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Factors influencing the choice of shared bicycles and shared electric bikes in Beijing

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ABSTRACT

China leads the world in both public bikeshare and private electric bike (e-bike) growth. Current trajectories indicate the viability of deploying large-scale shared e-bike (e-bikeshare) systems in China. We employ a stated preference survey and multinomial logit to model the factors influencing the choice to switch from an existing transportation mode to bikeshare or e-bikeshare in Beijing. Demand is influenced by distinct sets of factors: the bikeshare choice is most sensitive to measures of effort and comfort while the e-bikeshare choice is more sensitive to user heterogeneities. Bikeshare demand is strongly negatively impacted by trip distance, temperature, precipitation, and poor air quality. User demographics however do not factor strongly on the bikeshare choice, indicating the mode will draw users from across the social spectrum. The e-bikeshare choice is much more tolerant of trip distance, high temperatures and poor air quality, though precipitation is also a highly negative factor. User demographics do play a significant role in e-bikeshare demand. Analysis of impact to the existing transportation system finds that both bikeshare and e-bikeshare will tend to draw users away from the "unsheltered modes", walk, bike, and e-bike. Although it is unclear if shared bikes are an attractive "first-and-last-mile solution", it is clear that e-bikeshare is attractive as a bus replacement.

1. Introduction

Public bikeshare systems are among the world's fastest growing mode of public transportation, if not the fastest, growing at an average of 37% annually since 2009 (Meddin, 2015). The greatest growth is occurring in China, a country also experiencing rapid expansion of the use of electric bicycles (e-bikes). E-bike sales outpace all other personal motorized modes in China (CAAM, 2015a, 2015b; Jamerson and Benjamin, 2013). Fig. 1 shows the rapid growth of two emerging technologies, e-bikes and bikeshare systems. The rapid growth in personal e-bike ownership brings both benefits and costs. There are significant concerns about safety, disruption to traffic, and environmental impacts of these vehicles. However, e-bikes play an important role in the radically transforming Chinese urban form. Hyper urbanization, coupled with

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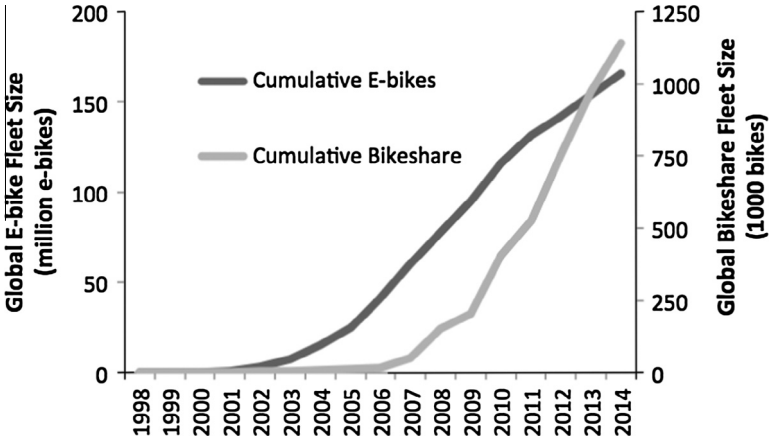

Fig. 1. Growth in personal e-bike and public bikeshare systems Note: Bikeshare data are developed and provided by Russell Meddin, head of research for the Bikesharing World Map (Meddin, 2015). E-bike sales data are reported in the Electric Bike World Reports (Jamerson and Benjamin, 2013, 2015). This chart uses combined annual sales data with an estimated five-year scrapage rate to estimate cumulative e-bike fleet size.

decentralization, has caused a host of transportation problems: runaway motorization, gridlock, increasing travel demand, tailpipe emissions, and decreasing accessibility. While in recent years, dozens of Chinese cities have implemented bikeshare systems in efforts to mitigate some of these problems, there are no known large-scale shared e-bike systems in existence. The current trajectory of bikeshare adoption, the popularity of e-bikes, and the presence of e-bikeshare pilot projects in other countries all support a future of e-bike sharing in China. Given the rapid evolution of transportation in China, it is not well understood how such a system will differ from standard bikeshare and how both types of shared bikes (hereafter "shared bike" is used to refer to both bikeshare and e-bikeshare) systems can best address the needs of urban China.

Although current trajectories suggest the emergence of e-bikeshare, as well as continued bikeshare propagation, there is little research investigating how cities can plan and implement these systems in a way that best suits their unique transportation, weather, and demographic markets. There have been some small e-bikeshare pilots (most notably in Japan, Europe, and on the campus of the University of Tennessee, Knoxville (City Bike, 2013; Langford et al., 2013)), and larger deployments recently in Europe (e.g. Madrid). Commercial e-bikeshare products are offered by companies in Europe and China, with about 4000 pedelecs in bikeshare systems in 2014 (Meddin, 2015), yet there exist no known investigation into how a large-scale system would be used (Ji et al., 2014). The majority of extant bikeshare research is backwards looking, focusing on user surveys and system-use data analysis (DeMaio, 2009; Fishman et al., 2013; Shaheen et al., 2011). These works have identified common factors that influence bikeshare usage, such as land-use, demographics, and environmental conditions, but they do not describe methods for investigating new markets or new technologies such as e-bikeshare. Furthermore, much of the research is qualitative or based on survey data from which general trends in travel behavior and usage among a self-selected sample can be identified. Recent bikeshare research quantifies the effects of environmental conditions and population demographics, yet these works are based on revealed preference data and thus retrospective (Buck et al., 2013; Buehler, 2013; Gebhart and Noland, 2014; Martin and Shaheen, 2014; Parkes et al., 2013).

Cities that are in the early phases of planning for new shared bike systems need tools to inform goals, budgets, and design. Questions of usage and demand forecasting are critical to achieving a successful system. We develop and implement a stated preference survey and estimate a multinomial logit (MNL) mode switching model for new shared bike markets. Our objective is to understand the factors influencing the decision to switch from existing modes to bikeshare or e-bikeshare and how a new shared bike system will interact with the existing transportation system. We expect that the adoption and usage of shared bike systems is contextually sensitive to transportation, environmental, and population variables that are unique to each market. To this end, we test trip and environmental factors as well as population factors that include travel habits and socio-demographic characteristics. The method is employed in a case study in Beijing introducing both bikeshare and e-bikeshare options. The policy and planning implications are considered in the Beijing context, a city with unique characteristics. But, the results are cautiously generalizable and can be applicable to many Chinese cities with diverse mode options.

Four aspects of this research are innovative. First, it is the only known study to introduce the concept of large-scale e-bikeshare and to investigate the factors influencing the choice to use such a system. Second, we quantitatively investigate a new bikeshare market through stated preference data, in contrast to the extant research using retrospective revealed preference data. Third, we introduce a novel stated preference (SP) pivoting design that allows for quality data collection through single-interview pen-and-paper surveys. Last, we explicitly quantify the effects of environmental variables that influence demand, but are often discounted in existing demand studies; in quantifying variables such as air quality, a particular concern in the Chinese market, we link China's unique environmental concerns to transportation demand.