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Ridership and effectiveness of bikesharing: The effects of urban features and system characteristics on daily use and turnover rate of public bikes in China

Jinbao Zhao [a,b,*], Wei Deng [a], Yan Song [b]

[a] School of Transportation, Southeast University, No. 2 Si-pai-lou, Nanjing 210096, China
[b] Department of City and Regional Planning, University of North Carolina at Chapel Hill, Chapel Hill, NC 27599, United States

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ABSTRACT

As a pinnacle of green transportation with transit attributes, bikesharing has become particularly popular since the mid-2000s. Two crucial questions for the success of bikesharing adoption are how many riders can bikesharing attract, and what influences its effectiveness. To shed light on answers to these questions, this paper models the impacts of urban features and system characteristics on bikesharing daily use and turnover rate, using data constructed on 69 bikesharing systems in China. Prior to modeling, we provide an overview of bikesharing adoption in China, describing why they have been adopted, how they have matured, and how they have expanded. Results from data regression and comparison indicate that bikesharing ridership and turnover rate tend to increase with urban population, government expenditure, the number of bikesharing members and docking stations, whilst the number of public bikes shows significant but adverse signs in impacting bikesharing ridership and turnover rate. Data comparison shows that, to pursue an ideal bikesharing turnover rate in most Chinese cities, the bike-member (supply-demand) ratio should be better controlled within 0.2. Moreover, this study suggests that personal credit cards (allowing bikesharing members to pay "personal credit" rather than money if they do not return public bikes within the free use hours) and universal cards (integrating bikesharing systems into other urban transit systems through the use of a rechargeable smart card that can cover a range of payments and trips) can significantly raise bikesharing daily use and turnover rate. We recommend that bikesharing operators and transit agencies take the supply-demand thresholds and the adoption of personal credit cards and universal cards into consideration in the future bikesharing operation and development policy.

1. Introduction

Serving as an alternative of urban transit systems, public bikesharing has developed and spread into a new form of mobility across the globe since the mid-2000s (Parkes et al., 2013). Bikesharing is viewed as an economic, efficient, and healthy means of navigating through dense urban environments (O'Brien et al., 2014), and it provides a variety of pickup and drop-off locations, enabling an on-demand, very low emission form of mobility (Parkes et al., 2013). Bikesharing users can access public bikes on an as-needed basis without the bearing costs of bike ownership (Shaheen et al., 2010). In addition, by integrating with public transportation and other alternative modes, bikesharing provides a low-carbon solution to the "last mile" challenge of urban transit systems (Shaheen et al., 2010).

Whilst bikesharing is a relatively new form of transport in urban areas, adoption of this evolving transit model has become particularly popular in recent years (Shaheen et al., 2010, 2013; O'Brien et al., 2014). There are more than 600 bikesharing systems currently operating worldwide (DeMaio and Meddin, 2014; Christensen and Shaheen, 2014; Hughes, 2014) and a growing number of cities are planning to launch bikesharing to increase bicycle use (García-Palomares et al., 2012). This growth is catching increasing attention in planning circles in its own right.

For bikesharing's early adoption and sustainable development, a crucial issue is the recognition of the factors affecting its ridership and effectiveness. A bikesharing system with few riders and low turnover rate implies a poor investment economically, environmentally, and socially. A better understanding of factors driving its ridership and effectiveness can help inform future adoption policy and improve the performance of existing systems.

* Corresponding author at: School of Transportation, Southeast University, No. 2 Si-pai-lou, Nanjing 210096, China.
E-mail address: jinbaozhao@seu.edu.cn (J. Zhao).

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To shed light on this issue, in this study, we evaluate how urban features and system characteristics impact bikesharing ridership (daily use) and effectiveness (turnover rate), using data constructed on 69 bikesharing systems in China. The remainder of this paper includes four additional sections. The following section gives an overview of recent research on bikesharing, in particular, the studies since the year of 2010. The bikesharing development in China and the research design for this study are presented in Section 3. Section 4 describes the modeling results and findings. Finally, Section 5 concludes with policy implications of, and development revelations from, the ridership and effectiveness perspective.

2. Background

The first public-use bikesharing can be found in Amsterdam (the Netherlands) as far back as the late 1960s, with the introduction of the famous “White Bicycles” system (Shaheen et al., 2010). It became widely recognized in the transportation community with the pioneering large-scale and third-generation bikesharing system – Velo'v – launched in Lyon in 2005 (DeMaio, 2009; Midgley, 2011). Since then, it is becoming increasingly popular in towns and cities around the world with the growing concerns about global motorization and the externalities associated with driving, such as traffic congestion and greenhouse gas emissions.

To date, the existing knowledge of bikesharing is relatively thin but is growing rapidly with bikesharing's widespread expansion. Shaheen et al. (2010) analyzed the evolution of bikesharing around the world. In that study, they discussed bikesharing business models and lessons learned, highlighting the social and environmental benefits associated with bikesharing. They argued that while bikesharing is growing worldwide and can help address many of the concerns about the global climate change, energy security, and unstable fuel prices, its future demand and long-term sustainability are still uncertain. More research is needed for a better understanding of bikesharing's effects, operations, and business models in light of its reported growth and benefits (Shaheen et al., 2010).

Interest in bikesharing research has become particularly popular since the important Shaheen et al. (2010) study. Two years later, Shaheen et al. (2012) released a key report on bikesharing usage data and user feedback from detailed interviews with governmental agencies and bikesharing users in the United States and Canada. Based on the user survey (completed in Montreal, Toronto, Washington DC and the twin cities) with a decent sample size ($n=10{,}661$), Shaheen et al. (2012) found that the most common bikesharing trip purpose is work- or school-related (50–56% in the two Canadian cities and about 38% in the two American cities). Respondents in all cities indicated that they increased bicycling, whist most of them indicated that they drive less, as a result of bikesharing. Moreover, a majority of respondents reported getting more exercise since becoming a user of bikesharing. At the same time, there is evidence from Shaheen et al. (2012) that public bikesharing is improving urban travel connectivity, reducing driving and thus lowering vehicle emissions.

Because of these benefits, in recent years many cities round the world show enthusiasms in bikesharing adoption. To explore the adoption patterns of bikesharing systems, Parkes et al. (2013) provided an analysis on the diffusion of public bikesharing systems in Europe and North America. They concluded that “Europe is still in a major adoption process with new systems emerging and growth in some existing systems”, while “in North America, the adoption process is at an earlier stage and is gaining momentum”. They declared that the notable and successful systems in Paris, Lyon, Montreal, and Washington DC have sparked great interest in bikesharing in Europe and North America, yet one of the most potential markets for bikesharing – Asia – was missed in their study. Considering automobile in most Asian developing countries, such as China, is still less popular but shows a rapid growth trend in comparison with most of European and North American countries, it is useful to outline the adoption patterns of bikesharing in a developing context (such as China in this paper) to complement the research of Parkes et al. (2013).

A recent study by O'Brien et al. (2014) took a global view of bikesharing characteristics by analyzing data from 38 systems located in Europe, the Middle East, Asia, Australasia and the Americas. Through the analysis of the variation of occupancy rates over time and comparison across the system's extent, O'Brien et al. (2014) proposed a classification of bikesharing systems, based on the geographical footprint and diurnal, day-of-week and spatial variations in occupancy rates, which laid foundations for the analysis of larger scale bikesharing systems.

Researchers also conducted bikesharing studies at the urban level rather than global view. For example, Jensen et al. (2010) analyzed 11.6 million journeys of the Vélo'v in Lyon, constructing a map showing the likely flows of the bicycles across the city. Lathia et al. (2012) assessed the impacts of the “open policy” (that allows casual users to use shared bikes with a debit or credit card) of the London shared bicycle scheme, finding that open-access to the system correlating with greater usages. García-Palomares et al. (2012) proposed a GIS-based method to calculate the spatial distribution of the potential demand for bikesharing trips in Madrid, locating stations using location–allocation models, which is of great use for managing the redistribution of bicycles among the stations. Jäppinen et al. (2013) modeled the potential effect of shared bicycles on public transport travel times in Greater Helsinki. They found that the adoption of bikesharing can reduce public transportation travel times in the study area, on average by more than 10%.

Recent bikesharing research is also found, for example, in Kaltenbrunner et al. (2010), Lin and Yang (2011), and Chemla et al. (2012). These studies addressed bikesharing's issues form different concerns, such as prediction of available public bikes (Kaltenbrunner et al., 2010), bikesharing planning strategic (Lin and Yang, 2011), and system rebalancing (Chemla et al., 2012; Raviv et al., 2013; Nair and Miller-Hooks, 2014). Regarding one of the most crucial issues as mentioned as the ridership and effectiveness analysis, related studies are quite few but can also be found. Particularly, a recent ITDP report by Gauthier et al. (2013) gave a global analysis that looks at scale and success factors driving bikesharing development. In their report, Gauthier et al. (2013) argued that turnover is critical to a successful bikesharing system, which is ideal to be four to eight daily uses per bike. Good station locations and sufficient station coverage are critical to ensuring that the system will have high usage and turnover. Generally, a quality system needs 10–16 stations for every square kilometer (approximately 300 m between stations). In addition, there should be 10–30 bikes available for every 1000 residents within the coverage area. A recent presentation by Hughes (2014) further confirmed these useful findings.

The increasing trend in bikesharing research in recent years indicates a bikesharing boom is taking place. As a continuation for and complement of these published materials, we make an effort to model and analyze the effects of urban population, government expenditure, bikesharing demand (the number of bikesharing members) and supply (the number of docking stations and public bikes), and operation policy (using *personal credit cards* or not, providing *24 h service* or not, adopting *universal cards* or not) on bikesharing daily use and turnover rate. The empirical analysis is based on available data from 69 bikesharing systems in China, one of the fastest growing markets for bikesharing across the globe.