



# Can bicycle relieve overcrowded metro? Managing short-distance travel in Beijing



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## ABSTRACT

Beijing is experiencing severe over-use of its metro system, as is the case in many large cities worldwide. Bicycle can be a competitive mode for short-distance intra-urban trips. In this paper, we explore whether it is possible to use bicycle to replace a portion of short-distance public transport trips. We collected data on bicycle choices and perceptions of bicycling environments. Participants are current metro, bus riders, and bicyclists from 8 short-distance travel scenarios which consisted of 24 study sites across Beijing. Multivariate binary logistic regression models were applied to test association between the perceived bicycling environment and bicycle choices of current metro riders, bus riders, and bicyclists. We found the highest potential for bicycle replacement was for travel distance equivalent to two stations, approximately 1.5km–2 km, with 13% of current metro riders and 10% of bus riders willing to switch. Several perceptual aspects of the bicycle and bicycling environments were revealed that influence intentions to shift to bicycling, including desires for a separated cycle lane, worries about exposure to air pollution and better travel time control. Also, we found there were clear differences between habitual bicyclists and those bicycling occasionally or never.

## 1. Introduction

Beijing is experiencing severe over-use of its metro system, as is the case in many large cities worldwide (China daily, 2016; Comet, 2011). The Beijing metro is the world's busiest in annual ridership, with 3.41 billion trips made in 2014 and peak single-day ridership reaching 10 million (Xinhua News, 2016). The metro experiences high levels of crowding and a large proportion of the metro network is officially over design capacity. During rush hour, 69 stations routinely restrict the number of passengers who can board to prevent the train from becoming too crowded for passengers waiting at other stations down the line (Beijing subway, 2015; People's Daily, 2015). At the same time, public buses carry a diminishing share of daily travel. The passenger volume in public buses saw 16 percent decrease from 2014 to 2016 (Xinhua News, 2016), resulting in a shift to metro and car since bicycling rates have been declining (Zhao, 2013). Bicycling for transport decreased from 62.6 percent to 17.9 percent of all measured travel during the period between 1986 and 2010 in Beijing. Meanwhile, the share of travelling by private car increased from 5 percent to 33.5 percent of the total. It seems that embracing motorized modes by car-oriented urban sprawl and densely developed multi-level road intersections are significantly related to less cycling (Zhao, 2013). Studies in

Beijing and Shanghai showed that closer proximity to public transport facilities tends to decrease use of bicycle for transport. A higher level of public transit services, usually with very low and subsidized fares (e.g., in Beijing), might also dramatically decrease the use of bicycle for commuting due to substitutive effects (Bamberg & Schmidt, 2003; Zacharias, 2002; Zhao, 2013). Fig. 1 shows situations of overcrowded metro in Beijing. Government has proposed to build metro lines parallel to the existing ones to relieve pressure on the system. The current metro system has 554 km of track in operation, and is expected to reach 1000 km by the end of 2020. Such an approach might relieve pressure on the existing system but is also very costly. Besides, urban rail transit provides no guarantee a city will save energy or meet greenhouse gas reduction targets (Mulley, Hensher, & Cosgrove, 2017; Toole, 2008).

On the other hand, bicycling is a mode of transport that can mitigate traffic congestion, improve environmental quality, and reduce the prevalence of physical inactivity and the associated burden of chronic non-communicable disease (Handy & Xing, 2011; Handy, van Wee, & Kroesen, 2014; Pucher, Dill, & Handy, 2010; Woodcock et al., 2009). Heavy car traffic made the bicycle less attractive (Yang & Zacharias, 2015). Surface congestion led to travel time increases by bus which decreased bus use rates. People shifted to the metro, which caused the overcrowding of the mass public transit system

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Fig. 1. Overcrowded metro in Beijing.

due to the complex interaction among the modes. In this study we focused purely on the role of the bicycle in relieving overcrowding in the metro for short-distance trips. Bicycling is one of the most direct, convenient, and pleasant options for many short-distance intra-urban trips (Woodcock et al., 2009). The bicycle can be seen as a complement to a city's public transit system (Martens, 2007; Sun, Webster, & Chiaradia, 2017; Sun, Zacharias, Ma, & Oreskovic, 2016; Zhao, 2013). The question is whether it is possible to attract a portion of short-distance public transport trips from metro to bicycle.

Using bicycle for short-distance travel could be a target of policy efforts in China. Travel distance is an important predictor for bicycling mode choice (Chillón, Molina-García, Castillo, & Queral, 2016; Handy et al., 2014; van Wee, Rietveld, & Meurs, 2006). Yang and Zacharias found relatively short commuting distance for many commuters in Beijing – 47.9% of residents and 32.5% of motorized commuters travel less than 5 km in three districts inside the 5th Ring Road (Yang & Zacharias, 2015). Correspondingly, a survey in Shanghai showed that in 80% of trips within 5 km distance, the bicycle was competitive in terms of time with the alternatives (Zacharias, 2005). Bicycle should be appealing for short-distance travel especially when bike ownership is ubiquitous, as is the case in China where there were 1.13 bicycles per household in 2008 (Zhang, Shaheen, & Chen, 2013).

Suggestions for facilitating bicycling relate to appropriate infrastructure such as separate bicycle lanes, dedicated bicycle pathways, bicycle parking, and traffic calming (Akar & Clifton, 2009; Meng, Koh, Wong, & Zhong, 2014; Pucher et al., 2010). However, evidence for a relationship between bicycling infrastructure and bicycle choice remains scarce in China's cities and shows mixed results in Western counterparts (Moudon et al., 2005; Parkin, Wardman, & Page, 2008; Zhao, 2013). Infrastructure alone cannot guarantee that more people will bicycle, especially those who usually do not bicycle (Gatersleben & Appleton, 2007). Previous studies have found low agreement between perceived and objective measures of bicycling environments (Ball et al., 2008; Kirtland et al., 2003; McGinn, Evenson, Herring, Huston, & Rodriguez, 2007). Non-bicyclists may incorrectly

report a lack of bicycle-supportive environments as a potential reason for not bicycling (Daley & Rissel, 2011; Daley, Rissel, & Lloyd, 2007; Fernández-Heredia, Monzón, & Jara-Díaz, 2014; Hoehner, Brennan Ramirez, Elliott, Handy, & Brownson, 2005; Ogilvie, Egan, Hamilton, & Petticrew, 2004). In China few studies have examined perceptions of bicycling environments by both bicyclist and non-bicyclist and their intentions to bicycle.

In this paper, we explore the potential of bicycling as a replacement for short distance public transport trips in Beijing. We used a series of short-distance travel scenarios to collect data on bicycle choices and perception of bicycling environments. Participants are current metro and bus riders, and bicyclists. The results can assist urban planners in restoring bicycle infrastructure, specifically by paralleling the metro system with bicycle facilities.

## 2. Methods

### 2.1. Short-distance travel environment selection

We used the daily passenger volume of metro stations as a criterion for selecting short-distance travel scenarios (Beijing Transportation Research Center, 2010), in an attempt to represent typical metro crowding levels. We deleted the highest, middle and lowest metro station passenger volume deciles. We then developed the short-distance travel environments for the selected metro stations. Four-station metro travel, which is about 5 km in Beijing, is used as the short-distance travel scenario in keeping with empirical evidence on bicycle use for intra-urban travel. The travel scenarios were located in three broad location categories, namely, the inner city, the fringe of the city, and the area between the inner city and the fringe. In addition, we set having bicycle lanes parallel to the metro line as a necessary condition in selecting candidates for the short-distance travel environments.

Eight short-distance travel scenarios were selected using the published metro maps of Beijing (Fig. 2). Sites for application of our survey were the two end and one middle stations on the metro line segment.

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