2010) analyzed factors related to the combined use of bicycle and transit such as transit mode, access and egress distance, and trip purpose. Several studies have explored the impact of weather on bicycle use. Brandenburg, Matzarakis, and Arnberger (2007) used a Psychological Equivalent Temperature rating system to conclude that recreational bicycle users are most sensitive to ambient temperature and precipitation. Flynn, Dana, Sears, and Aultman-Hall (2012) found that rainy days would reduce the likelihood of bicycling for commuters and higher temperatures would increase the likelihood of bicycling. In addition, Pucher and Buehler (2006) found that bicycle-friendly infrastructure can compensate for some weather impacts.

Social and psychological factors such as attitude, perception, subjective norms, social interactions and neighborhood effects are inherent determining factors that affect travel choice (Brock & Durlauf, 2001, 2002; Morikawa, Ben-Akiva, & McFadden, 2002; Morikawa, Tanaka, & Ogino, 1997). Some scholars also conducted exploratory research to analyze their impacts on bicycle choice behavior. Heinen, Maat, and van Wee (2011) analyzed the influence of commuters' attitudes toward convenience, low cost and health benefits for bicycle use on mode choice. Nkurunziza, Zuidgeest, Brussel, and Maarseveen (2012) examined the effect of various motivators, barriers and policy-related interventions on bicycle use.