INSTITUTE OF TRANSPORTATION STUDIES
UNIVERSITY OF CALIFORNIA, DAVIS

Year 2006 UCD—ITS—RR—06—15

The Transition to Electric Bikes in China and its Effect on Travel Behavior, Transit Use, and Safety

Jonathan X. Weinert

Chaktan Ma Dr. Xinmiao Yan

Institute of Transportation Studies ◇ University of California, Davis

One Shields Avenue ◇ Davis, California 95616

PHONE: (530) 752-6548 ◇ FAX: (530) 752-6572

WEB: http://its.ucdavis.edu/

The Transition to Electric Bikes in China: Effect on Travel Behavior, Mode Shift, and User Safety Perceptions in a Medium-Sized City
中国城市的电动自行车热潮：其在中型城市的交通行为、方式分担及安全性分析

Jonathan X. Weinert （乔文轩）

Institute of Transportation Studies, Graduate Student Researcher
University of California, Davis.
One Shields Avenue, Davis, CA 95616
Phone: 86-138-1813-1364
E-mail: jxweinert@ucdavis.edu

Chaktan Ma （马泽丹）

Institute of Transportation Engineering, Graduate Student Researcher
Tsinghua University
Beijing, China 100084
Phone: (86) 13811930082
E-mail: mzd@mails.tsinghua.edu.cn

Dr. Xinmiao Yang （杨新苗）

Institute of Transportation Engineering, Associate Professor
Tsinghua University
Beijing, China 100084
Phone: (86) 13911824937
E-mail: xmyang@tsinghua.edu.cn

Christopher R. Cherry

Institute of Transportation Studies, Graduate Student Researcher
University of California, Berkeley.
2614 Dwight Way, Berkeley, CA 94720
Phone: (510)717-9834
E-mail: cherry@berkeley.edu

Submitted for Presentation and Publication
Call For Papers ABE90
86th Annual Meeting
Transportation Research Board
Submitted July 31, 2006

Word Count: 4,711 + 11 Figures (2,750 words) = 7,561
(not including abstract (241) and references (290))

ABSTRACT

Despite rapid economic growth in China over the past decade and rise in personal car ownership, most Chinese still rely on two-wheeled vehicles (2WV) or public transport for commuting. The majority of these 2WVs are bicycles. In recent years, concern about poor air quality in urban areas and rising energy costs have caused cities to ban gasoline-powered scooters in city centers. Simultaneously, a new 2WV mode emerged to fill the void: the electric bike (e-bike).

This shift to e-bikes is occurring at rapid pace throughout China, especially in its cities. E-bike sales reached 10 million per year in 2005 as more bike and public transit users shifted to this mode. City planners and policy makers are undecided on how to plan for and regulate e-bikes because it is not yet clear what effect they will have on travel behavior, public transportation use, and safety. To begin to understand these effects, the authors have surveyed bike and e-bike users in Shijiazhuang, a medium-sized city with particularly high two-wheeled vehicle (2WV) use, to identify differences in travel characteristics and attitudes.

We conclude the following: (*partial list*)

- E-bikes are enabling people to commute longer distances. This has important implications on energy use, accessibility and urban expansion of cities.
- People under-served by public transportation are shifting to e-bike.
- Women feel safer crossing intersections on an e-bike compared to regular bike, however they have strong reservations about increasing e-bike speed capability.

摘要

虽然过去二十年中国快速发展的经济刺激了小汽车拥有量的快速提高，但绝大多数的中国城市居民仍然依赖于两轮车辆以及公交车通勤，而两轮车辆中绝大部分是自行车。近年来，对城市地区空气质量以及持续上涨能源成本的考虑，使得很多城市开始限制或禁止燃气动力摩托车在市区的使用。同时，一种新的二轮交通方式开始大量出现，称之为电动自行车。

向电动自行车的转变逐步向全国蔓延，特别城市地区。随着越来越多自行车及公交使用者选择转向这种交通方式，在2005年，电动自行车的销售量达到了壹千万辆。然而，城市规划师以及政策制定者尚未明朗如何规划应对或规范这种转变，因为其交通行为，安全性以及对公交的影响还不明朗。为了能够了解这样的影响，作者对中国石家庄（一个百万人口的中型传统城市，两轮车辆使用率较高）的自行车及电动自行车使用者进行了调查，以分析其交通特性和态度的不同。

通过研究，作者得出以下结论：

- 电动自行车能够延长人们的出行距离。这对于能源消耗，可达性以及城市扩张发展都有重要意义。
- 公交服务氛围外的人们将大量转向这种电动自行车交通方式。
- 女性认为在通过交叉口时，相对于自行车，电动自行车要更加安全。然而，她们强烈地反对继续提高电动自行车的速度。

INTRODUCTION

Two-wheeled vehicles (2WV; e.g. bicycles, e-bikes, motor scooters, motorcycles) have historically been an important component of traffic throughout China and many other developing countries. In medium and large Chinese cities like Shijiazhuang, the dominant 2WVs are bicycles.

Bicycles, estimated at 450 million nationally in 2004 [1], have been and still remain the dominant 2WV in Chinese cities, mainly due to low income, high population density (and thus short trips), and extensive bicycle infrastructure (e.g. lanes, parking). Based on statistical report in 2005, bicycle trip share is still over 50% in many large cities like Tianjin, Xi'an and Shijiazhuang [2].

Gasoline-powered motor scooters (GMSs) used to make up a larger percentage of the overall 2WV population, however, beginning in late 1990s, many large cities (population >1 million) and most capital cities have stopped licensing these vehicles. Total GMSs in China numbered 80 million in 2005 [3]. Although numbers are still growing in the wide rural areas and small cities, it is estimated that without urban restrictions, 4~5 million more would be on the roads [4].

In recent years however, due to improved standard of living and rapid urbanization, Chinese are shifting from bike (or public transit) to electric bikes (e-bikes) as they demand more flexible, convenient and comfortable mobility. In 2005, there were an estimated 20-22 million e-bikes in China [5]. Production is expected to grow 80% annually over the next five years [6].

Throughout China, however, there are mixed views by government about e-bikes and their effect on traffic. In May 2006, a national government agency issued a report promoting e-bikes for their air quality and energy-saving benefits [6]. In November 2006 though, Guangzhou became the third city in China to ban e-bikes (behind Fuzhou and Zhuhai), under advice from the traffic management bureau citing traffic safety concerns [7]. The safety issue of e-bikes mixed in traffic is a key consideration in the drafting of new National E-Bike Standards, which are under revision and under intense debate. The standard regulates the technical performance specification of e-bikes (see section below). Bicycle proponents such as the China Bicycle Association (CBA) want to limit e-bike performance to make them more similar to bicycle, and for fear that faster, heavier e-bikes will make them dangerous to cyclists. E-bike manufacturers, however, want to broaden the limits on weight, width and power to be able to build products that they claim customers want. Whatever new standard is adopted will greatly effect the future direction of e-bike development in China.

E-bike background

E-bikes can be classified as a "semi"-motorized vehicle because they can run on either human power or electricity. They have become a popular transportation mode in China because they provide an inexpensive form of private mobility and are thus an attractive alternative to public transit or regular bicycling. With an average energy consumption of 1.2-1.5 kWh/100km, e-bikes offer extremely efficient transportation with zero local air pollution. While local pollution is negligible, they do operate on electricity, mostly generated from coal fired power plants. Perhaps the most problematic environmental issue with electric bikes is the use of lead acid batteries that have high lead loss rates during the production, manufacturing and recycling processes [8].

There are two main types of electric bikes: "Bicycle style" (BSEB) (or "simple" style) and "scooter style" (SSEB) [9]. While the SSEB looks more like a typical scooter, both styles are subject to the same National E-bike Standards [10]:

1. Top speed= 20 km/h,
2. Max weight= 40 kg
3. Min range per charge = 25 km
4. Max power= 240W.

Despite these standards, most e-bikes exceed these performances limits due to strong consumer demand for better performance coupled with lax enforcement of the standard. A small sub-survey of 14 e-bike users reveal top speeds from 25-40 km/hr and ranges of 25-50 km on a single charge, which requires 6-8 hours. E-bike range in cost from $125-300 (USD) compared to gasoline scooters at $500-600. Operating costs (includes fuel, maintenance and battery replacement) are $0.007/km compared to 0.031/km for a gasoline scooter [11].

Different cities have adopted e-bikes at different rates. On-street surveying of e-bike proportions versus other 2WV modes by the authors in various cities has shown that some cities have low adoption, like Beijing (<10%), while others have high adoption, like Chengdu (>50%). In Shijiazhuang, e-bikes make up 22% of all 2WV traffic (bicycles=77.5% and motor scooters/bikes 0.5%). The level of e-bike adoption is related to income, local regulation, public transit service quality, terrain, and other factors. Most cities in east China are situated on relatively flat terrain and amenable to bicycle and electric bike use.

Shijiazhuang Background

Shijiazhuang city is located in south-central Hebei province. As the capital of the province it has recently developed into an important commercial port of regional agricultural and distribution center of industrial products in northern China. The total and urban population in 2005 was 9.2 and 2.2 million, respectively. Total and Urban Area is 15,900 and 3,850 km^2, respectively. The topography in this area is low (70 meters above sea level) and flat since it is situated in the Huabei Plain of China. The climate ranges from an average high of 26.9 ℃ in July and an average low of -2.4℃ in January.

Shijiazhuang's urban layout follows the typical Chinese model of a monocentric city with a high-speed ring road encircling the urban area. The urban area is divided into four quadrants by two railways and the city's commercial district is centered around the railway station. Zhongshan Road and Yuhua Road form the principle axis from west to east and serve as the main travel corridor for all modes, including 2WVs. Residential areas mainly stand on the northwest, center and east of city.

Bicycles and e-bikes compose the largest daily trip mode share in Shijiazhuang. A previous survey conducted by Shijiazhuang showed that in 2002, cycling trip share was 54% and reached a volume of 3 million trips per day. For comparison, public transit trip share was only 4.3% [12].

METHODOLOGY

Because of the institutional and logistical difficulty in conducting random household surveys in China, the authors designed and implemented an intercept survey of 751 bike and 460 e-bike users throughout Shijiazhuang. The survey was administered at bicycle and e-bike parking lots along the main travel corridor (Zhongshan Lu) in Shijiazhuang in order to capture a diverse range of respondents from many different parts of the city. The survey was administered on both a workday and weekend day in June 2006, from 7:30-11:30 and 3:00-6:00 to collect as broad a range of respondent types as possible (i.e. workers, retirees, students, etc.). Separate surveys

were given to bicycle and e-bike riders in order to identify any differences between their travel behavior and attitudes.

Before launching this survey, the authors first administered a trial survey on 50 bike/e-bike users to identify the potential problems with the survey and uncover any unintentional biases. We found some of the response choices inappropriate and certain questions confusing. These problems were corrected before administering the final survey.

Potential sampling biases/inaccuracies

Surveyors kept the sample balanced in gender and ages. However, based on site observation, the proportion of male and female e-bike users is not evenly balanced; in a random sample of 180 e-bike users, 62% were female, 38% were male. This may lead to an under-representation of female attitudes and travel behavior regarding e-bikes.

The same problem also occurs in representing the elderly age group. Our survey was conducted during the daytime on two days with hot weather. Because elderly people in China are more active in the early morning, and also due the hot daytime weather, this age group may be under-represented. The elderly reportedly make up the second largest e-bike user group [5]. This is conceivable since elder people usually have higher and stable income, and have weaker strength. The survey offers no obvious evidence to support this conclusion, however.

The survey was carried out only in the downtown areas of Shijiazhuang. This location may result in a slight bias towards higher-income users as well as individuals who use electric bikes for work commute trips.

In order to calculated trip distance, rather than ask people their trip distance directly, we asked respondents to locate their origins and destination using a grid map. We then asked people to estimate their travel time. Our data collection method for trip distance and thus travel speed could have inaccuracies if respondents chose a special route that was longer or shorter than the distance calculated using their origin/destination coordinates. Also, people have a tendency to include access and egress time in their total reported trip time, which would underestimate the average speed, especially for short trips.

Data Processing

The results in the section below were calculated using Excel. Data from the survey was input into an Excel spreadsheet, and response choices for each question were added together. The data was sorted by demographics when appropriate.

Since the streets in central Shijiazhuang follow a grid pattern, trip distance was calculated by measuring the ΔX and ΔY from respondents' stated origin and destination which they located using a grid map attached to survey. Trip speed is calculated by dividing calculated trip distance, by stated trip time. Calculated trip speeds were then averaged together to find the absolute average trip speed. Trip speed results exhibit the most uncertainty since our calculated responses ranged from 5-26 km/h for bike users and 4-34 km/hr for e-bikes. Responses under 6 km/hr were thrown out.

RESULTS

2WV User Demographic Differences

The differences in age, gender, and income between bike and e-bike users are presented in the sections below.

Age and Gender

Of the 751 bike riders and 460 e-bike users, 49% were male and 51% female. Figure 1 shows the distribution of bikes and e-bikes among men and women of different age groups. E-bikes are most popular amongst the "24-30" age group, especially among females. Almost half of all female e-bike riders are in this group. Nearly 73% of all e-bike users are between 24 and 40, compared to 51% of all bike riders. This could reflect higher-income career-aged commuters choosing e-bikes.

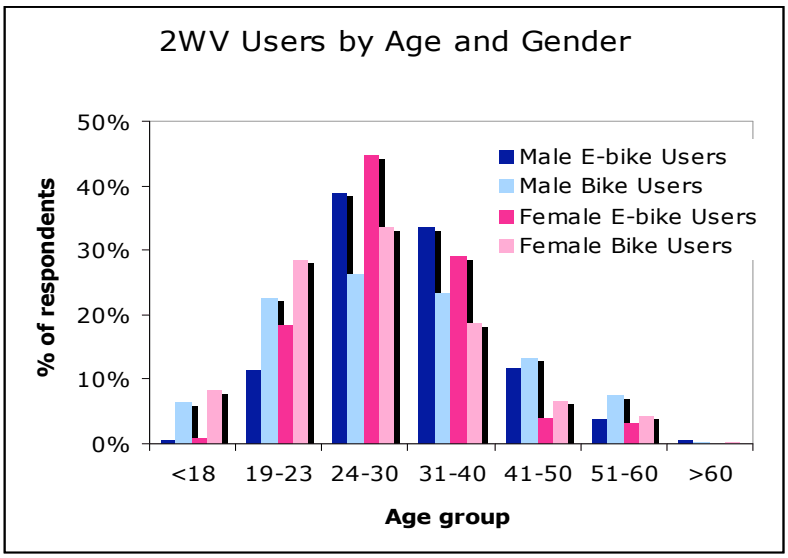

FIGURE 1 Bikes and e-bikes proportions by age and gender.

Income

The average income of bike users and e-bike users, 18,000 and 22,000 RMB/yr, respectively (8.0RMB = $1 USD). The small income gap indicates that there are other factors behind purchasing an e-bike than just price. These other factors are revealed in analyzing the trip characteristics of the two groups in the next section.

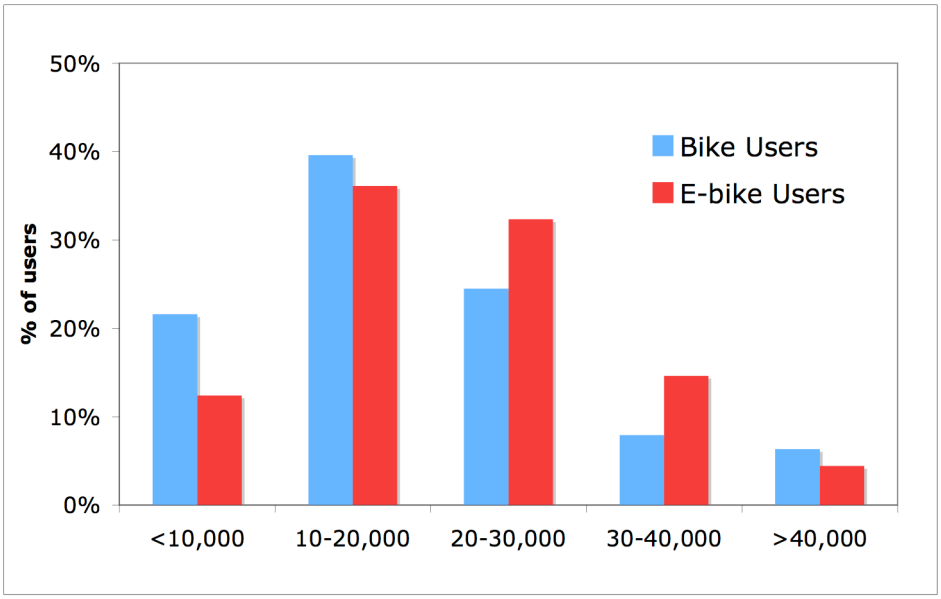

FIGURE 2 Income levels of bike and e-bike users (RMB/yr).

Trip Characteristics

The difference in trip characteristics between bikes and e-bikes are explored in the following section. This includes trip distance, time, frequency, speed, and purpose.

Trip Distance

Figure 3 shows distribution of trip distance for 2WV in Shijiazhuang. E-bike riders in general travel 32% farther than bicycle riders (5.8 vs. 4.4 km/trip average).

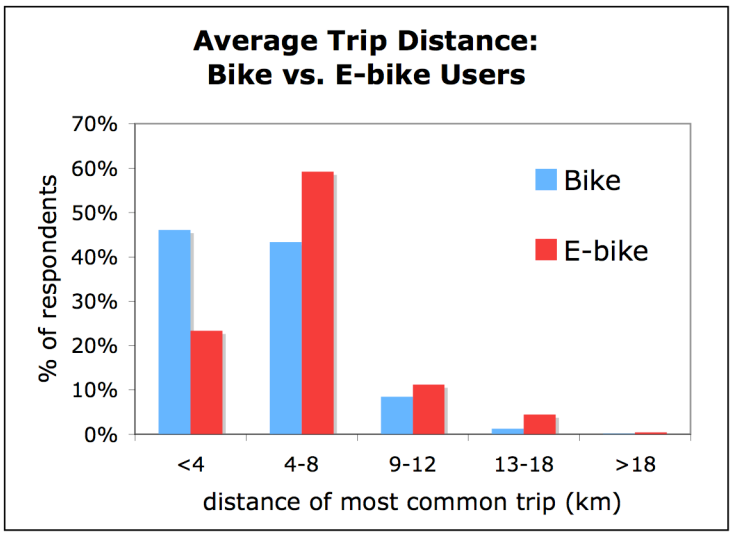

FIGURE 3 Distribution of trip distance for bike and e-bike.

Trip Time

E-bike riders' travel time is about 10% longer on average than bike riders (24.7 vs. 27.2 minutes, respectively). Approximately 80% of bikers make trip less than 30 minutes, which concurs with a previous survey of 14 Chinese cities (population >1million) in 1995 [13]. Only 70% of e-bikers

made trips less than 30 minutes, indicating that people are willing to travel for longer periods of time by e-bike.

Trip Speed
E-bike average speed is 17% higher than bike users: 14 vs. 12 km/hr. This is not surprising since they travel farther distances over the same commute time, and they are supported by electric propulsion. The statistical significance of this result however is uncertain due to the data collection method. Speed studies in Shanghai and Kunming show about a 30% difference in speeds (14.5 km/hr vs. 11.1 km/hr and 14.7 km/hr vs. 10.9 km/hr, respectively), which is consistent with users in Shijiazhuang with longer trip distances [14]. The difference in speeds might be under-estimated if respondents included their access and egress times. This would more heavily under-estimate the on-vehicle speed of faster modes.

Trip Purpose
Commuting is the dominant trip purpose for both bike and e-bike users (61% and 77% respectively). Going to school, picking up children from school, and shopping make up the smaller share of trips. "School" is a more common trip purpose for bike users since, as people under 23 more commonly ride a bicycle.

Trip Frequency
Both bike and e-bike users on average make between 2-4 trips per day. There is no significant difference between e-bike and regular bike users.

Passenger and cargo carrying
Site observation and survey results revealed that e-bikes carry cargo and passengers more often than bicycles. SSEBs users are commonly seen carrying as many as two passengers. In some instances a small child would stand on the foot platform in front of the driver. Clearly, the increased power offered by the battery and motor makes this behavior much easier. This is particularly appealing to mothers and grandparents who are generally responsible for transporting their children to and from school daily.

Vehicle performance in traffic
Due to e-bike's higher acceleration and speed (>20 km/hr), they typically lead each wave of NMVs traveling through the bike lane from one intersection to the next. E-bikers tend to reach the intersection before bicyclists, and thus quickly accelerate through the intersection once the signal turns green, unimpeded by bicyclists. Bicyclists are typically the last to pass through an intersection. Along the width of lane, speeds are usually faster closer to the motorized vehicle lane. E-bikes normally ride on the left side of lane or use this lane to pass other riders.

Travel Mode Choice:
In order to make better urban planning decisions about road capacity, public transport, and traffic policies affecting bike and e-bike users, it is important to understand why 2WV users choose these modes, how they would travel is these modes weren't available, and their plans to switch modes. The following section presents results from the survey regarding these issues.

Reasons for choosing bike/e-bike

Respondents were asked why they choose to ride a bike/e-bike for commuting. They were given 10 options and could select multiple answers. The five most popular responses for bike and e-bike users are shown below.

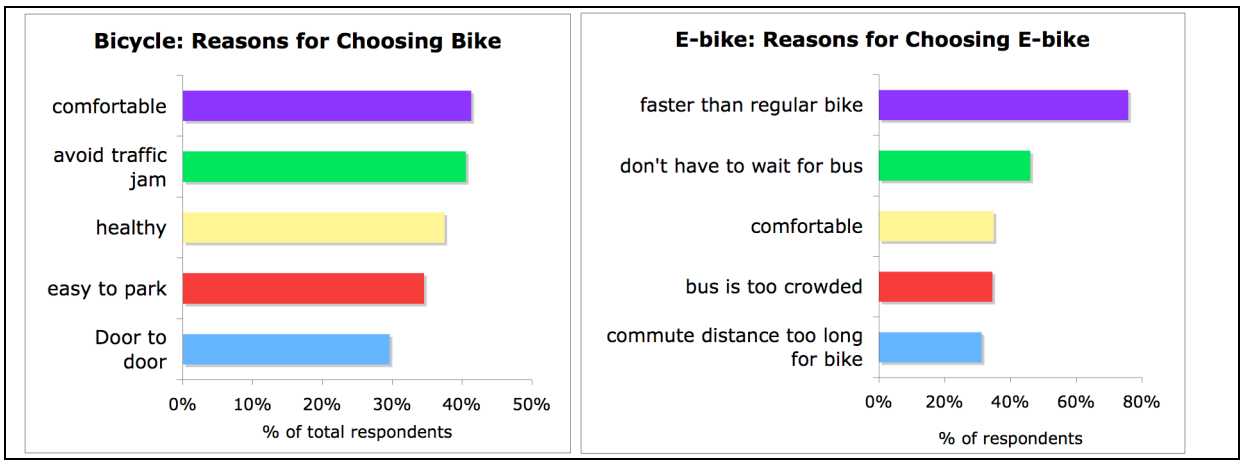

FIGURE 4 Reasons why users choose bikes/e-bikes for commuting.

These results indicate the e-bikes are offering users a better alternative to biking and riding the bus. They also reinforce results about trip distance that people are commuting farther to work. For bike users, the results show that people choose to ride a bike for other reasons than just low-income. Road congestion, health, and convenience are also important factors.

2WV Users and Public Transit

The results of the survey indicate that the public transit network in Shijiazhuang is an important part of the 2WV users' transportation system. 2WV users were asked questions about their bus-riding habits and attitudes. The first question asked why they don't ride the bus, and if they sometimes ride the bus, why. We found that the majority of 2WV users (~60%) depend on the bus during bad weather and often use it when their bike is unavailable.

2WV users don't regularly ride the bus because it is too crowded, the bus route is inconvenient, and it's too slow. Another reason revealed through the survey is that some people are concerned with thieves on the bus, and thus choose to ride a bike.

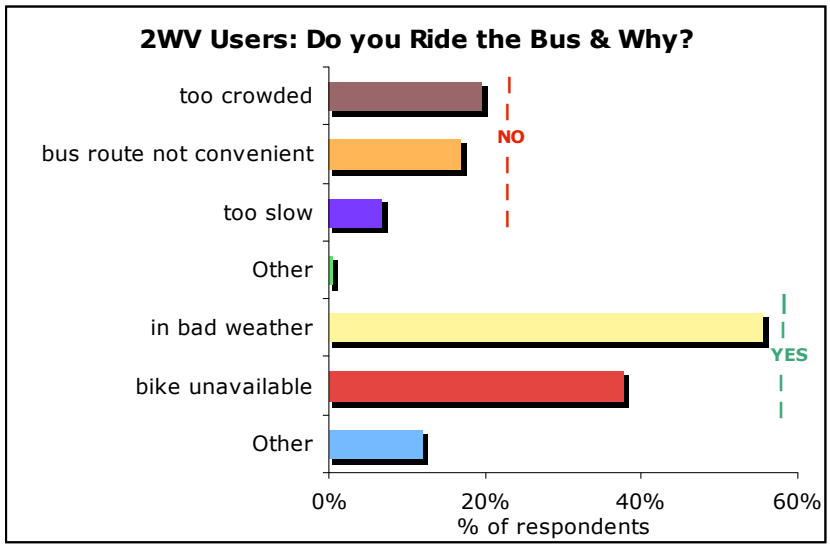

FIGURE 5 Bike/e-bike users reasons for choosing/not choosing bus.

We also asked 2WV users how they would choose to commute if biking was no longer an option. Figure 6 below indicates that the bus is the next best alternative for over 60% of bike users. The bus system therefore plays a critical back-up role if the biking option is unavailable. Surprisingly, 7% of bike riders would travel by car, which indicates some are choosing biking for reasons other than economic necessity.

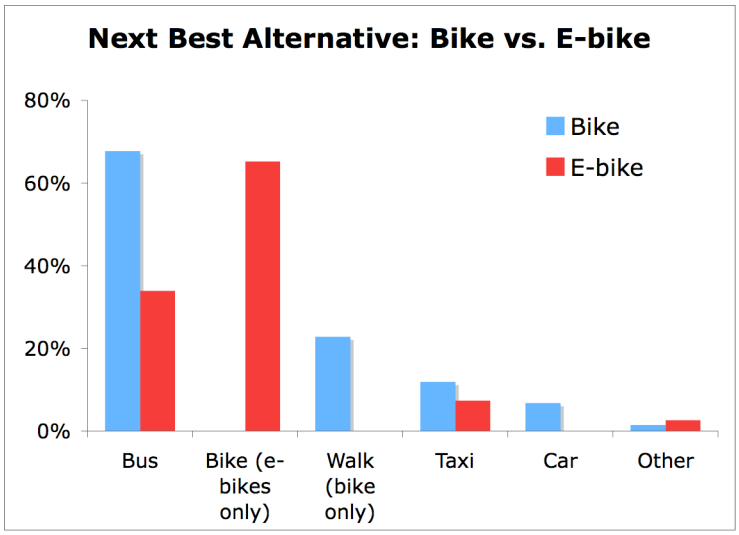

FIGURE 6 Next best alternative for bike/e-bike users.

A similar survey in Kunming and Shanghai was carried out and found slightly different results. In both of these cities, most of the e-bike users would otherwise choose bus for their trips, 54% and 58% for Shanghai and Kunming, respectively. The second most popular response was bicycle, with 12% and 21% of the responses in Shanghai and Kunming, respectively. In both of these surveys, an overwhelming majority of respondents chose bus, perhaps because of higher quality of bus service and city size difference (i.e. longer trip distances), compared to Shijiazhuang.

Future Plans to Change Travel Mode

To understand the future of 2WV use in Shijiazhuang, we asked current 2WV users if they had plans to switch to different travel modes in the next year. Responses are shown in Figure 7. We found that the most popular future option for bicyclists is the e-bike. Current e-bike users plan to switch to a better e-bike or a car. Very few 2WV users plan to switch to riding the bus. Many Chinese cities (e.g. Shanghai) believe the improvement of public transport services is the final solution for inner-city transportation challenges, however service has lagged behind demand. Thus users who face long trip distances have resorted to e-bikes.

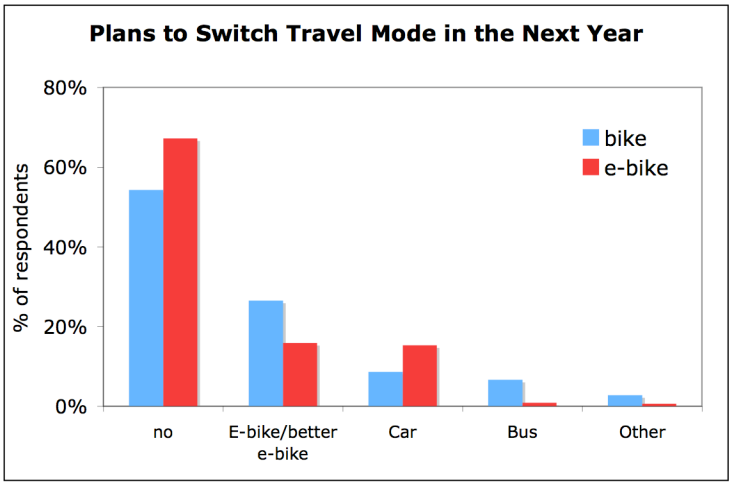

FIGURE 7 Future purchase plans of bike/ebike users.

Stratifying results based on income level shows that future purchase plans are dependent on income. Of the low and mid-income bike users that plan to change mode in the next year, the majority plan to switch to e-bike. For high-income 2WV users (both bike and e-bike) that plan to switch modes, the most popular choice was to buy a private car. Other options such as bus, taxi, or (other) were minimal.

Traffic Safety

Traffic safety for 2WV is a serious problem in China. There were an estimated 500,000 traffic deaths between 2000-2005, 60% of whom are 2WVs users [15]. From site observation and interviews with traffic management, the most difficult and dangerous part of a 2WV users' journey occurs at intersections due to the mix of automobiles, various 2WVs, and pedestrians [12]. In Shijiazhuang, intersections were particularly chaotic due to the massive amounts of 2WVs crossing the street from both directions and their strong tendency to disobey traffic lights. Another safety issue is the mixing of bikes and e-bikes in the bike lane.

We thus surveyed 2WV user attitudes on safety at intersections and e-bike speed. Survey respondents were asked to rank how much they agree or disagree to the statements shown in the figure below (1= Strongly Agree, 2= Agree, 3= Neutral, 4=Disagree, 5= Strongly Disagree).

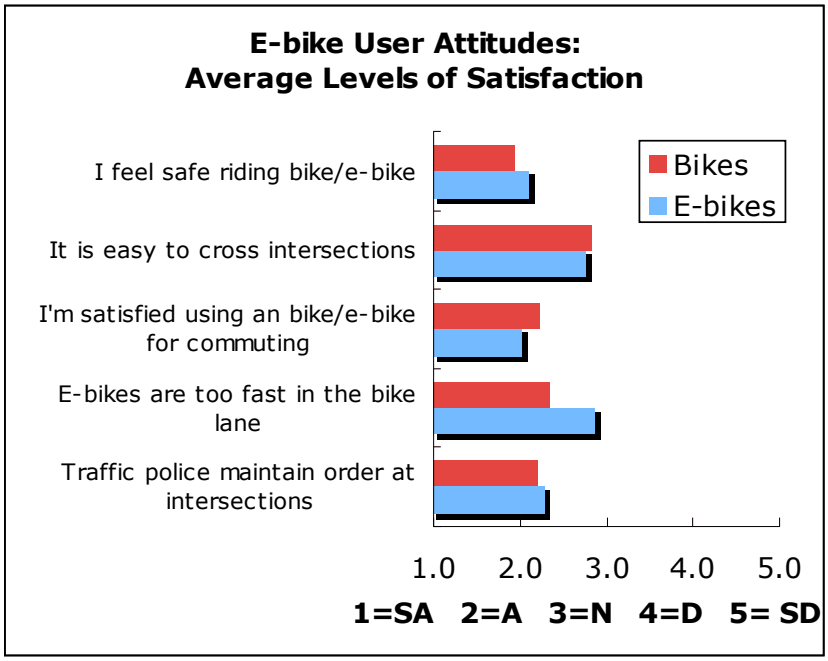

FIGURE 8 Bike/e-bike user attitudes.

Safety at intersections

Results show that both bikers and e-bikers generally are satisfied (avg. response= "agree") and feel safe using this mode of travel, and feel traffic police do a good job maintaining order at intersections (question 1, 3, 5). E-bikers feel slightly more satisfied with their mode than bikers, but they also feel slightly less safe.

On the other hand, both bike and e-bike users were on average neutral about the ease of crossing intersections (question 2) and there were a large amount of both "agree" and "disagree" responses for both bikes and e-bikes. Sorting these responses by gender reveals that female bike riders have the most difficult time crossing intersections, whereas male e-bike riders find it easiest. The responses showed that women find it easier to cross the intersection when riding an e-bike. This points to one reason why e-bikes are so popular amongst women. Site observation also confirmed that e-bike users generally have an easier time crossing intersections. The highly "stop-and-go" nature of intersection makes crossing easier with the aid of electric propulsion.

Conflict between E-bikes and Bikes

We asked several attitudinal questions about the more controversial issues of e-bikes to reveal the nature and reality of the conflict between bike and e-bike riders. Regarding e-bike speed, the majority of bike riders agree that e-bikes are too fast in the bike lane (Figure 10). E-bike riders on average felt neutral about e-bikes being too fast, indicating nearly 50% of e-bike riders themselves think e-bikes are too fast.

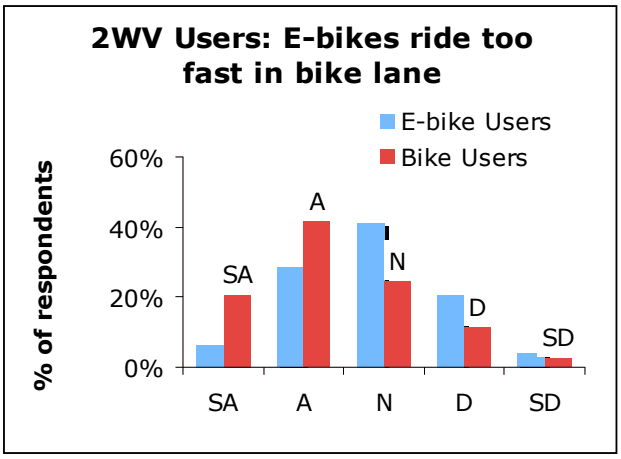

Figure 10 Bike/e-bike user attitudes on speed of e-bikes.

E-bike riders were also asked whether they would like a faster, more powerful e-bike. Results uncovered a large gender difference in responses. Whereas men have a neutral opinion about this issue, women are strongly opposed (Figure 11).

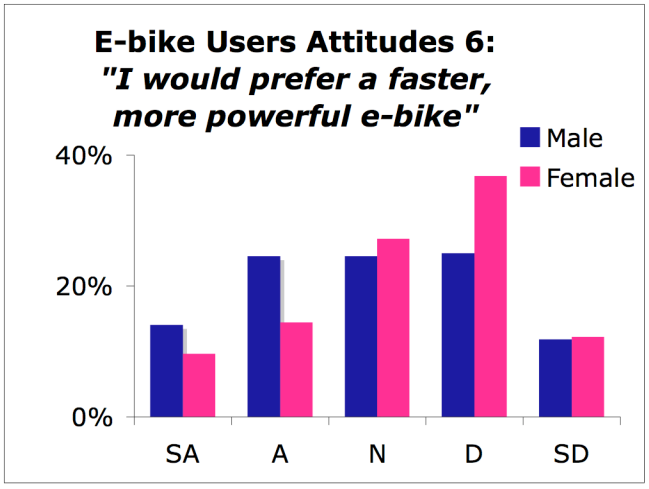

FIGURE 11 Bike/e-bike user attitudes on desire for faster, more powerful e-bike.

The second issue relates to the nature of the conflict between e-bikes and bikes (i.e. "who is bothering whom?"). Survey results revealed that a conflict indeed exists between bikes and e-bikes users, however it is bi-directional and also includes pedestrians. Respondents were asked what is most bothersome to them during their commute (they could choose multiple options). Results show that the biggest annoyances to 2WV users are in fact other 2WV users. E-bike riders feel that other bike riders and pedestrians are the 1st and 2nd most bothersome. Bicyclists, however, ranked pedestrians and other bicycles 1st and 2nd. Automobiles were surprisingly low on the list, most likely because of Shijiazhuang's extensive network of segregated bike lanes and relatively small car population. Other included the bus, improper signal timing, and taxis.

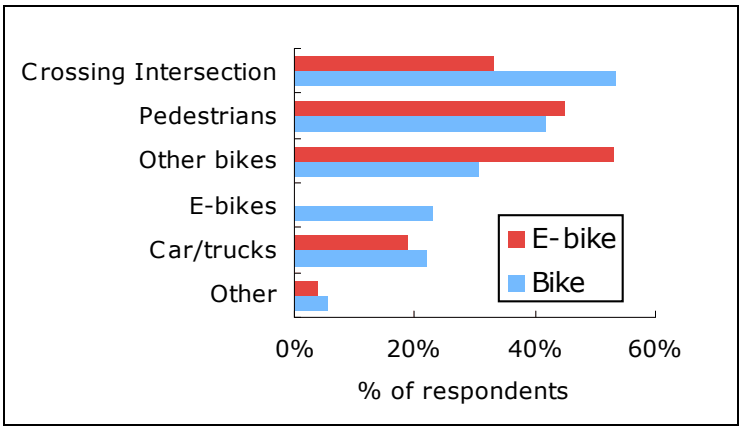

FIGURE 12 Most bothersome aspects for bike/e-bike users.

One reason for this problem amongst 2WV users and pedestrians is the poor enforcement of traffic rules for this group. Interviews with local traffic police revealed two reasons for weak enforcement: 1) they have a responsibility is to maintain vehicle flow and thus they don't have time to strictly monitor NMVs and 2) NMV population is so large and violations so frequent, they don't have the resources to punish them. The difficulty enforcing such a large number in turn encourages more people to disobey (e.g. jay-walking pedestrians).

Another reason for this conflict is likely due to the speed difference between bikes and e-bikes, which is easily observed along bike lanes throughout Shijiazhuang. E-bikes generally travel faster, and thus are often interrupted by slower bikes.

CONCLUSIONS

Electric bikes are providing low-income commuters a mode of transportation that provides high levels of personal mobility at low personal cost. As cities expand, e-bikes are allowing people to commute longer distances and reach more goods and services than alternative modes. This improved mobility could lead to further urban expansion in the long term.

People are choosing e-bikes for a number of reasons; including reduced travel times, increased range compared to bicycles, increased cargo or people carrying capacity, comfort and ease of use. Electric bikes have improved the mobility of the elderly, who often have the responsibility of transporting children.

E-bike users would mostly use bus or bicycle in the absence of electric bikes. E-bikes seem to be acting as a near-term remedy for people who are under-served by public transportation. This mode seems to fill the transportation niche, providing personal transportation to people who do not have traditional transportation patterns. Many users however still rely on bus transit in the case of bad weather.

Based on mode shifting behavior revealed and stated by the survey, e-bikes will continue to grow in popularity as incomes rise and cities expand. It is clear that income is not the only factor contributing to the popularity of electric bikes; their performance characteristics make them a popular mode for all income classes. Many electric bike owners state that the next step along the transportation pathway will be a personal car, implying that electric bikes could be a transitional mode on the motorization pathway.

One of the reasons cited for regulation of e-bike use and performance characteristics is safety. The survey results show that e-bike users, especially woman, feel safer when crossing

intersections compared to when using a bicycle. Most users feel that bicyclists and pedestrians are the greatest source of traffic conflict. Surprisingly, bicyclists identify the most conflict with other bicyclists, however they do think that e-bikes operate too quickly in the bike lane. Female e-bike users are generally opposed to electric bikes with higher speed characteristics. This supports the Chinese Bicycle Association's goal to regulate the speed and performance characteristics of electric bikes operating in bike lanes

RECOMMENDATIONS

Traffic Management

- Impose license system for e-bikes. Licensing vehicles makes it easier to enforce traffic laws and control the e-bike population, thus improving safety. E-bikes are required to register and have special license in some cities like Shanghai, Tianjin, and Suzhou. But some cities like Shijiazhuang have no specific e-bike regulations. Enforcement of licensing is problematic and in many cities, a large portion of electric bikes are unlicensed, despite license requirements.

- Enhance traffic management at intersections to improve traffic safety for both 2WV and pedestrians. Enforcement of local traffic violations such as red-light running will benefit all road users and improve traffic conditions by reducing vehicle interactions.

E-bike Standards

New standards should consider allowing an increase in weight, but keeping speed constant. The survey has revealed that e-bike users do not want an increase in speed. However, weight limits should be increased to accommodate longer commute distances and improve e-bike safety. Increased weight would enable larger battery capacity, a sturdier frame, better braking systems and more comfortable vehicles. As long as vehicle acceleration rate and top speed is well controlled, the safety of other road users need not be compromised.

Areas of Future Analysis

Future studies will examine the regional differences between bike and e-bike travel behavior. Shijiazhuang is classified as a medium sized city, it would therefore be useful to examine the differences between a small and large city as well. China is large country and thus the differences between city size, income level, regional climate, terrain, transit service levels, and average travel distance may result in different conclusions.

The effect of land-use policies on travel behavior and the shift from bike to e-bike also warrants future analysis. The housing policy reform initiated in the early 90s (employees were no longer forced to live in government provided housing close to work) has had a considerable impact on commuter behavior, travel distance, urban transport and land use. Future study could examine whether e-bike use is a result of expansion of cities or is partially responsible. .

The environmental costs and benefits of e-bikes are not yet fully understood and thus it is necessary to carefully evaluate the positive and negative externalities of e-bike use in order to guide the policy debate on e-bikes.

ACKNOWLEDGEMENTS

The survey is supported by the WORLD BANK Beijing Office. The related study of e-bike issues is supported by the ITS-Davis Hydrogen Pathways program and the Hong Kong Fok Ying Tung Education Foundation, Project No. 94027 and the UC Berkeley Center for Future Urban Transport-A Volvo Center of Excellence. We would like to thank Joan Ogden, Dan Sperling, Lee Schipper, Julia Silvas and anonymous referees for their thoughtful review of this work.

REFERENCES

1. Kang, L. Feasible Study On Introducing Fuel Cell Two-Wheeler Technologies Into Shanghai Market (*Chinese*), Shanghai Jiaotong University Report, March 2004 http://www.sj998.com/subject/show_content.asp?id=590. Accessed June 2006

2 . Zhang Y. et al. Research on the Development of Bicycle Traffic in Big Cities, Journal of Transportation Engineering and Information (*Chinese*), No.4, Vol.3, Dec 2005

3. National Bureau of Statistics, China Statistical Yearbook, 2005

4. Interview with vice-president of China Light Automobile Association Motorcycle Branch Zhang Dahu (*Chinese*), Feb,2005, http://www.qglt.com/bbs/ReadFile?whichfile=876281&typeid=17, Accessed July 2006

5. Ni J. Feasibility Study: Proposal for the Manufacture of Mini Electric Cars Based on Experience with Large Scale Manufacture of Light Electric Vehicles, China LEV Development and Strategic Study Report (*Chinese*), Luyuan Bicycle Company, p.49

6. "China Expected to Get Back on Their (Electric) Bicycles", China People's Daily Online, May 2006 http://www.chinadaily.com.cn/cndy/2006-05/16/content_590600.htm (Accessed Nov 2006)

7. "Guangzhou bans Electric Bikes", Xinhua Net (*Chinese*), Nov 2006 http://news.xinhuanet.com/fortune/2006-11/03/content_5284544.htm (Accessed Nov 2006)

8. Cherry C., Weinert J., Ma Z. The Environmental Impacts of Electric Bikes in China, UC Berkeley Center for Future Urban Transport, Working Paper 2006

9. Jamerson, F. and Benjamin, E. 2004 Electric Bicycle World Report, 7th Edition with 2005 update, 2005, p.10

10. General Technical Standards of E-Bike (GB17761-1999), National E-bike Compelling Standards, Chinese Standards Publisher, Beijing, 1999

11. Weinert, J., Ma, Z., and Cherry, C. The Transition to Electric Bikes in China: History and Key Factors for Rapid Growth, 22nd Electric Vehicle Symposium Conference

Proceedings, Yokohama, Japan Oct 25-28, 2006

12. Shijiazhuang Traffic Management Planning and Development Report (*Chinese*), Shijiazhuang Public Security Traffic Management Bureau, 2002

13. Xu Jiqian et al. Bicycle travel characteristics and proper travel distance (*Chinese*), Urban Transport, 1995 Vol.2 p.30

14. Cherry, C. Implications of Electric Bicycle Use in China: Analysis of Costs and Benefits. in UC Berkeley Center for Future Urban Transport-Volvo Summer Workshop. July 24-26, Berkeley, CA. 2006

15. "Traffic Accidents Impair China's GDP Growth", People's Daily Online, Dec 2005. http://english.people.com.cn/200512/16/eng20051216_228514.html. Accessed July 2006