The Determinants of Commuting Satisfaction in Low-Income Population: A Case Study of Xi'an, China

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Abstract

A growing number of studies have investigated the relationship between travel characteristics and satisfaction with travel and life. However, little previous research has focused on low-income populations. Due to economic constraints, low-income populations have relatively fewer travel options, and are more likely to experience transport poverty, which may prevent them from participating in social activities, reducing their life chances and wellbeing. Studying factors contributing to lower levels of travel satisfaction of low-income populations is important to improve their life satisfaction of and overall societal wellbeing. Drawing on recent survey data from Xi'an, China, this study explored factors associated with commuting satisfaction amongst the lower income working population. This study found that the lower income respondents consistently reported lower levels of commuting satisfaction. Such factors as commuting characteristics and the attitudes towards travel significantly influence commuting satisfaction. Also, a mismatch between commuting mode choice and travel attitudes contributes to a lower level of commuting satisfaction. Bicycling commuters have the highest level of commuting satisfaction in the higher income group, while the differences in commuting satisfaction between modes users are not significant in the lower income group. Travel attitudes towards specific travel modes are significantly associated with commuting satisfaction in the lower income group but not in the higher income group. After accounting for attitudes and commuting mode choice, the independent effects of the built environment on commuting satisfaction are not significant.

INTRODUCTION

A growing number of studies have investigated the relationship between the travel characteristics and subjective wellbeing of travel and life (Abou-Zeid, 2009; Cao and Ettema, 2014; De Vos et al., 2015; Ettema et al., 2011; Morris and Guerra, 2014; Olsson et al., 2013; St-Louis et al., 2014). Subjective well-being (SWB), as an alternative and enrichment to utility, has recently attracted significant attention from transportation researchers. SWB offers a direct measurement of individuals' mood, emotion and cognitive judgment on travel experiences, and thus better captures the experienced utilities of travel (Kahneman and Krueger, 2006; Kahneman et al., 1997). Several studies have compared the happiness levels of travelers when they used different travel modes (Abou-Zeid, 2009; Duarte et al., 2010; Morris and Guerra, 2014; Olsson et al., 2013; Smith, 2013). Many empirical studies, based on evidence from Europe and North America, have found significant associations between travel characteristics and satisfaction with travel and life (Cao and Ettema, 2014; Ettema et al., 2011; Morris and Guerra, 2014).

However, little previous research has examined whether the relationship between travel and satisfaction varies among different income groups, particularly between lower- and higher- income populations. Compared with higher income populations, due to economic constraints, lower income populations tend to have relatively fewer travel options, and are more likely to experience transport poverty, which may limit their involvement in social activities, work or education opportunities , healthcare access etc., thereby reducing their life chances and wellbeing (Currie et al., 2009). Understanding the factors that contribute to lower levels of travel satisfaction of lower income populations is important for improving life satisfaction of low-income populations and overall wellbeing of society. Further, travel for the purposes of commuting is of particular interest with regards to wellbeing. Commuting is often associated with particularly poor travel conditions created by serious congestion; it may make up the greatest proportion of daily travel time, and has been a major target of travel management policies (Redmond and Mokhtarian, 2001; Shiftan and Barlach, 2002).

China has been undergoing a period of rapid urbanization and its cities have been changed radically (Ding, 2007; Ma, 2002). Alongside increasing urban expansion, China

has seen increasing travel distances and worsening transportation conditions, particularly for the daily commute (Guan and Cui, 2003). For many residents in the megacities of China, commuting has become a physical and mental burden, significantly affecting their wellbeing. Those members of the population that are on low-incomes may especially suffer during the daily commute. They are more likely to live on the outskirts of the city in more affordable accommodation, and thus may have longer commuting distances, spend a higher share of their income on commuting cost, and have fewer choices of travel modes (Choi et al., 2013; Morris and Guerra, 2014). They are also more likely to have a poor quality living environment and less likely to have flexible working times (Swanberg et al., 2008). This highlights the importance of exploring factors associated with commuting wellbeing of low-income populations. However, little previous research on commuting wellbeing has focused on low-income populations, particularly in the Chinese context.

This study aims to investigate the relative effects of factors such as the built environment, commuting characteristics, and travel attitudes on commuting wellbeing amongst different income groups with a focus on the comparison between the lower- and higher- income working population using data from Xi-an, China. This study also aims to inform policies that help to improve the wellbeing of the urban lower income population in China from a transportation planning perspective.

LITERATURE REVIEW

Many studies have examined the factors that influence travel experience or travel satisfaction. Anable and Gatersleben (2005) evaluated the relative importance of instrumental (e.g., cost, flexibility, predictability) and affective (e.g., relaxing, restful, stress, excitement) attributes for commuting and leisure trips, and they found that instrumental factors are slightly more important than affective factors for commuting, while they are equally important for leisure trips. This is one of the earliest studies that highlight the importance of affective factors in travel behavior research. Further, this study found that active travel commuters rated high on affective factors such as no stress, relaxation, and freedom, all of which are components of SWB. However, the small sample size (n=235) of this study limits the generalization of its findings. Based on work

in customer service literature, Stradling et al. (2007b) developed a six-step method to measure satisfaction with travel modes. This method plots user dissatisfaction against importance for every element that matters for service delivery. This method is innovative in identifying the gaps between customer expectations and actual service supply. Using the same method, Hickman et al. (2015) explored the experiences of travel through the interchange at several high-speed rail hubs in China, by identifying the gaps between user's expectations and actual service provisions in two dimensions: instrumental factors (time, cost, flexibility etc.) and attitudinal/ affective factors (perceptions of service quality, feeling and emotions while using the services). This study highlighted the importance of attitudinal/affective factors in forming the utility (i.e., subjective experience) of public transport. Based on survey data collected in the City of Edinburgh, Stradling et al. (2007a) investigated the factors that discourage people from using the bus in Edinburgh. Through factor analysis, they identified eight key dimensions of bus user dislike with the bus travel experience, and they also found that the importance of these factors varied significantly with age and frequency of bus use. Similarly, Carreira et al. (Carreira et al., 2014; 2013) further analyzed the travel experience of bus users and what factors contribute to the travel experience using qualitative analysis. These two studies highlighted that evaluation of travel experience should not only consider cognitive assessments but also emotional and sensorial aspects.

In addition to the above studies focusing on travel experience, several studies have explored the determinants of travel satisfaction using Satisfaction with Travel Scale (STS) developed by Bergstad et al. (2011) and Ettema et al. (2011). Using data from a web-based survey of workers (n=828) in Portland, Oregon, U.S.A., Smith (2013) found those who bike and walk to work have significantly higher satisfaction with their commuting than transit and car commuters. He also found that, along with travel mode, traffic congestion, travel time, income, health, travel attitudes, job and residential satisfaction also play important roles in shaping commuter satisfaction, which in turn may affect SWB. Relying on a commuter survey (n=3,377) carried out at McGill University in Montreal, Canada, St-Louis et al. (2014) found that pedestrian, train commuters, and cyclists are significantly more satisfied with their commuting than drivers, metro and bus users, and they also found that commuting satisfaction is generally

low with modes that are more affected by external factors. De Vos et al. (2015) investigated the relationship between travel mode choice and travel satisfaction for leisure trips, using survey data (n=1,720) collected in twelve neighborhoods in the Belgian city of Ghent. They found that participants using active travel (especially walking) are most satisfied with travel, while public transit users experience the lowest levels of travel satisfaction. There are also studies that particularly examined the association between travel and the affective component of travel satisfaction. Gatersleben and Uzzell (2007) found that active commuting by walking and bicycling is perceived as more relaxing and exciting than commuting by car and public transit, which is perceived as being more stressful and boring. They also found that the affective appraisals of the daily commute are not only related to instrumental aspects, such as journey time, but also to general attitudes toward various travel modes. Morris and Guerra (2014) also explored the relationship between the affective component of travel wellbeing (i.e., mood) and mode using data from the American Time Use Survey, and found that bicycling has the most positive affect on mood, followed by driving a car, with bus and train riders showing the most negative emotions. However, they found most of these relationships are weak and not statistically significant in their models.

While most of previous empirical studies on travel satisfaction have focused on North America and Europe, a number of recent studies have explored travel satisfaction in Chinese cities. Although there are differences in transport conditions, social norms, and the built environment between Chinese cities and cities of developed countries, findings from recent studies based on Xi'an (Ye and Titheridge, 2017; Zhu and Fan, 2018) and Beijing (Mao et al., 2016) are quite consistent with previous research from North America and Europe. For example, all of these studies found that active travel commuters are more satisfied with their commuting compared with car and transit commuters, and a longer commuting time is associated with a lower level of commuter satisfaction. The unique findings of these studies include the relatively high level of satisfaction with worker bus and low level of satisfaction of e-bike and the indirect impact of the built environment on commuting satisfaction, however, more studies from Chinese cities are needed to confirm these findings.

Although many studies have examined the relationship between travel and travel satisfaction, little research has particularly focused on low-income populations. The low-income population in China is more likely to live in outer suburban or remote communities (Chen et al., 2012), where there are higher levels of car dependence coupled with lower availability of transit and poor quality pedestrian and bicycling infrastructure. As a consequence, this group of people often has a long commuting distance and very limited access to high-quality transit services. Further, the lack of affordable public transport options (e.g., transit) means lower income households may be forced to own and operate cars and spend a greater share of their income on transport, experience transport poverty, or they may have to walk or bike for quite a long distance in a poor walking and bicycling environment to access transit stations or jobs. The low-income communities may also suffer disproportionately from pedestrian deaths, pollution and the isolation which can result from living near busy roads. Fear of injury from traffic, fear of falling on poorly maintained footways, pollution and difficulty crossing busy traffic further lower the lower income residents' subjective experience of travel and deter them from leaving their homes and thus reduce levels of social interaction (Social Exclusion Unit, 2003). This highlights the importance of investigating the travel experiences of the low-income population.

In addition, few previous studies have systematically investigated the role of the built environment and attitudes on travel satisfaction with a focus on low-income populations. The built environment potentially influences travel satisfaction both directly and indirectly. First, the built environment impacts travel behavior by affecting the generalized cost of travel to various destinations (Boarnet and Sarmiento, 1998). New urbanism and related designs, such as higher densities, mixed land use, and pedestrian-friendly design, can alter the time-cost of traveling from one location to various other locations by concentrating trip origins closer to destinations and by influencing travel speed. Low-income households living in neighborhoods with such design have more transport options (e.g. walking and bicycling) to meet their needs of daily activities, and are more likely to feel safe to travel within the neighborhood. In addition, a pedestrian friendly neighborhood may help to reduce the psychological costs of travel by improving traffic safety and enjoyment during travel. The built environment, therefore, may help to

lessen disamenities of travel and improve travel wellbeing for the lower income population through reducing travel costs, providing more transport options and providing a better travel experience.

Attitudes towards travel may directly influence subjective evaluations of the travel experience. Attitudes also indirectly affect subjective wellbeing through travel behavior. Travel behavior theory has long recognized the role of attitudes and preferences in influencing travel behavior (Cao et al., 2009; Handy et al., 2005, 2006; Kitamura et al., 1997; Naess, 2005). Several studies have directly modeled the associations between travel attitudes and travel satisfaction (Cao and Ettema, 2014; De Vos et al., 2015; Manaugh and El-Geneidy, 2013; St-Louis et al., 2014; Ye and Titheridge, 2017). All of these studies have confirmed the significant role of travel attitudes or preferences on travel satisfaction. For example, these studies found that positive attitudes towards travel in general and any travel mode specifically have a strong and positive effect on travel satisfaction. However, few of these studies have explicitly explored the disparities of the effects of travel attitudes on travel satisfaction between different income groups. As discussed above, the lower income populations may have fewer transport options and poor travel experiences compared with their higher income counterparts, and therefore their attitudes may play a more important role in forming their satisfaction with travel.

Despite the potential links between the built environment, attitudes, travel characteristics and travel satisfaction, few previous studies have systematically assessed how the relationships could be moderated by income. Further, none of the previous studies have explored the impact of mismatch between travel attitudes and travel mode choice on travel satisfaction. The lower income population might have a higher level of mismatch due to their socio-economic disadvantages, which thus leads to a lower level of travel satisfaction. This study aims to fill these research gaps.

DATA AND METHODOLOGY

The data used in this study was gathered through a survey conducted in Xi’an, China. As a hub and mega-city in western China, Xi’an has undergone massive urban development in the past 30 years. The population increased from 5 million in 1980 to about 8.5 million in 2010 (Xi'an Bureau of Statistics, 2011), and the urban built-up area

has increased twenty-six fold, from 14 square kilometers in 1950 to 369 square kilometers in 2010 (Xi'an Bureau of Statistics, 2011). This dramatic expansion of the urban space has had two significant consequences on travel activities, especially commuting. First, commuting distance and time have increased dramatically due to the increased separation of jobs and housing. Based on a web-survey conducted in 2012, the average commuting time in Xi'an is 70 minutes (round trip) (Xi'an Bureau of Statistics, 2011) and this number might increase due to the continuing urban expansion and increasing congestion levels. Second, the traditional travel modes of bicycling and walking are gradually becoming impossible due to these longer trip distances. Instead, more and more people have to rely on either a private car or transit for their daily commute.

The study is limited to residents of Xi'an aged over 18 who are in employment within Xi'an and do not work from home. Participants for the questionnaire survey were recruited through their employers and the survey was conducted at their employers' sites. Employers were sampled by industry type from the current industry listings (catalogues); a quota-based approach was taken to ensure that each industry type was represented in the survey. Once companies were selected, they were contacted to ask their permission to distribute the questionnaire to their employees. For those who accepted, a letter to explain the purpose of the survey, a consent form and a link to the web version of the survey were sent to the person in charge, and then distributed to the employees through their internal mailbox or instant messaging software. For those employees, who had difficulty obtaining internet access, such as those working in factories or banks, the survey and consent form were distributed in paper and/or e-form format. All participants were given a small gift to thank them for their participation. The survey was conducted in May-June 2013.

In total, 1364 valid surveys were collected, including 794 web-based surveys and 570 paper-based surveys. After excluding cases with a lot of missing data, 1215 cases were used for the data analysis.

The survey collected data on the characteristics of the respondents' commute, their satisfaction with various aspects of their commute, their attitudes towards different modes and aspects of travel, their socio-economic characteristics and their overall

satisfaction with various non-travel aspects of their life. All respondents were then divided into two groups, lower income group and higher income group, using median income splits. Due to the lack of household income data, individual income was used to define the groups. Using individual income to differentiate between low- and high-income groups may affect our results slightly because some low-income individuals might belong to a higher-income household and vice-versa. However, we also compared other socio-economic characteristics between the two groups as we defined, and we found that the lower income group was less likely to own a car and a property than the high-income group. Around 50% of the respondents had an annual income of below 30,000 Yuan, which is about 60% of the average annual income (49,350 Yuan) of all employees in the urban area of Xi'an in 2013. These were classified as lower income workers. Table 1 provides a comparison in socio-demographic characteristics between the lower income and higher income groups. Compared to the higher income group, low-income workers are more likely to be female, young, live in a bigger household and have a lower level of education and poor health condition, while they are less likely to hold a driver's license, own a car or a flat.

All responses with a valid home and work address have been geocoded in GIS. Both ¼-mile and ½-mile Euclidean buffers were created around each home and job location. These buffer widths were chosen following the previous literature on the relationships between the built environment and travel behavior. The built environment characteristics around each home and job location were calculated by overlaying the buffers with a land use GIS layer. The street network GIS layer was extracted from OpenStreetMap (OSM, 2014). The land use GIS layer was acquired from the Xi'an Bureau of City Planning. The spatial distribution of the home and job locations is presented in Figure 1.

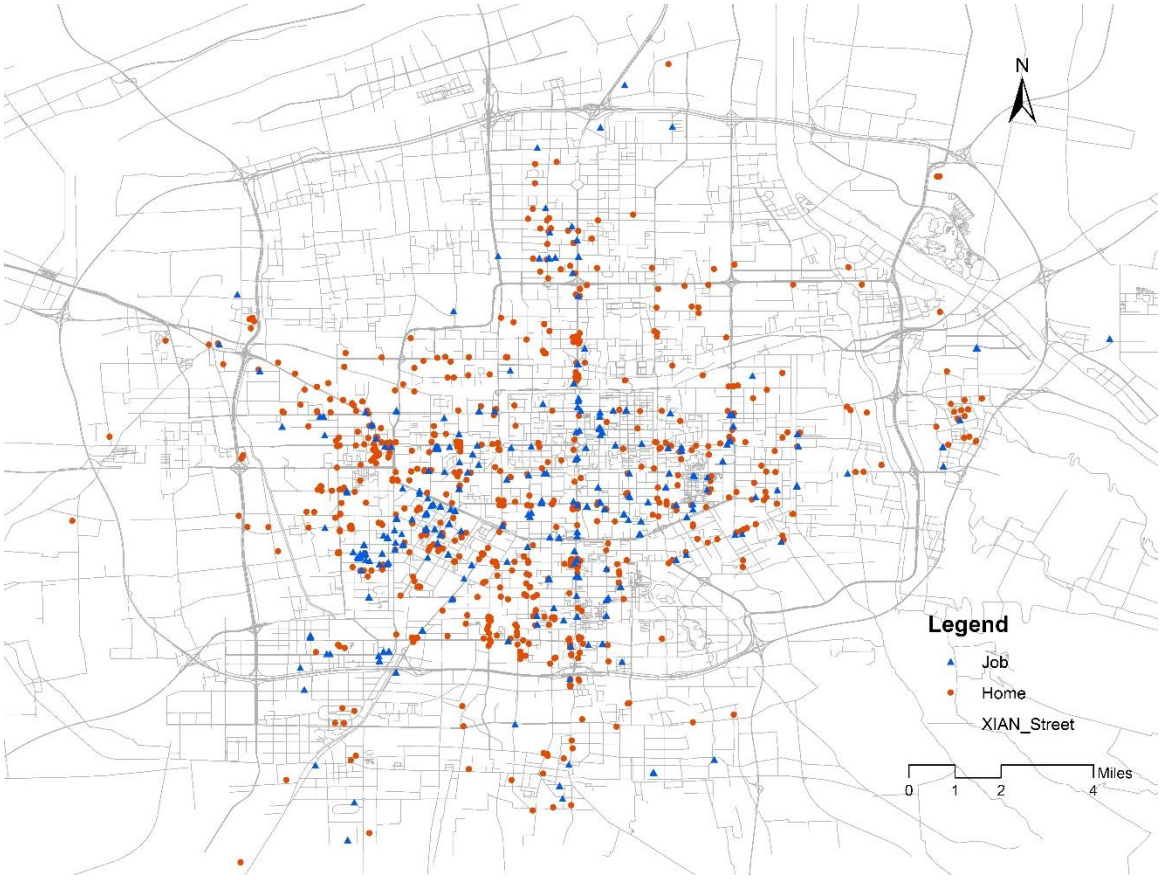

Figure 1 Distribution of home and job locations of the sampling employees

Attitudes were measured based on 31 survey questions adapted from Handy et al. (2005) that assess the respondents' attitudes regarding their daily travel using a 5-point Likert scale from strongly disagree (1) to strongly agree (5). In order to reduce the dimensions, exploratory factor analysis was conducted based on the 31 survey questions. The initial eigenvalues showed that the first eight factors explained 58% of the variance, with values greater than one. Different factor solutions were examined using varimax rotations of the factor loading matrix which did not improve the results. We chose the original eight-factor solution, because of the 'leveling off' of eigenvalues on the scree plot after eight factors, the insufficient number of primary loadings, and the difficulty of interpreting the ninth and subsequent factors. The factor loading matrix of this eight-factor solution is presented in Appendix.

Descriptive analysis was first conducted to explore the differences between low-income and higher income respondents in terms of their socio-demographic

characteristics, their commuting characteristics, their home and job environment and their attitudes towards travel.

Table 1 Sample characteristics for lower and higher income employees

	Lower income	Higher income	p-value*
Household number	3.60	3.33	0.00
# children	0.57	0.65	0.06
# full-time worker	2.01	2.07	0.21
% hold driver license	40%	72%	0.00
# cars	0.42	0.83	0.00
# bikes/e-bikes	0.82	0.73	0.07
Female	58%	46%	0.00
Age	31.71	35.62	0.00
Body Mass Index (BMI)	22.05	22.82	0.00
Self-reported health (1-5)[1]	3.44	3.55	0.03
Education (1-6)[2]	3.12	3.75	0.00
Annually income before tax (1-10)[3]	2.01	5.25	0.00
Owner or renter of the property (1=owner)	44%	78%	0.00

*p-values are from ANOVA or chi-square tests as appropriate

Regression models were then used to further explore the relative contributions of socio-demographics, the built environment, commuting characteristics, and attitudes to commuting satisfaction. Since the measurement of the dependent variable, commuting satisfaction, is bounded at -3 on the left and 3 on the right, we employed the Tobit model (Tobin, 1958) to handle the censoring characteristic of the dependent variable. The Tobit model is based on an unobserved (latent) continuous dependent variable y_i^* that can take on any value:

$$y_i = \begin{cases} y_i^* & if\ -3 < y_i^* < 3 \\ -3 & if\ y_i^* \le -3 \\ 3 & if\ y_i^* \ge 3 \end{cases}$$

$$y_i^* = \beta_0 + \beta_1 S_i + \beta_2 E_i + \beta_3 A_i + \beta_3 C_i + \varepsilon$$

[1] 1 - Poor; 2 - Fair; 3 - Good; 4 - Very good; 5 - Excellent.

[2] 1 - Junior high school or less; 2 - High school or technical secondary school; 3 - Some College; 4 - Bachelor's degree; 5 - Master's degree; 6 - Doctoral or professional degree.

[3] 1- less than RMB10,000; 2- ¥10,000-¥19,999; 3- ¥20,000-¥29,999; 4 ¥30,000-¥49,999; 5- ¥50,000-¥74,999; 6- ¥75,000-¥99,999; 7- ¥100,000-¥149,999; 8-¥150,000 and ¥199,999; 9- ¥200,000 and ¥399,999; 10-¥400,000 and over.

where y_i is the observed variable (commuting satisfaction in our case) for individual i, S_i is the socio-demographic characteristics of individual i, E_i is the built environment around individual i's home and job locations, A_i is the individual i's attitudes towards travel, and C_i is the characteristics of the commuting trip by individual i. The Tobit model can be estimated with maximum likelihood estimation.

DESCRIPTIVE ANALYSIS

Satisfaction with commute and life

Commuting satisfaction was measured using The Satisfaction with Travel (STS) Scale developed by Ettema et al. (2011). This measure includes both affective and cognitive components related to daily travel, and consists of nine items scoring from -3 to 3 to assess each aspect of travel experiences. In this study only seven of the nine items were used because after the pilot study we found the two items "Fed up- engaged "and "Travel was low-high standard" showed insufficient differences with items "bored-enthusiastic" and "worst-best" respectively after translating into Chinese. The seven items for measuring commuting satisfaction are: (1) I felt time was pressed - I felt time was relaxed during the commute; (2) I was worried I would not be in time – I was confident I would be in time; (3) I was stressed – I was calm; (4) I was tired – I was alert; (5) I was bored – I was enthusiastic; (6) I think this commute is the worst – I think this commute is the best I can think of; (7) I think this commute worked well – I think this commute worked poorly. Figure 2 provides a comparison for each item of commuting satisfaction between lower income respondents and others. A lower level of satisfaction was reported for every item of commuting satisfaction by lower income respondents, and follow-up ANOVA tests indicate that these differences were statistically significant ($p<0.01$).

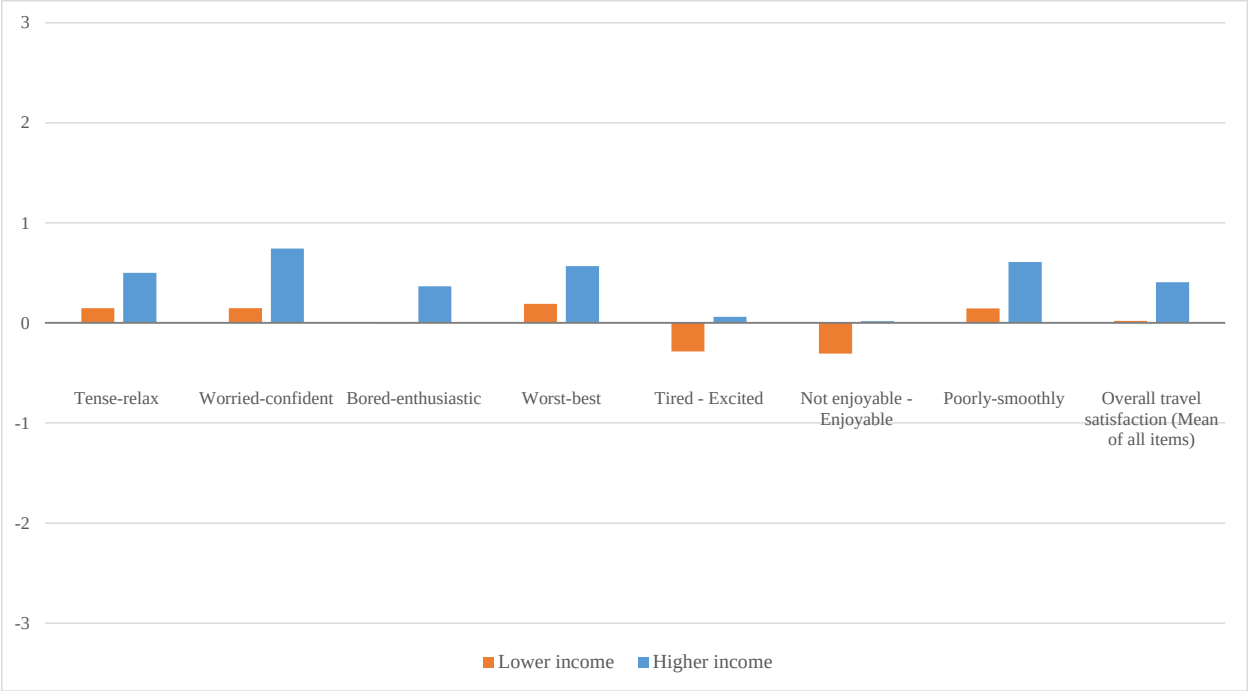

Figure 2 Mean satisfaction with commute by income group

Life satisfaction was measured using the Satisfaction with Life Scale (SWLS) developed by Diener et al. (1985). The five items for measuring the SWLS are: (1) In most ways my life is close to my ideal; (2) The conditions of my life are excellent; (3) I am satisfied with my life; (4) So far I have gotten the important things I want in life; (5) If I could live my life over, I would change almost nothing. Each item is measured on a 1-7 scale, where 1 is strongly disagree and 7 is strongly agree. Figure 3 illustrates the difference between lower income respondents and others in each item of life satisfaction. Similarly, the lower income respondents reported lower levels of life satisfaction compared with others. However, the differences in life satisfaction between the two groups of respondents were not as much as the differences in travel satisfaction. This indicates that life satisfaction is more affected by other factors in addition to income.

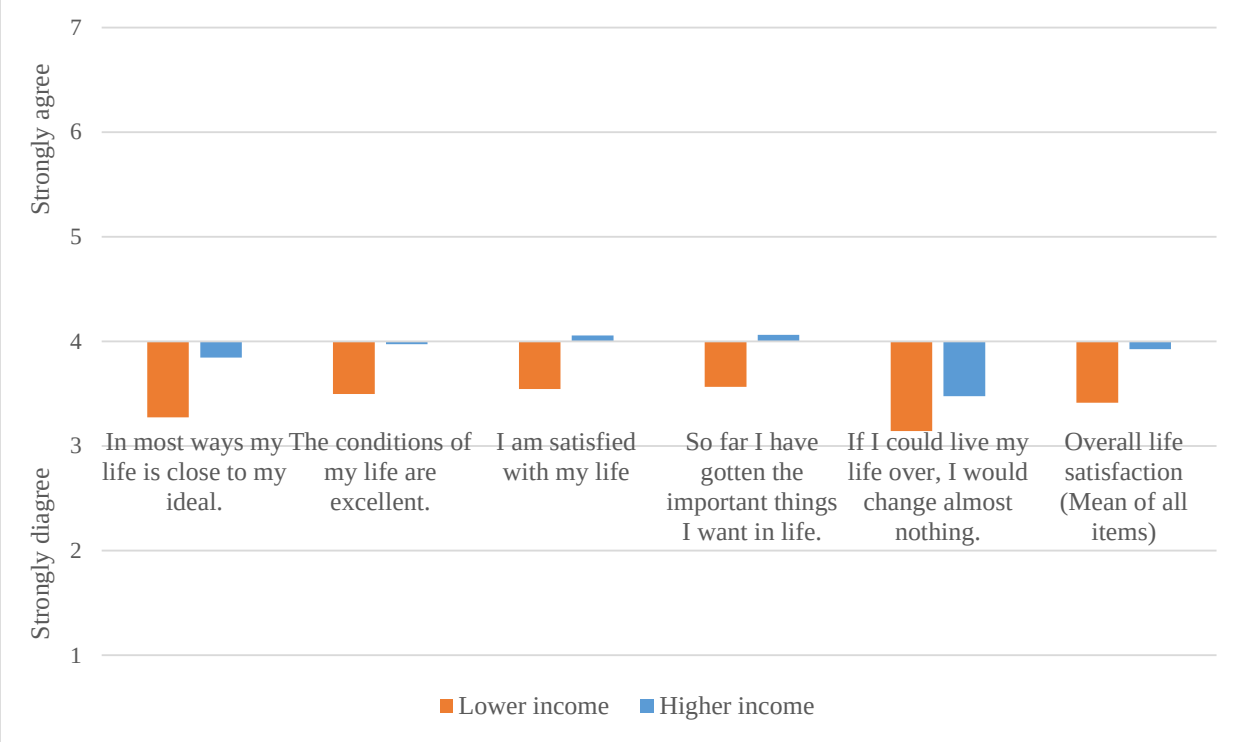

Figure 3 Mean satisfaction with life by income group

Travel Characteristics

Figure 4 provides the commuting mode choice between the lower income respondents and the higher income group. Compared with others, lower income respondents were more likely to use buses (44% vs. 27%) for their daily commuting. About one in four lower income respondents walked to work, higher than for higher income respondents (23% vs. 15%). In total, nearly 70% of lower income respondents relied on buses or walking for commuting. There was also a higher level of bike/E-bike use amongst lower income respondents compared with the higher income group (14% vs. 6%). As expected, compared to the higher income group, lower income respondents were much less likely to use a car (14% vs. 44%) for their commuting.

Figure 5 further illustrates the different relationships between travel modes and commuting satisfaction for the lower income group and the higher income group. Commuting satisfaction was measured using the mean of the seven items. The lower income group reported lower travel satisfaction than the higher income group across all the travel modes except rail. For bike and e-bike commuters, it is interesting to note that,

the overall travel satisfaction level among the lower income group is negative, while it is positive among the higher income group.

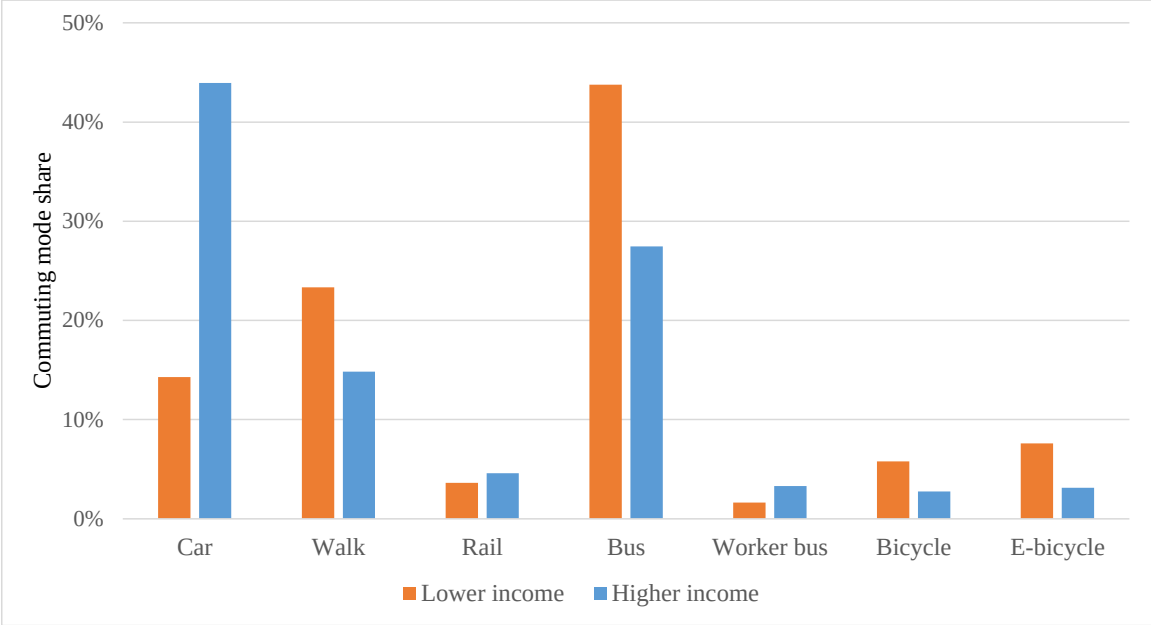

Figure 4 Commuting mode share by income group

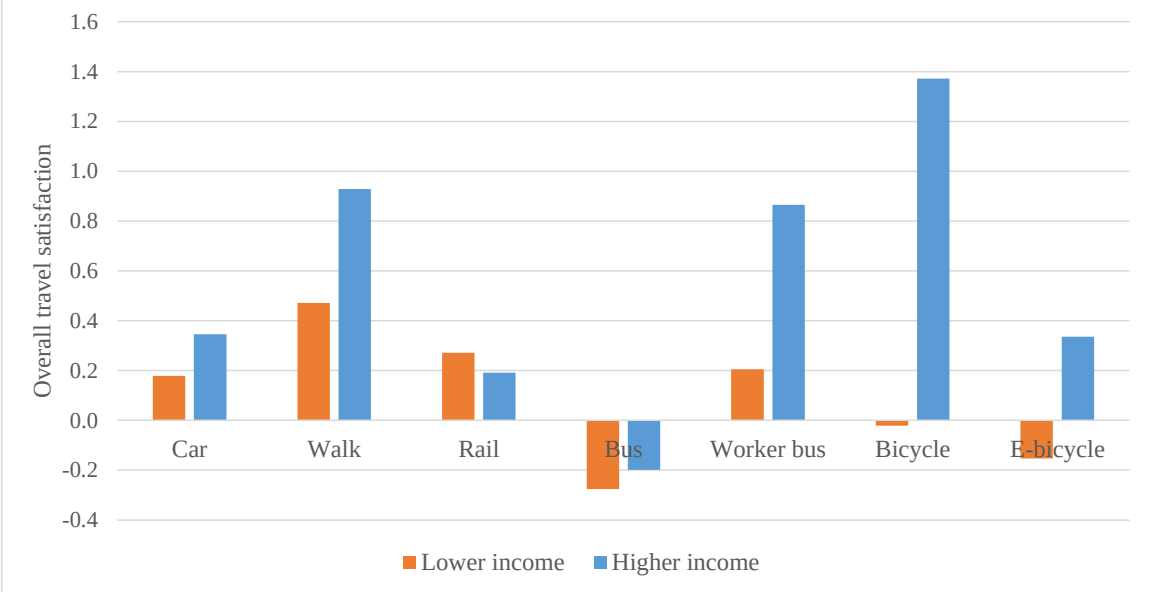

Figure 5 Mean commuting satisfaction by travel mode and income group

Table 2 compares the self-reported commuting time and distance by travel modes between the lower income and higher income groups. The lower income respondents had

longer perceived commute times across almost all of the travel modes, with the exception of rail, bus and worker bus. Similarly, the lower income respondents had longer perceived commuting distances across all travel modes except worker bus. The longer perceived commuting time and distance by the lower income respondents could result from actual differences in commuting time and distances between the two groups, but could also be attributed to differences in perception per se between the two groups. It is possible that overall experiences of the commute are different between the two groups even if they use the same mode for commuting. For example, driving in a spacious, luxury car is more comfortable than in an old, compact car for commuting, and thus the perceived time and distance in latter may be longer. For transit commuters, waiting time and level of crowding could increase perceived travel time.

Table 2 Mean self-reported commuting time and distance by mode and by income group

	Self-reported commuting time (minutes)		Self-reported commuting distance (km)	
	Lower income group	Higher income group	Lower income group	Higher income group
Car	41.3	33.7	14.7	10.2
Walk	28.4	20.3	6.3	4.0
Rail	41.2	48.5	11.4	10.9
Bus	49.1	53.0	12.5	11.6
Worker bus	29.2	49.7	16.5	22.4
Bicycle	30.6	22.3	15.7	6.0
E-bicycle	32.3	20.1	10.7	7.5

Among the lower income respondents who choose to commute by transit, around 39% need to transfer during the trip. This is lower than the transit commuters of the higher income group. However, a higher percentage of low-income transit commuters needed to transfer more than once. This group possibly has no choice other than using transit for their commute. Almost all of the transit riders reported that the carriage of bus or train was crowded during the commute, but more low-income respondents reported "very crowded" compared with higher income respondents (Table 3).

Table 3 Characteristics of the transit commute by income group

	Lower income	Higher income
How crowded were bus or rail?		
Not at all	3%	2%
Somewhat	43%	50%
Very crowded	54%	48%
Need transfer?		
No interchange	61%	52%
Interchange needed	39%	48%
Number of transfer		
1	59%	70%
2	33%	28%
3 and over	8%	2%

Travel Attitudes

Table 4 shows the differences in travel attitudes between the low and high income groups. The lower income group has more positive attitudes towards bike and transit than the higher income group; conversely, less people in this group are prone to car or think car is safer than other modes. As for walking, although from figure 4 we can see 25% of people in this group walk to work, which is much higher than higher income group (16%), their attitudes towards walking is negative compared with the other group. This implies that there is a mismatch between the walking behavior and attitudes towards walking among lower income respondents. Forced to walk may also contribute to the lower level of satisfaction in lower income respondents.

Table 4 Mean travel attitudes rating between different income groups

	Lower income	Higher income	p-value*
Fuel Efficiency	-0.05	0.05	0.150
Pro Bike	0.12	-0.12	**0.000**
Car Safer	-0.17	0.17	**0.000**
Pro Transit	0.05	-0.05	0.179
Pro Walk	-0.14	0.13	**0.000**
Pro Driving	-0.06	0.07	0.057
Environment	0.05	-0.05	0.140
Positive Travel	-0.04	0.04	0.225

*p-values are from ANOVA tests

Built environment

Table 5 shows the characteristics of the built environment around home and job locations of the lower and higher income groups. Compared to the higher income group, lower income people are more likely to live in the suburbs and bigger block, which have fewer bus stops and less commercial land use. While for job location, there are less rail/bus stops and poorer street connectivity compared to the higher income group.

It is worth pointing out that although the GIS measured home-job distance are quite similar for the two groups, those from lower income group report longer commuting distance than those from higher income group.

Table 5 Built environment around home location between two different income groups

	Lower income	Higher income	p-value*
Distance from home to CBD (meters)	7,545	7,081	0.052
Rail station within ¼-mile of home	11%	10%	0.696
Rail station within ½-mile of home	18%	18%	0.969
Average perimeter of the blocks around home	1,171	1,083	**0.030**
Street connectivity (nodes ratio) around home	88%	88%	0.817
% commercial land use around home	7%	10%	**0.004**
% green land use around home	6%	6%	0.464
# bus stops within ¼-mile of home	23	27	**0.005**
# bus stops within ¼-mile of job	21	25	**0.002**
Distance from job to CBD (meters)	7,170	6,867	0.148
Rail station within ¼-mile of job	6%	12%	**0.003**
Rail station within ½-mile of job	11%	19%	**0.003**
Average perimeter of the blocks around job	1,048	1,088	0.198
Street connectivity (nodes ratio) around job	89%	92%	**0.037**
% commercial land use around job	8%	11%	**0.000**
% green land use around job	7%	6%	0.197
Home-job distance (GIS measured, km)	5.11	5.24	0.737
Home-job distance (self-reported, km)	11.39	9.83	**0.027**

*p-values are from ANOVA tests or chi-square tests as appropriate.

MODEL RESULTS

The Tobit model was employed to investigate factors contributing to commuting satisfaction. Before model estimation, three categories of travel modes including drive alone, carpool, and taxi were combined into one category-Car to have a big enough sample in each category. To compare the differences between the lower income group and higher income group, separate models were used for the two groups. The

independent variables include four sections: social-demographics, commuting characteristics, travel attitudes, and the built environment. The models were tested using these four sets of variables at the beginning; however, we found that none of the built environment variables were statistically significant in any models. This indicates that the built environment had an insignificant effect on commuting satisfaction, after accounting for socio-demographics, travel characteristics and travel attitudes. Further, because many respondents did not report either their home or job location or both, including the built environment variables decreases the sample size for model estimation. The built environment variables, therefore, were excluded in the next step model development. All the models were checked for heteroskedasticity, which may bias the estimation. The plots of residuals against the predicted value did not show a strong trend, indicating no serious heteroskedasticity in the models.

Although the built-environment variables were not statistically significant in the models, this does not mean the built-environment contributes nothing to commuting satisfaction. The built environment could affect commuting characteristics (e.g. travel mode choice) as well as travel attitudes, which directly influence commuting satisfaction. As indicated in Table 5, the lower income respondents were more likely to live in areas with big blocks, disconnected streets and fewer bus services, which are unpleasant for walking, bicycling and transit use, and thereby leading to lower levels of satisfaction with these modes. Different from the results of our study, a recent study of the Twin Cities, Minnesota (Cao and Ettema, 2014) found independent effects of the built environment on travel satisfaction after accounting for attitudes, though the contribution of the built environment is relatively very small, ranging from 3-4%. The difference in results could be from the different measurements of the built environment. All the built environment variables in our study were calculated in GIS, while Cao and Ettema (2014) used a number of self-reported (or perceived) measures. Objective and perceived measures of the built environment could influence travel satisfaction in different ways.

The model results are reported in Table 6. Each of the two models explained approximately 11-13% of the variations in commuting satisfaction, however, there are some differences in contributory factors between the two models. For both the lower income group and the higher income group, congestion and longer commute times were

associated with lower levels of commuting satisfaction. These findings are in line with previous studies (Smith, 2013; Stutzer and Frey, 2008). However, age was positively associated with a high level of commuting satisfaction for the lower income group only, whilst those who were married and those with good health were more likely to be satisfied with their commuting trip, but only for those on higher incomes.

A striking difference between the two groups is the effect of travel mode choice on commuting satisfaction. For the lower income group, travel mode choice makes no difference to commuting satisfaction. For the higher income group, however, travel mode choice does matter for commuting satisfaction. In particular, bus commuters are less likely to be satisfied with their commute than those relying on car, rail transit, worker bus, walking or bicycling to get to work. Bicycling commuters have the highest level of commuting satisfaction, and this is followed by worker bus, walking, rail transit and car commuters. Bus and e-bike commuters had the lowest levels of satisfaction with commuting amongst those in the higher income group. The lower level of satisfaction with bus commuting has been reported in several studies (De Vos et al., 2015; Smith, 2013; St-Louis et al., 2014), but no studies have explored the relationship between using e-bike as a commuting mode and commuting satisfaction. The negative perception of e-bike commuting in Xi'an could result from the frequent conflicts between e-bike commuters and commuters using other traffic modes.

Differences in reasons for choosing a commute mode between the two groups may contribute to the different effects of travel mode on commuting satisfaction between the two groups. A further ANOVA analysis on the importance of the 15 factors that influence commuting mode choice between the two groups reveals that the lower income group rated higher in instrumental factors such as punctuality and cost, while the higher income group rated higher in affective factors such as comfort and physically relaxing, which are directly related to the subjective evaluation of commuting trips. This means that the commuting modes that are comfortable and physically relaxing, such as car and active travel, will have a higher impact on travel satisfaction in the higher income than in the lower income group. Another explanation for the different effects of travel mode choice on commuting satisfaction is the hypothesis of the impact of the mismatch between travel attitudes and travel behavior on travel satisfaction. It is reasonable to

argue that people who have mismatched travel preferences and travel behavior may have a lower level of travel satisfaction compared with those whose travel behavior is consistent with their preferences. To test this hypothesis, we have created a mismatch variable by interacting the travel mode dummy variables and travel attitudes dummy variables. The results of a Tobit model (Table 7) confirmed this hypothesis. Further, we found that there were higher percentages of mismatch in the lower income group compared with the higher income group. This may also help to explain why travel modes variables were not significant in the lower income group.

The effects of attitudes on commuting satisfaction also showed differences between the two groups. Among the lower income respondents, those who hold positive attitudes towards transit, walking, and driving were more satisfied with their commuting than those who hold negative attitudes. Interestingly, attitudes towards travel modes had no impact on commuting satisfaction in the higher income group. As suggested above, the lower income commuters perhaps had limited capacity to choose the commute mode they like and had poor travel experiences, and thus their attitudes towards the mode they chose would become more important to influence their subjective evaluation of the commuting trip. Further, environmentally friendly respondents were more likely to be satisfied with their commute than those who had less environmentally-friendly attitudes, but this is only significant for the higher income group. Finally, for both groups, those who hold positive attitudes towards travel were more likely to be satisfied with their commuting trip.

Finally, we conducted sensitivity tests to explore whether our findings are influenced by the classification of the income groups. In addition to the median split, two additional income split methods were applied. Table 8 reports the model results that compare the top 32%, middle 38%, and bottom 30% income groups. Table 9 reports the model results that compare the top 18%, middle 66%, and bottom 16% income groups. By comparing model results from three different income classifications, the impact of commuting modes on commuting satisfaction is quite consistent across models. Commuting modes were not significantly associated with commuting satisfaction in the lower income group regardless of what income category (bottom 50%, 32% or 18%) we used to define the lower income group, and they tended to be significant in middle or

higher income groups. Particularly, the mode of bicycling was more likely to be significant in the highest income group. In terms of the effects of travel attitudes, the results from the model that used the bottom 32% of personal income as the lower income group (Table 8) was quite consistent with results of the median income split model (Table 6). However, while we used the lowest 18% of personal income as the lower income group (Table 9), the two attitudinal variables, *Pro Walk* and *Pro Driving*, became insignificant in affecting commuting satisfaction. These two variables were significant in the model of the middle income group. The variable, *Environment Friendly*, was only significant in the high income group, and this is consistent across different income classifications. These sensitivity tests confirm that different factors are associated with commuting satisfaction between the lower and higher income group.

Table 6 Factors contributing to commuting satisfaction for lower income and higher income groups.

	Lower income group		Higher income group	
	Coef.	P>t	Coef.	P>t
Socio-demographics				
Age	0.022	**0.012**	-0.004	0.576
Female	-0.080	0.588	-0.080	0.544
Education	-0.049	0.536	-0.080	0.310
Income	-0.056	0.513	0.000	0.996
Married	0.138	0.436	0.391	**0.018**
Self-reported Health	0.142	0.068	0.444	**0.000**
Travel Characteristics				
Congestion[4]	-0.651	**0.000**	-0.520	**0.000**
Commuting time	-0.007	**0.007**	-0.006	**0.041**
Car	0.237	0.259	0.541	**0.002**
Rail	0.356	0.361	0.693	**0.047**
Worker bus	0.746	0.325	1.031	**0.009**
Walk	0.044	0.817	0.909	**0.000**
Bicycle	-0.407	0.211	1.776	**0.000**
E-bicycle	-0.237	0.429	-0.088	0.805
Bus	Ref.		Ref.	
Attitudes				
Fuel Efficiency	-0.012	0.861	-0.041	0.565
Pro Bike	0.068	0.355	-0.042	0.518
Car Safer	-0.070	0.308	0.056	0.455
Pro Transit	0.225	**0.000**	-0.097	0.176
Pro Walk	0.235	**0.001**	0.079	0.273
Pro Driving	0.232	**0.000**	0.086	0.251
Environment Friendly	0.005	0.942	0.189	**0.004**
Positive Travel	0.359	**0.000**	0.258	**0.000**
constant	0.866	0.154	-0.145	0.818
Log-Lik Intercept Only	-661.704		-661.809	
Log-Lik Full Model	-588.264		-576.399	
McFadden's R2	0.111		0.129	
Number of observation	363		373	

Note: Bold font indicates significant at 5% level.

[4] 1= not at all congested; 2= somewhat congested; 3= very congested.

Table 7 Impact of mismatch between travel preference and travel behavior on travel satisfaction

	Lower income group		Higher income group	
	Coef.	P>t	Coef.	P>t
Age	0.032	0.000	0.003	0.732
Female	-0.024	0.878	-0.096	0.485
Education	-0.086	0.303	-0.059	0.490
Income	-0.018	0.845	0.034	0.509
Married	-0.155	0.409	0.222	0.213
Self-reported Health	0.271	0.001	0.493	0.000
Congestion	-0.706	0.000	-0.571	0.000
Commuting time	-0.010	0.000	-0.014	0.000
Mismatch	**-0.386**	**0.010**	**-0.332**	**0.017**
constant	0.701	0.273	0.323	0.628
Log-Lik Intercept Only	-612.873		-618.329	
Log-Lik Full Model	-567.62		-565.074	
McFadden's R2	0.074		0.086	
Number of observation	337		349	

Note: Worker bus and e-bike were not included in creating the *mismatch* variable, as we did not have travel attitudinal variables that are directly relevant to these two modes. Bold font indicates significant at 5% level.

Table 8 Model results based on income classification: 32%, 38%, and 30%

	Bottom 32%		***Middle 38%***		***Top 30%***	
	Coef.	P>t	Coef.	P>t	Coef.	P>t
Socio-demographics						
Age	**0.030**	**0.003**	-0.006	0.612	-0.011	0.229
Female	-0.058	0.749	-0.015	0.934	-0.208	0.178
Education	-0.074	0.451	-0.132	0.185	0.053	0.567
Income	-0.162	0.345	0.181	0.298	0.059	0.349
Married	0.015	0.947	0.285	0.180	**0.441**	**0.022**
Self-reported Health	**0.184**	**0.041**	**0.257**	**0.023**	**0.443**	**0.000**
Travel Characteristics						
Congestion	**-0.699**	**0.000**	**-0.682**	**0.000**	**-0.366**	**0.007**
Commuting time	-0.006	0.120	**-0.007**	**0.022**	-0.007	0.072
Car	0.011	0.970	**0.678**	**0.002**	0.354	0.084
Rail	0.271	0.611	0.591	0.115	0.194	0.751
Worker bus	0.631	0.403	0.875	0.160	0.926	0.066
Walk	0.014	0.950	**0.649**	**0.013**	**0.777**	**0.007**
Bicycle	-0.189	0.632	0.642	0.173	1.264	0.054
E-bicycle	-0.549	0.179	0.570	0.120	**-1.029**	**0.019**
Attitudes						
Fuel Efficiency	-0.026	0.758	-0.071	0.422	0.038	0.637
Pro Bike	0.098	0.254	0.010	0.913	-0.078	0.302
Car Safer	-0.093	0.255	0.059	0.523	0.048	0.591
Pro Transit	**0.157**	**0.043**	0.145	0.114	-0.079	0.332
Pro Walk	**0.248**	**0.007**	0.129	0.159	0.092	0.277
Pro Driving	**0.163**	**0.043**	**0.297**	**0.002**	0.078	0.363
Environment Friendly	-0.018	0.828	0.147	0.102	**0.193**	**0.013**
Positive Travel	**0.327**	**0.000**	**0.272**	**0.008**	**0.303**	**0.000**
constant	0.816	0.290	0.570	0.525	-0.983	0.196
Log-Lik Intercept Only	-426.335		-515.393		-379.399	
Log-Lik Full Model	-376.316		-457.536		-319.087	
McFadden's R2	0.117		0.112		0.159	
Number of observation	235		276		225	

Note: Bold font indicates significant at 5% level.

Table 9 Model results based on income classification: 18%, 66%, and 16%

	Bottom 18%		***Middle 66%***		***Top 16%***	
	Coef.	P>t	Coef.	P>t	Coef.	P>t
Socio-demographics						
Age	**0.042**	**0.001**	-0.008	0.323	-0.024	0.064
Female	0.165	0.513	-0.131	0.298	-0.211	0.319
Education	-0.221	0.112	-0.026	0.715	0.000	0.999
Income	0.000	(omitted)	0.009	0.887	0.026	0.773
Married	-0.023	0.944	**0.325**	**0.028**	0.420	0.137
Self-reported Health	0.129	0.282	**0.235**	**0.002**	**0.474**	**0.000**
Travel Characteristics						
Congestion	**-0.608**	**0.002**	**-0.699**	**0.000**	-0.334	0.114
Commuting time	-0.009	0.077	**-0.006**	**0.016**	-0.007	0.239
Car	0.135	0.719	**0.505**	**0.002**	0.385	0.223
Rail	0.635	0.401	0.425	0.146	0.000	(omitted)
Worker bus	0.353	0.704	**1.092**	**0.030**	0.463	0.436
Walk	0.271	0.363	**0.391**	**0.032**	**1.200**	**0.013**
Bicycle	0.256	0.646	0.358	0.296	**1.856**	**0.022**
E-bicycle	0.157	0.803	0.040	0.879	-1.406	0.074
Attitudes						
Fuel Efficiency	0.137	0.197	-0.100	0.124	0.021	0.843
Pro Bike	0.122	0.270	-0.009	0.888	-0.101	0.298
Car Safer	0.089	0.395	-0.030	0.648	0.063	0.622
Pro Transit	**0.240**	**0.027**	0.112	0.069	-0.051	0.645
Pro Walk	0.152	0.182	**0.184**	**0.008**	0.016	0.885
Pro Driving	0.187	0.105	**0.227**	**0.000**	-0.075	0.520
Environment Friendly	0.035	0.743	0.078	0.223	**0.213**	**0.042**
Positive Travel	**0.270**	**0.012**	**0.315**	**0.000**	**0.341**	**0.005**
constant	0.607	0.507	1.018	0.069	-0.175	0.878
Log-Lik Intercept Only	-228.459		-892.363		-202.335	
Log-Lik Full Model	-196.142		-792.528		-170.328	
McFadden's R2	0.141		0.112		0.158	
Number of observation	126		489		121	

Note: Bold font indicates significant at 5% level.

CONCLUSION

This study explored the commuting satisfaction of the lower income population in Xi'an, China. Lower income respondents consistently reported lower levels of commuting and life satisfaction. A previous study has found that commuting satisfaction is significantly associated with life satisfaction (Ye and Titheridge, 2015), and this highlights the importance of exploring factors that contribute to commuting satisfaction.

This study further investigated various factors contributing to the lower level of commuting satisfaction among the lower income population compared with the rest of the population. It was found that such factors as commuting characteristics and the attitudes towards travel significantly influence commuting satisfaction. After accounting for the attitudes, the independent effects of the built environment on commuting satisfaction become insignificant, but the built environment could affect commuting satisfaction through other mediators, such as travel behavior.

Commuting time and congestion are two strong determinants of commuting satisfaction. The effects of travel mode choice on commuting satisfaction were only significant in the higher income group, where bicycling commuters have the highest commuting satisfaction, and this is followed by worker bus, walking, rail transit and car commuters. These modes differences in commuting satisfaction are not significant in lower income group. The motivations in commuting mode choice help to explain the divergence in the association between mode and satisfaction between the two groups. The lower income group rated higher in instrumental factors (e.g., cost, predictability) while lower in affective factors (relaxing, feeling and emotions) that determine the mode choice, compared with the higher income group. Previous studies have highlighted the importance of affective factors in forming the utility (i.e., subjective experience) of travel (Anable and Gatersleben, 2005; Hickman et al., 2015; Stradling et al., 2007b).

Consistent with previous studies, travel attitudes play an important role in commuting satisfaction, though different associations were found between the lower and higher income group. In particular, positive attitudes towards travel in general are associated with a higher level of commuting satisfaction, and this is consistent in all models regardless of income classification. Travel attitudes towards specific travel modes are more likely to be significantly associated with commuting satisfaction in the lower income group, while environmentally friendly attitudes are only significantly associated with commuting satisfaction in higher income group. Taken together, these results suggest that travel mode choice and travel attitudes have relatively different effects on commuting satisfaction in lower and higher income group. Travel mode choices seem to be more important than attitudes in influencing commuting satisfaction in the higher

income group, while travel attitudes are more important than travel mode choices for commuting satisfaction in the lower income group.

In addition to the independent effects of travel mode choices and travel attitudes on commuting satisfaction, this study also found that a mismatch between travel attitudes and travel mode choices had a negative effect on commuting satisfaction. Further, this study found that there were relatively higher percentages of mismatch in the lower income group compared with the higher income group. This may also help to explain why travel modes variables were not significantly associated with commuting satisfaction in lower income group.

The lower income population of Xi'an is more likely to choose the bus, walking or bicycling as their primary commuting mode. However, the bus was rated with the lowest level of satisfaction by both income groups (Figure 5). This suggests that overall the quality of bus services in Xi'an is low. In addition, those on lower incomes may experience poorer services. Higher levels of in-vehicle crowding and higher levels of +2 interchanges are reported by lower income respondents. For walking commuting, the lower income group holds negative attitudes towards walking despite it being a significant share of the chosen commuting mode of lower income respondents. This implies that many walking commuters in the lower income group may not have other travel options and this leads to a lower level of satisfaction with walking commuting in that group compared with the higher income group. For bicycling commuters, the lower income group reported much lower levels of commuting satisfaction compared with the higher income group, even though the attitudes of the lower income group on bicycling are positive overall. When comparing the commuting distance for cyclists, we find that the distances cycled to work are much higher among the lower income group than for the higher income group. Finally, the built-environments immediately around the home and job locations tend to be different for the two income groups. A greater proportion of lower income respondents lived in suburban areas in big-block neighborhoods, with fewer bus services. A greater proportion of lower income respondents worked in areas with a low percentage of commercial land use, less connected streets, and less transit services. It is interesting to note that the objectively measured (GIS) commuting distance was similar between the lower income and higher income groups, however, self-reported

commute distances were significantly longer for the lower income group. This implies that creating a walking, bicycling, and transit friendly environment may help the lower income population to overcome actual and perceived difficulties with commuting, thereby improving their overall satisfaction with commuting.

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APPENDIX

Factor analysis for attitudes

	Fuel Efficiency	Pro Bike	Car Safer	Pro Transit	Pro Walk	Pro Driving	Environment	Positive Travel
I prefer to organize my errands so that I make as few trips as possible	**0.545**	0.063	0.006	-0.054	0.432	0.182	0.060	0.192
The price of gasoline affects the choices I make about my daily travel	**0.658**	-0.033	0.131	0.231	-0.073	-0.034	0.136	-0.053
The region needs to build more highways to reduce traffic congestion	**0.568**	0.200	0.103	-0.226	0.076	0.246	-0.025	-0.123
Fuel efficiency is an important factor for me in choosing a vehicle	**0.662**	0.009	0.117	0.154	0.061	0.066	0.293	0.020
I often use the telephone or the Internet to avoid having to travel somewhere	**0.656**	0.048	0.078	-0.066	0.208	0.064	0.154	-0.039
When I need to buy something, I usually prefer to get it at the closest store possible	**0.484**	0.287	-0.098	0.028	0.153	0.420	-0.024	-0.043
My household spends too much money on owning and driving our cars	**0.405**	0.108	0.474	0.137	-0.166	-0.034	-0.274	0.035
I like riding a bike	0.047	**0.769**	-0.058	0.242	-0.033	-0.010	0.023	-0.077
I prefer to walk rather than drive whenever possible	0.020	**0.555**	-0.030	0.369	0.469	-0.132	-0.019	0.158
I prefer to bike rather than drive whenever possible	0.021	**0.782**	-0.012	0.177	0.115	0.046	0.120	-0.014
Biking can sometimes be easier for me than driving	0.123	**0.609**	-0.126	0.004	0.258	0.114	0.334	0.078
We could manage pretty well with one fewer car than we have (or with no car)	0.193	**0.414**	-0.311	0.263	-0.110	0.258	0.169	0.136
Traveling by car is safer overall than walking	-0.009	-0.089	**0.655**	0.180	0.109	0.100	0.067	-0.142
I need a car to do many of the things I like to do	0.324	-0.170	**0.504**	-0.139	0.308	0.232	-0.093	-0.136
Traveling by car is safer overall than riding a bicycle	0.024	-0.074	**0.563**	0.045	0.009	0.259	0.320	-0.108
Traveling by car is safer overall than taking transit	0.029	-0.009	**0.736**	-0.059	0.012	0.063	0.081	0.119
Getting to work without a car is a hassle	0.231	-0.025	**0.674**	-0.182	-0.034	0.122	-0.232	0.010
I prefer to take transit rather than drive whenever possible	0.083	0.398	-0.047	**0.691**	-0.004	-0.045	0.020	-0.071
I like taking transit	0.031	0.211	-0.010	**0.725**	0.145	-0.037	0.108	0.141
Walking can sometimes be easier for me than driving	0.082	0.154	-0.191	0.315	**0.544**	0.318	0.143	-0.044
Air quality is a major problem in this region	0.245	0.075	0.215	-0.069	**0.615**	-0.011	0.158	-0.161

I like walking	0.016	0.429	0.025	0.224	**0.550**	0.009	0.105	0.295
I am willing to pay a toll or tax to pay for new highways	0.084	0.080	0.217	-0.010	0.114	**0.688**	-0.030	0.051
I like driving	0.143	-0.067	0.430	-0.055	-0.118	**0.646**	0.111	0.044
I would like to own at least one more car	0.283	-0.120	0.278	-0.037	0.343	**0.431**	0.039	-0.301
Public transit can sometimes be easier for me than driving	0.175	0.078	0.006	0.357	0.143	0.111	**0.612**	-0.008
I try to limit my driving to help improve air quality	0.256	0.321	0.053	0.069	0.246	0.008	**0.581**	0.115
Vehicles should be taxed on the basis of the amount of pollution they produce	0.284	0.334	0.030	-0.176	-0.038	-0.117	**0.506**	0.082
I use my trip to/from work productively	-0.073	0.195	0.186	0.449	-0.043	0.075	0.012	**0.506**
The trip to/from work is a useful transition between home and work	0.371	0.025	0.053	0.132	0.156	0.215	0.118	**0.592**
Travel time is generally wasted time	0.267	0.096	0.248	0.077	0.086	0.168	-0.015	**-0.679**

Bond font indicates a relatively high loading.
Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.