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Dynamics of electric bike ownership and use in Kunming, China

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ABSTRACT

The rapid adoption of electric bikes (e-bikes) (~150 million in 10 years) has come with debate over their role in China's urban transportation system. While there has been some research quantifying impacts of e-bikes on the transportation system, there has been little work tracking e-bike use patterns over time. This paper investigates e-bike use over a 6-year period. Four bi-annual travel diary surveys of e-bike users were conducted between 2006 and 2012 in Kunming, China. Choice models were developed to investigate factors influencing mode-transition and motorization pathways. As expected, income and vehicle ownership strongly influence car-based transitions. Younger and female respondents were more likely to choose car-based modes. Systematic and unobserved changes over time (time-dynamics) favor car-based modes, with the exception of previous car users who already shifted away from cars being less likely to revert to cars over time. E-bikes act as an intermediate mode, interrupting the transition from bicycle to bus and from bus to car. Over 6 years, e-bikes are displacing prospective bus (65→55%), car/taxi (15→24%) and bicycle (19→7%) trips. Over 40% of e-bike riders now have household car access so e-bikes are effectively replacing many urban car trips.

1. Introduction

Electric bikes (e-bikes) are two-wheeled vehicles powered by electric motor and battery. Some styles resemble bicycles, while others are larger and have the appearance of gasoline scooters; all possess nearly identical underlying technology. The e-bikes typically have top operating speeds around 30 km/h and weights ranging from 30 to 80 kg. Because of their light weight and efficient drive train, e-bikes are among the most energy efficient modes of motorized transport that exist, consuming about 1.8 kWh/100 km, about one-tenth of an electric car (Ji et al., 2012).

Favorable regulatory status has facilitated rapid growth in e-bike use and ownership over the past decade – e-bikes are generally legally defined as bicycle and therefore face less strict regulation than gasoline-powered modes. In fact, e-bikes are the most rapid adoption of an alternative-fuel transportation mode in the history of motorization. This mode has the potential to disrupt traditional motorization pathways and cause substantial shifts in travel patterns and behavior (Weinert et al., 2007a). With nearly zero e-bikes on the roads at the turn of the century, it is estimated that about 150 million e-bikes are in-use on Chinese streets, and about 30 million are sold annually (Jamerson and Benjamin, 2013). In many Chinese cities, there are now more e-bikes in-use than bicycles, leading to heavy debate over their role on Chinese roadways.

Compared with alternative modes of transportation, e-bikes have several advantages and disadvantages in terms of environment, mobility, and safety. They have significantly better environmental performance than most alternative modes (Cherry et al., 2009), and since e-bike emissions generally originate at remote power plants, populations typically have lower exposure rates to those emissions (Ji et al., 2012). Effective battery production and recycling practices is one environmental challenge facing the e-bike industry (van der Kuijp et al., 2013). E-bike users also realize a significant benefit of improved mobility and accessibility where mobility and job access can be many times higher than bus, despite quality bus systems (Cherry and Cervero, 2007; Cherry and He, 2010; Lin et al., 2008; Montgomery, 2010). Furthermore, e-bikes are among the most cost effective modes when considering travel time as a cost of transportation (Cherry, 2007; Montgomery, 2010). However, they have been criticized on the grounds of safety, an often-cited reason when they are banned or restricted in certain cities. Several studies have investigated e-bike safety in

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China with mixed results. It is clear, that e-bike riders are increasingly represented in crash statistics as their population grows though there is little consensus if e-bikes are intrinsically less safe than other modes (Bai et al., 2013; Du et al., 2013; Feng et al., 2010; Ni, 2008). E-bikes also outcompete transit systems for short trips, eroding ridership. Effectively regulating e-bikes is challenging, in part because little is understood about how this mode affects motorization pathways.

While the majority of analyses focus on specific impacts of e-bikes relative to other modes, few studies attempt to estimate behavioral factors influencing mode shift. The relative impact of a new technology is tied to the substitution from other technologies. Three studies have explicitly investigated the characteristics of e-bike riders and e-bike use. First, a survey in Shijiazhuang focused on differences between bicycle and e-bike riders, finding that e-bikes enable longer commute distances compared to bicycles and that people who are underserved by public transit are shifting to e-bikes. Most e-bike (60%) riders were diverted from traditional bicycles (Weinert et al., 2007b). Montgomery (2010) investigated the relationship and competition between cycling (bicycle and e-bike) and bus transit in Jinan and found that a majority of bicycle (69%) and e-bike (65%) riders would use the bus in the absence of their two-wheeled mode. A paper describing two surveys in Kunming and Shanghai revealed similar findings—most e-bike (~55%) riders are would-be bus riders. Importantly, about 15% of e-bike riders are would-be car-mode (taxi or personal car) users. That study developed a mode choice model to estimate the probability of switching from bicycle to e-bike and found that travel time savings, household e-bike ownership, increasing age, younger females, and attitudes about reduced cycling effort all had a significant positive influence on e-bike use. Moreover, the probability of switching from e-bike to transit versus bicycle is influenced again by relative travel time differences, age (younger people choose transit), and congestion (Cherry and Cervero, 2007). The study presented in this paper extends (Cherry and Cervero, 2007), also incorporating a portion of that dataset.

Those studies show that important questions related to e-bike policy depend on alternative transportation systems. Banning e-bikes to improve certain transportation metrics could result in unintended outcomes, for instance higher car use or oversubscribed bus service. In the four cities cited above, traditional motorcycles are heavily restricted and do not enter the mode choice decision. There has been some effort to identify e-bike (e-scooter) market potential in other Asian cities, where motorcycles dominate the market, including Taipei, Hanoi, and Ahmedabad (Chiu and Tzeng, 1999; Jones et al., 2013). In these cases, a shift from gasoline motorcycles to e-scooters produces high benefits on almost all metrics.

Each paper above describes e-bike use as a snapshot in different cities providing important insight to current and past behavior, yet lacking any dynamics (e.g. How do mode preferences change over time within a city? How and by whom are e-bikes used now, compared to a few years ago?). This paper discusses some of the temporal variation of e-bike use in Kunming, China over a 6-year period (2006–2012). This effort is meant to identify how use characteristics or demographics of users are changing over time. This paper models these changes over time and also introduces a mode-transition model, providing first insights into how e-bikes could disrupt the traditional motorization pathway.

Four surveys were conducted in Kunming over 6 years. The first survey was conducted in spring 2006 and was the basis of Cherry and Cervero (2007). The second survey was conducted in summer 2008, the third in summer 2010, and the fourth in summer 2012. All of these surveys were conducted by the same research teams, using a nearly identical instrument, coupled with an identical sampling approach aimed at surveying similar populations to identify any trends that might occur over time. The rest of this paper is organized as follows. The next section gives a brief background of Kunming, focusing on population growth and e-bike use. The following section discusses the four e-bike surveys conducted in Kunming, followed by a discussion of the sample demographics. The next section describes the results of two sets of choice models—alternative mode choice and mode choice transition. The final section discusses policy implications.

2. Kunming background

Kunming is the capital of Yunnan province. The population of the city itself is about three million, while the population of the larger metropolitan area exceeds six million. Kunming residents have quickly adopted e-bikes, from nearly 200,000 e-bikes in 2005, to more than one million in 2012. Kunming residents have also been purchasing cars on a wide scale. In 2010, Kunming had 1.3 million registered motor vehicles; an ownership rate of more than 200 vehicles/thousand population, about five times the national average (National Bureau of Statistics, 2010). Kunming has one of the highest quality bus systems in China, a Bus Rapid Transit (BRT) system spanning nearly 100 km and is currently developing an extensive subway system. To reduce traffic congestion and increase safety, motorcycles are heavily restricted in the urban core. Between 2006 and 2011, mode share has increased for bus (19→22%) and car (11→20%), and decreased for taxi (3→2%), bicycle (including e-bike) (28→25%), and walking (34→29%). E-bikes are officially classified as bicycles and in 2011, accounted for 75% of all bike mode share, or 19% of all trips (Kunming Urban Transportation Institute, 2012). Other cities in China are developing in much the same way as Kunming. Unlike China's megacities, Kunming is representative of China's small and medium sized cities (less than 4 million), which contain three quarters of China's urban population (National Bureau of Statistics, 2010).

3. Survey methods

The four surveys used in this study followed a specific protocol to allow comparison. All were conducted between 8 am and 7 pm, on Tuesday–Friday, to gain a representative sample of average workday travel. The surveys were nearly identical and contained two parts. The first part included a travel diary that asked respondents to report their travel patterns the previous day (Monday–Thursday), including mode, origins and destinations, trip purpose, trip time, and best alternative modes by trip. This identifies the amount of displaced kilometers traveled by mode. The second part was a questionnaire that asked respondents about their vehicle purchase decisions, demographics, perceptions, and motivation for using e-bikes. The surveys included commonly understood demographic and perception variables that influence vehicle ownership and use (Chiou et al., 2009; Flamm, 2009).

The sampling scheme was identical for all surveys. We followed an intercept survey approach where e-bike users were surveyed as they exited bike-parking facilities at the same locations in the city, mostly inside the first ring road. A thorough description of the sampling approach is found in Ni et al. (2012). The bike-parking facilities served large and diverse mixed-use developments that included informal markets, big-box stores, entertainment and restaurant venues, and services. Survey respondents were given a small gift as a token of appreciation, such as paying their parking fee. While this sampling approach is not ideal, we aimed to sample typical e-bike riders in urban Kunming. We likely undersampled certain types of e-bike users (e.g. rural/urban fringe e-bike users or those who use e-bikes for commercial/delivery purposes). The four