A Project entitled

The psychological factors influencing people's frequency of cycling commuting within the "bicycle highway" in Beijing

Submitted by

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Declaration

I, Xu Bingfeng declare that this research report represents my own work under the supervision of Title and Name of Project Supervisor, and that it has not been submitted previously for examination to any tertiary institution.

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Content

Abstract

This thesis explores the relationships between psychological factors and cycling commute. The construction of the "bicycle highway" in Beijing gives the local people a new alternative to travel modes. In terms of the time-and-cost related factors, the shortest commute time and low cost were supposed to attract cyclists to use this new infrastructure every day. However, data shows that not all cycling commuters have a high use frequency, and this provokes the author's thinking. When people under uncertain conditions of transport, they are more likely to be partially rational. This situation could be explained by Prospect Theory (PT) which is used as the core theoretical basis in this paper to explore individuals' psychological mechanisms when choosing cycling commuting on daily basis. By introducing the notion of Sense of Place (SOP), a guiding principle in human geography, combined with the Ecological Model which had been widely used in physical activity research, the author was able to select and develop an original set of measuring indicators for this research. Correspondingly, several socio-demographic indicators, like gender and level of education, were also put into analysis. Besides, investigating the use frequency of the "bicycle highway" could quantify the cycling commute choice of an individual. All of these are preparations for further quantitative analysis in this research. We hypothesize that people who grade social-related indicators higher see higher use frequency of the "bicycle highway". Furthermore, we also hypothesize male should have a higher using frequency than female. To investigate these interrelationships, we conduct a series of intercept survey containing Likert scale attitudinal statements to measure 17 psychological indicators of cycling commuters within the "bicycle highway" and analyze the collected questionnaire data to investigate the magnitude and direction the different psychological factors impact on bicycle commute frequency of the local people. The analysis results indicate that social or interpersonal factors statistically impact the cycling frequency; Gender factor was also found to affect the decision-making progress on commuting behaviours.

1. Introduction

Cities are enlarging arbitrarily in China, which has triggered a series of urban problems. In Beijing, the situation is more visible. The area of Hui Longguan is known as one of the largest residential communities in Beijing (Figure 1). The area of Shangdi, adjoining Hui Longguan, is a famous information industry base established by the Beijing government. As the crow flies, the distance between these two areas is only around 4.5 kilometres. Some reasons such as several regional motorways and high-speed railways serve as 'solid walls', however, to extremely hinder the transport movement between these two places, which gives a great inconvenience to residents especially commuters daily.

Cycling transport has some differences from traditional urban traffic modes. First, cycling requires people to take physical efforts, and which indirectly improve the physical vitality of participants. Second, cycling is an environmentally friendly travel mode with little greenhouse gas emission. "Bicycle highways" are generally connections of the bicycle transport network of one place and its surrounding area that connects significant origin and destination points and also enable high speed, safe, and attractive bicycle travel over long distances (Grigoropoulos et al., 2021). In recent decades, many countries have introduced the idea of "bicycle highways" in urban transport development. Similarly, the Beijing government built a "bicycle highway" between Hui Longguan and Shangdi areas and hope it can ease transport pressures.

Up to now, this cycling infrastructure has been opened to the public for one year. After one year of tracking surveys, the authority claimed that this "bicycle highway" had made a great success in easing traffic pressure and, according to a report, there were around 1,500 commuters used this infrastructure per day. However, this figure cannot deliver a clear picture of the commuters' choice on cycling because we still cannot know the concrete composition of these daily commuters (around 1,500 individuals) on the "bicycle highway". First, do they cycle every day? Or each day this group of people has different compositions? If the latter was correct, why do some people choose to ride bikes once a week, but others prefer to ride every day? Thus, it is highly needed for us to find the factors that influence the choice frequency on using this facility

so that we can modify the design works and improve the attractiveness of this facility.

This research uses Prospect Theory as the core theoretical basis and is intended to explore individuals' psychological mechanisms when choosing cycling commuting. Also, by introducing the notion of "Sense of Place" (SOP), combined with the Ecological Model as a reference, the author selected appropriate measuring indicators for the questionnaire survey which could accurately and comprehensively measure the psychological characteristics of respondents. At the same time, this research is also valuable for city planners who are willing to encourage cycling commutes.

2. Literature review

2.1 Influential factors

Regarding previous studies, there are some cycling researchers that mainly pay attention to influence factors on cycling commutes in specific places. The several main factors are 1) environmental factors (which include built environment and natural environment); 2) psychological factors (which include social environment and personal attitude factors); and 3) socio-demographic factors (such as gender, income, and homeownership).

2.1.1 Environment factors

The **built environment** has been proved to play a role in influencing cycling commute. For instance, the *trip distance* between workplaces and home can affect the cycling commute mode choice negatively or positively. In addition, according to Southworth (2005), the *roadways in dense* are suitable for non-motorized transports such as cycling. Apart from this, the *design of bicycle infrastructures* can also influence the cycling commute. Heinen et al. (2013) made a difference in study areas and focused on *facilities at work* and expected to find which factors could influence people to become cycling commuters and which factors could affect the frequency of using bicycles to work.

The **natural environment** is also another factor contributing to differences in cycling commute choices. Briefly speaking, the factors of *landscape* and *weather conditions* are usually discussed in various analyses. For instance, a place containing a lot of hills and slopes dissuade people from cycling. Similarly, a harsh weather condition like the strong wind could also impede cycling behaviours.

2.1.2 Psychological factors

Even though in some ways the environmental factors are important, psychological factors have been gradually paid more attention by the public. For example, Stinson and Bhat (2005) distinguished between the *experienced and inexperienced cyclists* and showed the latter are more willing to ride on a flat road, while the former tended to choose the hilly terrain for commuting. What is more, *personal attitude* is important in explaining travel behaviours like driving; Handy & Xing (2011) also pointed out its possibility of being used in bicycle commuting research. Hull and O'Holleran (2014) did a case study comparing relevant influential factors to cycling commute in six cities in the U.S. and personal attitude is also included in this study. This analysed data was collected by an online survey and the results showed that the most important factor was people's preference for living in areas with good bicycle facilities around. Likewise, Gatersleben and Appleton (2007) found people holding more positive attitudes to cycling behaviours also consider cycling more than others. To some degree, people who dislike the car also intend to choose cycling for commuting (Stinson and Bhat 2005). In light of the recent research, we could also realise the determined influence of *personal environmental beliefs* on non-motorised commuting mode choices including cycling, this notion could be explained as people who hold an environmental concern are predicted to cycle more to work. Apart from this, *social environment* is another consideration in some articles. Handy & Xing (2011) defined the social environment as the attitudes and behaviours of co-workers at the workplace; in specific, whether some partners of the employee bicycle to

work, or whether they are fitness-conscious.

2.1.3 Social-demographic factors

Some scholars (Moudon et al., 2005) claimed that the socio-demographic factors played a predominant role over the built environment factors. Some researchers evaluated the relationship between *gender difference* and cycling commuting and found men cycle more than women for commuting purposes. Moreover, the *personal income level* is another factor. Stinson and Bhat (2005) found a positive relationship between cycling and income, which means if a person could earn more money, he would cycle to work more frequently. What is more, the *age* factors should also be taken into consideration. Moudon et al. (2005) made a conclusion that cycling decreases with age. Furthermore, there is evidence that the *employment status* could determine the commute choice. Moudon et al. (2005) also found the higher social status was associated with lower cycling frequency.

However, there is increasing evidence showing that the relationship between cycling and socio-demographic and cycling behaviours is mixed and ambiguous. For example, not like the general idea, research (Witlox, 2004) found that female commuters are more likely to cycle than male.

2.2 Prospect Theory

Prospect theory (PT) was originally proposed to describe the choice between lottery alternatives and gambling. This theory has already achieved fruitful results in the field of economics (Avineri & Bovy, 2008). Gradually, however, PT has been usually used in transport behaviours' analyses, especially in daily-commuting modes' choices of residents, because of some special features of travel journeys and the decision-making environment. For instance, **when people under uncertain conditions** like traffic congestions, **they are more likely to be partially rational**. An et al. (2014) discussed the effects of "traffic congestion charging policy" on

people's travelling choices based on the Cumulative Prospect Theory (CPT), and the results showed that CPT is more suitable for describing commuters' travel modes. Liu and Lam (2014) also used PT to analyse the influence of fixed population density on personal choices of travelling and they found that the park-and-ride strategies may not be suitable for areas with high population density. Xin et al. (2017) also adopted PT to analyze the travel mode choice of electric bicycle users and these scholars differentiated prospect theory from utility theory: PT could take both travellers' psychological factors and risk attitude into account. But up to now, PT is still in the research stage and further research is needed in terms of travel route selection, travel mode selection and road network balance.

2.3 Research gap and research question

Although there are countless reports which explore commute behaviours multidimensionally, most of these have focused on the morning home-to-work journey but **ignored the evening return-home commute** (Hatcher & Mahmassani, 1992). This study pays attention to the evening peak time, which makes the result more representative.

Also, many studies focused on the relationship between various potential factors and cycling commuting, and **most paid attention to cycling behaviours within an area, rather than one specific bicycle infrastructure like a "bicycle highway".**

Additionally, **bicycle-relevant research is rarer in China**. Bicycle research had been conducted well in some western countries, but it should also be conducted across a wider range of countries (Heinen et al., 2010) since social contexts vary from different countries, which results in diverse or even contradictory findings.

Although there are several official reports about Beijing's "cycle highway" published by Beijing Transport Institute, the contents in these materials are not clear at all. For example, the reports only tell us tangible factors, such as the time and cost, about why cycling is becoming the preferred choice in the HuiLongguan area. In terms of the time-related factors, the experts

find that the people who use the "bicycle highway" to workplaces could take the shortest commute time (around 45 minutes), compared with those using other travel modes, between the areas of Hui Longguan and Shangdi. In terms of the cost-related factors, it is obvious that bicycle commuting is the least costly mode except walking. However, if this is the only reason, why do some people cycle once a week, but do not cycle on a daily basis? There must be some intangible reasons attracting commuters to ride bikes more frequently than others. However, **the reasons for the diverse frequency of using Beijing "bicycle highway" to work is still not studied by scholars.**

Also, based on the literature review section shown above, we know that psychological factors may play a determining role in people's decision-making of choosing cycling commuting. In some ways, **different research had contradicted findings of the actual effects of the psychological factors on travel mode choices.**

In terms of the application of Prospect Theory, **although much research applied PT in predicting and describing commuting modes' choices among several alternatives such as subway, private car, and bus commutes, few studies use PT to analyse cycling commuting.** At the same time, the author will pay more attention to one factor, *social*, in the study. *Social* concludes the topics of the social atmosphere, the crowdedness, activities, families, friendliness, and safety. The reason for choosing this factor is that **other factors (such as the built *environment*) had been discussed frequently in articles.** What is more, Páez and Scott (2007) claimed "the need for social contact, and the effect of social influence on travel behaviour is one such aspect of decision-making that deserves attention." In terms of those being employed in the IT industry, many of them have hectic working schedules and lack enough time in social or interpersonal activities. Fortunately, "bicycle highway" gives them a space to socialize. So, it is an opportunity for us to focus on social factors.

There is another point that should be noticed. Due to the specific social context in Beijing, the authority issued regulations to restrict cars and properties purchasing behaviours among people

who have no Beijing **"*hukou*", a special outcome under regional policies in modern China**. Therefore, the questions set by overseas research could not be applied in this study.

Therefore, this research will make up these gaps through an analysis of commuting activities in the Beijing "bicycle highway" and find reasons which facilitate or deter the local people's use of "bicycle highway" in the Hui Longguan area.

2.4 Hypothesis

Based on previous research, the author proposed two hypotheses of the study: 1) People who grade social-related indicators higher see higher use frequency of the "bicycle highway"; 2) Male should have higher using frequency than female.

3. Conceptual model

In terms of the traffic model choice studies, most analyses rely on the **expected utility theory (EUT)**, which is a normative decision theory revealing how people make choices based on complete rational thinking. That is to say, people only pursue utility-maximizing. Based on this assumption, most commuters in HuiLongguan are supposed to cycle every day because this is the fastest and cheapest way. However, the real situation is different if we look at the commuting mode share in HuiLongguan. Therefore, people are somehow definitely not rational when making decisions among diverse alternatives. So, there must be other latent factors that influence one's decision-making progress subtly.

Thus, the notion of this research is enlightened by another theory. Based on the **Prospect Theory (PT)** proposed by Kahneman and Tversky (2013), people's decision-making progress is dependent on not only the value of money but also the psychological value. To some extent, people's psychological values also are influenced by their attitudes to risk conditions and learning experiences in the past. Turning back to this research, the frequency difference of commuting in the "bicycle highway" could be explained by the Prospect Theory. More

specifically, psychological factors affect people's choice of cycling commuting, especially the choice frequency, when uncertainties exist. Therefore, studying the psychological factors is a profound way to understand human behaviours on commute choices.

Bicycling is not only an option of travel to the destination but a type of physical activity (Handy & Xing, 2011). According to special characteristics of cycling commuting (health promotion and environmentally friendly), the author applied the **Ecological Model** (Sallis et al., 2015) to this research, for it had been widely introduced in physical activity research (Sallis et al., 2015) to better understand the cycling behaviours in human society. The Ecological Model assumes a specific behaviour is affected by diverse factors consisting of individual reasons and social or physical environment. Also, Handy and Xing (2011) made a comprehensive list (Figure 2) about all the influential factors to cycling commutes based on the Ecological Model. Therefore, the author planned to select measuring indicators from this list by doing some modification. Because this study will only focus on the psychological factors (including individual and social environment factors) in the research, the irrelevant factors (the physical environmental factors) have been removed. Therefore, the psychological factors were assumed to influence the individual's decision of cycling on the "bicycle highway" (Figure 3).

4. Indicators selecting

After establishing the conceptual model for the research, some effective and meaningful measuring indicators also need to be evaluated and selected.

In terms of the **psychological factors**, the author arranged and classified all indicators according to Figure 2 and found many of these indicators were overlapping each other. For example, both *need car*s and *limit driving* emphasized individuals' demands on vehicles. At the same time, both *pro-exercise* and *good health* emphasized individuals' health concerns. Not only this, but some indicators did not fit into this research. For example, *Carry Materials* and *Dress Professionally* would be more suitable for those being employed in the service industry

rather than the IT industry. According to the reasons above, the author tried to select suitable and precise indicators which could clearly and systematically measure the psychological factors of individuals. After reading a lot of literature and theories, a classic theory about people and places, called **"Sense of Place" (SOP)**, is utilized to help to select relevant indicators, because this theory focuses on one's psychological needs and it has been widely used in many disciplines. And by measuring SOP, geographers and city planners could identify the main factors affecting people's psychological value and then propose useful measures to improve the environmental design. After some modifications and redevelopments from scholars, Chen and Sekar (2018) found six constructs of SOP (including satisfaction, attachment, identity, aesthetics, social and dependence) were suitable in the studying of traffic behaviours. These constructs provide us with a more systematic select instruction on examining the psychological value of people. Moreover, other scholars also reached a consensus on the importance of these six dimensions on the measurement of SOP (Deutsch et al., 2013). Therefore, based on the explanatory variables in Figure 2 and six constructs of "Sense of Place", a new indicator list for researching psychological factors (Figure 4) was developed by the author. From this list, some indicators were added by the author, which include P4, P5, P6, P7, P8, P10, P11, P13, P15. The reason is that these were not included in the Ecological Model but included in six dimensions of SOP. So, it is better to add them to the measurement indicators in order to fully explore people's SOP.

5. Data source and research approach

5.1 Research period

Based on the official report from the Beijing Transport Institute, there are two separate time periods which are suitable for data collecting: 1) 8 am to 10 am (morning peak hours); 2) 6 pm to 9 pm (evening peak hours). However, it might be difficult for us to collect data in the first period (morning peak hours) because commuters have no time and are not willing to finish a

time-consuming questionnaire survey. Thus, in this research, **we only collect data during the evening peak time from November to December of 2020**. As a result, our respondents will have more time and patience to complete the whole questionnaire survey. This also prevents the shoddy or low-quality responses.

5.2 Respondent type

Unlike other research which did surveys toward all kinds of daily commuters by randomly sending questionnaires within an area, in this study the author will **only focus on cyclists in the "bicycle highway"**. That is to say, people who use bicycles on normal roads will be excluded in this survey. Furthermore, because this research is aiming at studying commute behaviours, those who do not use the "bicycle highway" for commute will also be excluded.

5.3 research approach

The whole data will be collected by questionnaire surveys on commuters in the "bicycle highway" (the complete questionnaire design will be shown after the Appendix). The survey consists of three main sections, each section asks for different types of information.

There are no descriptive answers in questionnaire settings so that all the data could be analyzed under **quantitative approaches**. By the way, instead of using traditional questionnaire paper, our two collectors allowed participants to scan a QR code through their smartphones so that they did not worried about any infection opportunities during pandemic.

As for the **SOP sector** (the first part in questionnaire design), intercept surveys could be meaningful when the research topic has a place-based nature (Rookey et al., 2012). Therefore, in this study, the author adopted intercept surveys containing Likert scale attitudinal statements to better measure 17 indicators of SOP (Stedman, 2003). The description of these indicators in the questionnaire is shown in the appendix (Figure 4). As for the **frequency sector (the third part in questionnaire design)**, the author designed several choices which are less than one

time per month, one to three times per month, one time per week, two to four times per week, and almost every workday per week respectively (notice: cycling in the morning peak time should be excluded in the research). Finally, the writer tried to **relate SOP with frequency** to find certain internal connections. In addition, some of the **social-demographic variables** (the second part in questionnaire design) will be also collected because there may be endogeneity between them and other main variables, ensuring the integrity of the data and allowing us to get a full appreciation of the samples' background information.

6. Sample characteristics

This section presents descriptive statistics on our survey responses. A total of 101 responses were collected during November and December of 2020.

6.1 Gender

Based on Graph 1, the total respondent number is 101 and the number of males (75) is larger than female (26), which may deliver an inappropriate message that men have more devotion to cycling. On the other hand, this deduction might be arbitrary because male seemed to constitute the majority of working staff in the IT industry, and this 'bicycle highway' was built for people working in Shangdi, the IT base in Beijing.

6.2 The level of education

As for *the level of education* (Graph 2), the percentage of "undergraduate" degrees is the largest at 69.3%, followed by "postgraduate" accounting for 20.8%. Several respondents (8.9% of the total number) only finished "high school, secondary vocational school or college". Only 1% of the respondents hold a PhD degree or above.

6.3 Car ownership and home ownership

As for *car ownership in Beijing* (Graph 3), most respondents (65) have no private car. Interestingly, the number of people who have a car with a Beijing license plate (23) is slightly more than those of people having non-Beijing license plates (13). This may be related to road traffic congestion which reduces the incentives of driving. That is, license plate restriction in Beijing may not be the main reason that influences people's choice on cycling commute. As for *home ownership* (Graph 4), most respondents (64) are renting apartments and the others (37) living in their own apartments. The information about the car and home ownership could indirectly reflect the personal financial status, to some degree, because in Chinese culture, possessing a car and home are the main material goals that people have been trying to achieve.

6.4 Frequency of cycling commute

Travel frequency in the "bicycle highway" (Graph 5) is one of the most significant indicators in this study. It represents commuters' willingness to participate in cycling commuting. The data shows that most people (71.3%) in the intercept survey cycle almost every weekday; in other words, they are 'regular customers' of this "bicycle highway". Besides, the overall descriptive statistics table (Table 1) is shown in Appendix.

Together the above descriptive statistics give an overview of the sample characteristics, but it can only deliver extremely superficial information to readers but not establish the internal connection between the variables. Therefore, more complex quantitative analysis approaches are needed.

7. Analysis

This section describes the main steps during the analysis and all analyses were carried out using SPSS, version 26.

7.1 Reliability

Checking the reliability of a scale is a necessary step before employing factor analysis because it ensures an internal consistency among variables (Pallant, 2020). According to Table 2 below, the Cronbach alpha coefficient is 0.909 (above 0.7), which means the internal consistency is high. Table 3 demonstrates the Cronbach alpha value under the situation of deleting one of the items one by one. It shows all the items are reliable (above 0.7). However, the item "Is not overcrowded" shows a higher value than 0.909 (0.942). Not only this but its Item-Total Statistics is a negative value (-0.362), indicating that this item does not measure the same underlying characteristics (Pallant, 2020). So, we would better delete this item to improve the reliability of overall data sets before doing factor analysis.

7.2 Factor analysis

Previous literature has suggested six dimensions governing people's perceptions of SOP. But we could not directly use these as six factors in regression analysis, since the number of latent factors may vary according to changing research places. There are 16 indicators in this research (after omitting *Is not overcrowded*), which simultaneously explore all constructs of the SOP of people. However, some of the indicators from different dimensions measure respondents' similar aspects. For example, both "It has a visually appealing architecture" and "I am satisfied with the amenity facilities" ask people's feelings toward the built environment. This negatively affects the interrelationship between the variables in each dimension of SOP. So, it is better for us to focus on fewer factors rather than many trivial variables. Factor analysis attempts to find the easiest and straightforward way to explain observed data (Harman, 1976) and place

variables into meaningful categories (Yon & Pearce, 2013). It utilizes mathematical procedures, which simplifies interrelated measures, to explore diverse patterns (Child, 2006). Therefore, there is a need to rearrange all indicators and simplify the model to best represent the interrelationships among indicators. In this study, factor analysis serves as a 'filter' to find underlying latent constructs with respect to attitudinal responses.

Table 4 shows that the data set is suitable for factor analysis because the Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO) value (0.927) is above 0.5 (Hair, 2009) and Bartlett's test is significant (p= 0.000).

Based on Table 5, after removing "Is not overcrowded", other factors were regrouped to two sets of variables: 12 of them constitute *Component 1*, 4 of them constitute *Component 2*. All the indicators in *Component 1* referred to **intrapersonal factors** consisting of affective, cognitive and conative subcomponents (i.e. "This is a place that makes me feel relaxed and happy", "This place correspond with my environmental concerns", "It meets my needs better than any other traffic modes", etc.) and the indicators in *Component 2* were evaluating the **interpersonal factors** (i.e. "I can always interact with my friends or colleagues", "Is a great family-friendly place to be", etc.).

7.3 Standard multiple regression

Standard multiple regression is the most commonly utilised multiple regression analysis. We may use it when we had some variables (in this case, we had *gender*, *car ownership*, *education level*, *component 1*, and *component 2* as variables) and intended to learn about how much variance in the dependent variable (*using frequency of "bicycle highway"*) they could explain.

According to Tabachnick et al. (2007), the independent variables with a bivariate correlation of more than 0.70 should not be included in multiple regression analysis. Table 6 shows that *car*

ownership and *home ownership* have a high bivariate correlation (0.747). Thus, omitting one of these two variables is needed. *Home ownership* was excluded in this study, because *car ownership* may influence the travel mode preference of an individual more obviously than another. Wardman et al. (2007) also pointed out the increase in car availability is the main deterrent hindering the promotion of cycling commuting in the future.

After removing the variable of "home ownership". The analysing results could be seen in Table 7 and 8. According to the ANOVA test result (Table 6), we learn that the model of this study reaches statistical significance at the 0.1 level. Then, Table 7 indicates that *Component 2* and *Gender* show a significant negative effect on "Travel frequency in the 'bicycle highway'" (b=-0.285 & -0.472, P=0.020 & 0.092 < 0.1). Whereas, *Component 1* has no significant effect on cycling frequency (b=-0.039, p=0.739>0.1).

7.4 Research findings

Based on the above analysis, there are three main findings in this research:

1) **Gender** influences the cycling frequency.

2) Negative correlation between **interpersonal factors** and cycling frequency.

3) No evidence shows that **intrapersonal factors** influence cycling frequency.

Therefore, we find the reasons which facilitate or deter the using frequency of commuters and our hypotheses have partially been supported.

8. Discussion

In this section, we explore the potential causes behind the three findings and then propose

corresponding measures to government officials and city planners as references.

8.1 Gender factor

Many articles had claimed that *gender* is one of the determinants on cycling commute. For example, De Geus et al. (2014) pointed out male cycle more frequently than female in terms of commute behaviours, and our research also confirms this. What are the reasons for gender differences in cycling choices?

Based on the literature review, the first reason could be the **physical and external features of women**. Clothing style (Emond & Handy, 2012), such as dresses, make it hard for employed women to choose the bicycle as travel mode. Also, women's physical capacity is generally lower than man, and they are more distance-sensitive (Heinen et al., 2013). The whole distance of the "bicycle highway" is around 6.5 kilometres and it has exceeded a reasonable distance threshold (5 kilometres) for general cycling commuters (Grudgings et al., 2018).

The second reason could be women's **risk perception**, for people prefer riding in safer conditions (Wang et al., 2012); and indeed, females held higher levels of risk perception of riding than males (Prati et al., 2019). Although the "bicycle highway" has been highly segregated from motorways, women are more worried about being crushed by other cyclists who ride fast.

The third reason could be the **traditional sexual division of labour**. According to Garrard et al. (2012), women's travel behaviour is more likely to include many things, such as picking up children from school, doing grocery shopping. In Chinese society, women also undertake this family responsibility. These commute errands contain a lot of uncertainties which in turn creates a barrier for women to enter the bicycle highway.

For these reasons, we came up with several measures to attract female cyclists. First, adding some clothes-changing facilities (Heinen et al., 2013) to provide women convenience and privacy. Second, more entrances need to be constructed along the bicycle path so that women

could do more things from the workplace to home, like buying food and going shopping. Third, improving the safety standard such as implementing a tighter speed control within the road in case women are crushed by some rude cyclists.

8.2 Interpersonal factors

The relationship between interpersonal factors and cycling choices is the most important finding in this study. There have been many researchers who concluded that interpersonal characteristics have a positive effect on cycling choices (Bopp et al. 2012; De Geus et al., 2008). In other words, having a co-worker or partners to bicycle with could encourage one to cycle more. However, in this research, we have an opposite result. After confirming that there was no problem with the data analysis process, we started to find possible reasons to explain.

The first one is about **commute time**. As we know, more interpersonal interactions like talking with other cyclists might bring extra time during commuting. A longer commute time contributes to lower levels of both life satisfaction and happiness (Nie & Sousa-Poza, 2018); therefore, people try to avoid wasting time. Another reason is related to this specific **global pandemic period**. During the COVID-19 spreading, people are willing to avoid public transport such as metro or buses (Goodwin et al., 2011), which further pushed them to travel with caution by adopting other ways such as cycling (Campisi et al., 2020). These conclusions can be well proved by a set of data collected from the Beijing Transport Institute (Figure 5). Therefore, it is the fear of being infected and the willingness to keep a social distance but not the needs for social interaction that encourage the public to bicycle to work.

Therefore, the policy advice is to improve sanitary standards on the “bicycle highway” and parking lots near the bicycle path. Abdullah et al. (2020) also indicated females might be more concerned about the infections during pandemics. So, this measure could attract more commuters of different genders to participate in cycling behaviours.

8.3 Intrapersonal factors

In this research, intrapersonal factors including affective, cognitive and conative dimensions and all these have been proved to influence the overall SOP score and finally affect cycling frequency (Chen & Hu, 2017). But in this research, we could not find significant influences brought from intrapersonal factors to cycling frequency.

The first reason may be also related to **COVID-19**, that is, respondents placed a higher priority on infection-related factors than the others during pandemic (Abdullah et al., 2020). Perhaps the intrapersonal factor will be more important after the pandemic. Another reason is about **the strength of SOP**. Many scholars, Tuan (1990), for instance, declared the Sense of Place of an individual could have been changing over time. Specifically, Sense of Place could be reinforced and created by a sense of recurring events (Jackson, 1994) and direct engagement with a place over a long time period (Tuan, 1977). The "bicycle highway" in Beijing is still too new for people to establish their SOP through engaging in repeated bicycling behaviours over just one year. People's cycling frequency now might be more affected by other factors such as *time* and *money*. Maybe in the future, intrapersonal factors will become dominant.

9. Summary, contribution and innovation

This research used quantitative analysis combined with a series of questionnaire surveys in the "bicycle highway", aiming to find psychological factors which influence the use frequency of this cycling infrastructure and propose useful advice on encouraging more people to commute by cycling.

9.1 Contribution of the research

Some researchers had contradictory findings of the actual effects of the individual factors on travel mode choices. For this reason, the author assumed that these contradictions might be derived from the different cultural backgrounds and this study may explore the individual

factors based on a Chinese cultural background so that provide a reference for other scholars. Furthermore, during this COVID-19 pandemic period, it is highly difficult for both researchers and respondents to finish a real face-to-face intercept survey within the study area, the "bicycle highway". This study provides scholars with valuable first-hand data of the cycling commute behaviours in Beijing and also, our team could ensure that each piece of the collected questionnaire has a high quality, which improves the reliability of the research.

9.2 Innovation of research

In this research, the author utilised various concepts and theories, like Prospect Theory, the Ecological Model and the "Sense of Place" theory, as a whole to establish a new conceptual model. In this way, the author integrates and develops the original research framework from three different academic domains (economics, psychology and geography), which reflects an interdisciplinary nature of the study.

10. Limitation and future direction

10.1 Limitations of the research

To sum up, the limitations of the research are mainly reflected in the following four parts: 1) Time and space constraints; 2) The type of respondents; 3) The selection of indicators; 4) Study approaches.

In this study, the author mainly did a questionnaire survey within the "bicycle highway" but not extended the survey to other places. Therefore, there is a limitation that we cannot know the thoughts of **those who do not cycle to work**. Not only this, but the difficulty of collecting data in the **morning peak time** makes the author lose this opportunity to explore cycling commuting in the morning, which is also a pity for this research. Another limitation is the **weather condition**. Because the survey will be conducted in autumn, and in that period the outdoor

temperature will be low and the wind will be stronger than other seasons, which may affect the cyclists' choice in commuting and influence the accuracy of the result of this study.

As for the respondents' type in this study. Because the author only focused on the commuters' decision making; however, there should be other non-commuters using this bicycle facility. For this reason, we cannot cover the research to **people of different travel purposes** (i.e., leisure or adventure) and different ages (i.e., the old).

As for the selection of indicators, some need to be added in the future study such as ***age, habits, culture*** (Rietveld & Daniel 2004), and ***work environment*** (Heinen et al., 2013). ***Ownership of bicycles*** has also become an important socio-demographic variable during the pandemic. For example, people may not prefer to use shared bicycles to avoid possible infection risks.

As for the study approaches, the author had not enough time to conduct **qualitative analysis**, such as interviews, and field observations, so that lacked in-depth conversations with the cyclists to verify the previous speculations about the causes of the three findings in this study.

10.2 Future directions

This would be a fruitful area for further research, the author highly recommends that we could enlarge the time periods of research and do a comparative analysis in three different stages (which is before, during and after the pandemic, respectively). The author also hopes to cover other journey purposes in order to enlarge the scope of research.

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12. Appendix

Figure 1 The Area of Hui Longguan in Beijing

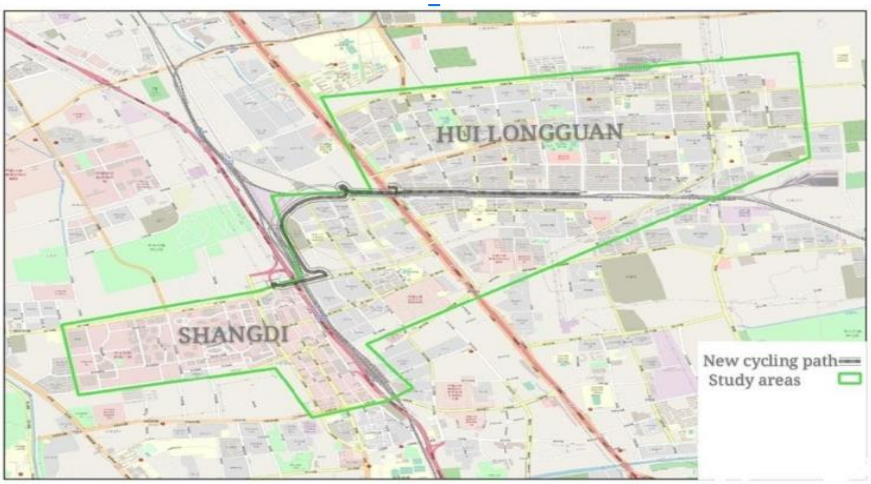


Figure 2 Description of Variables in the Ecological Model

Description of Variables in the Ecological Model	
Explanatory variable name	Description
Biking Comfort	Average comfort biking on an off-street path or quiet street, two-lane-local street with or without bike lane, four-lane-street with or without bike lane
Safety Concern	Average concern of being hit by a car, being hit by another bicyclist while biking, being bitten by a dog, being mugged or attacked, or crashing because of road hazards
Biked in Youth	"Did you ever ride a bicycle when you were about 12 years old"
Like Biking	Agreement that "I like riding a bike"
Like Driving	Agreement that "I like driving"
Need Car	Agreement that "I need a car to do many of the things I like to do"
Limit Driving	Agreement that "I try to limit driving as much as possible"
Like Walking	Agreement that "I like walking"
Like Transit	Agreement that "I like taking transit"
Environmental Concern	Importance of environmental benefits when choosing mode
Pro-Exercise	Average agreement that "It's important to get regular physical exercise" and "I enjoy physical exercise"
Bike Community Preference	Importance of "a good community for bicycling " when choosing the residential location
Good Health	A constraint factor measured by agreement that "I am in good health"
Commute Errands	Average frequency of running errands on the way to or from work: drop off and pick up children on way to work and on the way home; shop for groceries on the way home; stop for other errands; go out for dining/entertainment on the way home; visit friends on the way home.
Carry Materials	Agreement that "I often need to carry materials to or from work (more than a briefcase/backpack)"
Need Use Car	Agreement that "I often need to use my own vehicle to travel to different sites during the day"
Dress Professionally	Agreement that "People in my workplace need to dress professionally"
Some Bike	Agreement that "Some of my co-workers bike to work"
Incentives	Agreement that "My employer offers incentives to carpool, bicycle or take transit to work"
Supervisor Disapproval	Agreement that "My supervisors disapprove of commuting by bicycle"
	(Handy & Xing, 2011)

Note. This table was arranged by the author based on a piece of study on the Ecological Model (Handy & Xing, 2011).

Figure 3 Conceptual Model of This Paper

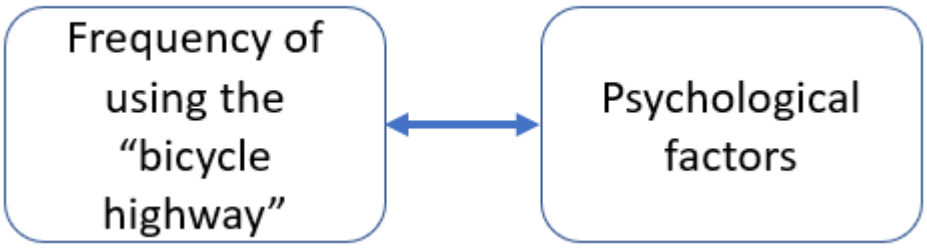


Figure 4 Factors model structures

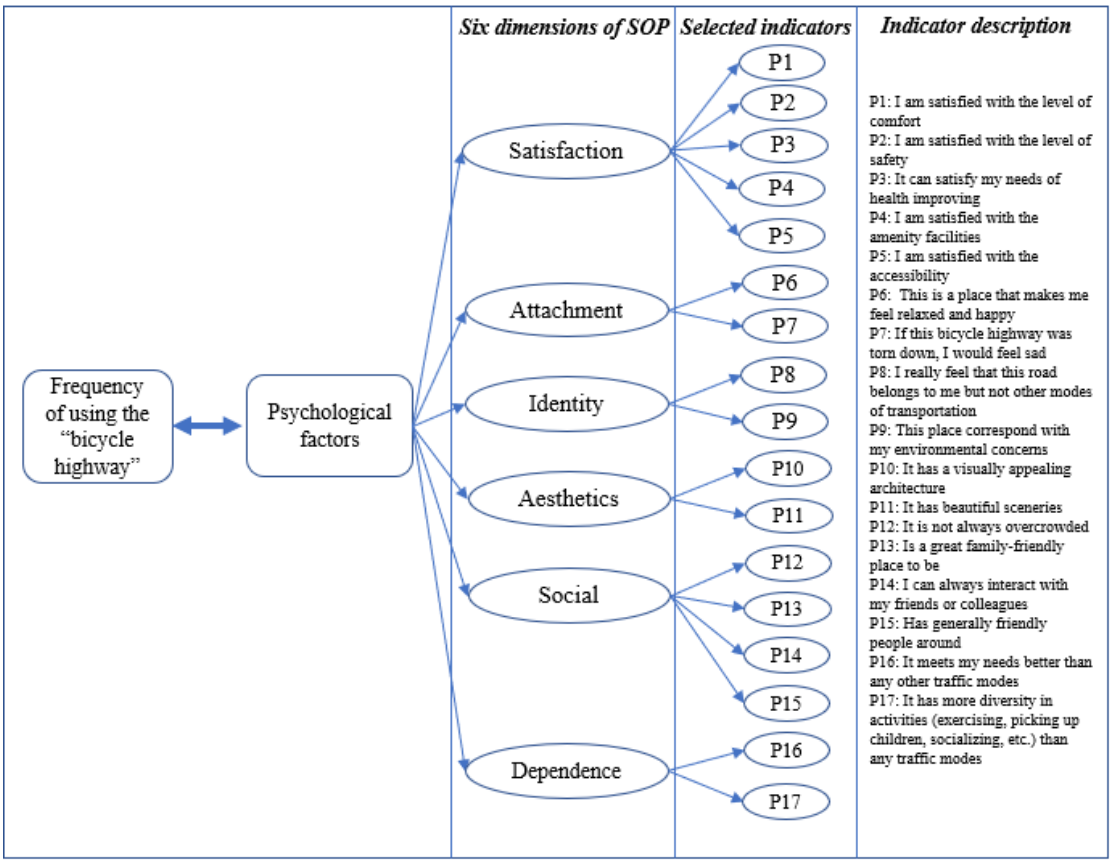
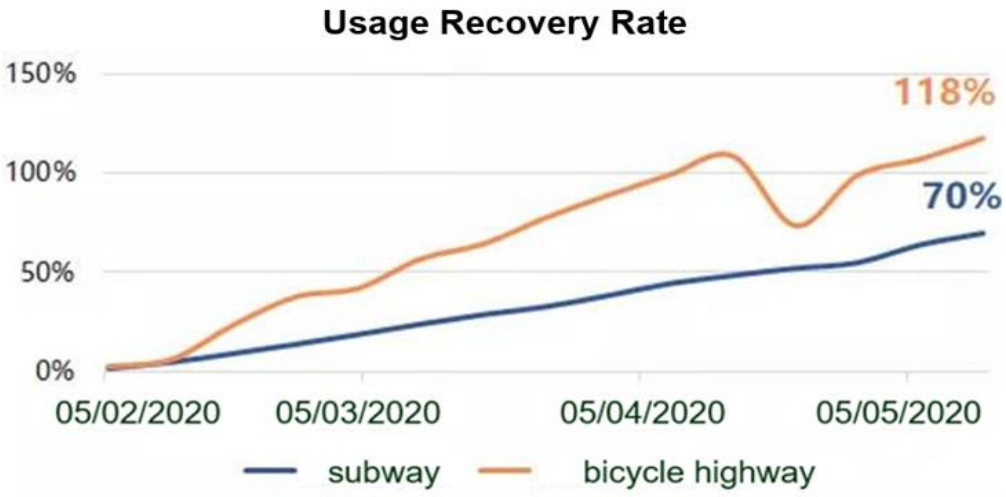


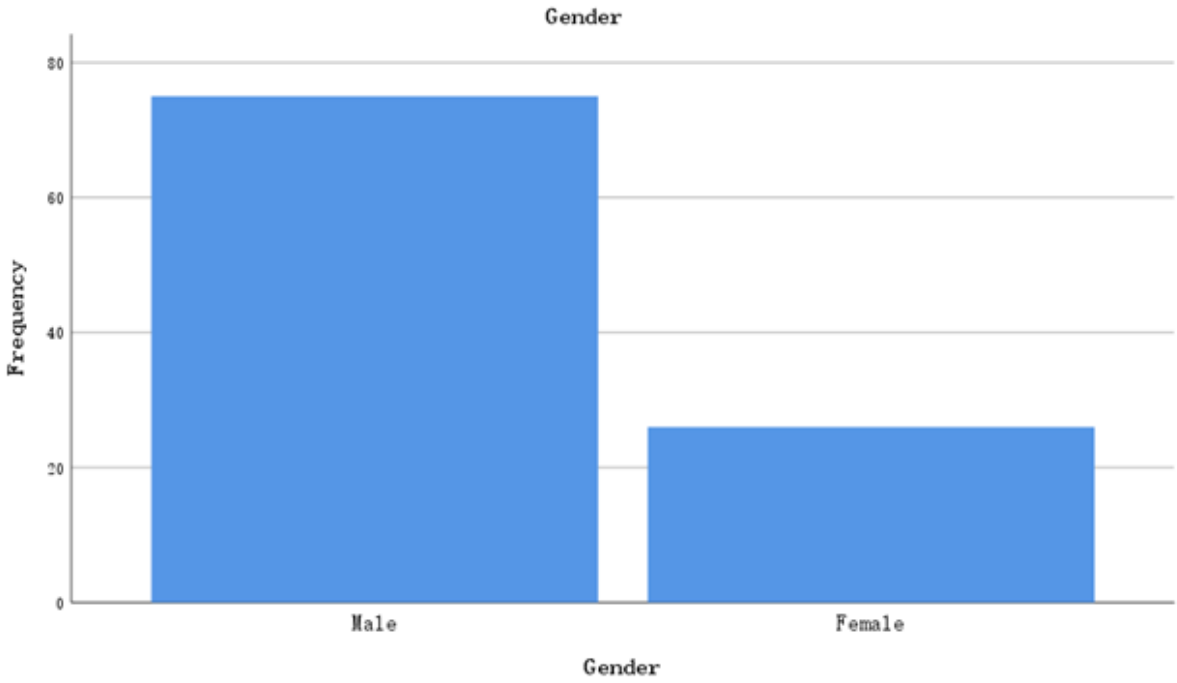
Figure 5



*Source: Beijing Transport Institute. (2019)

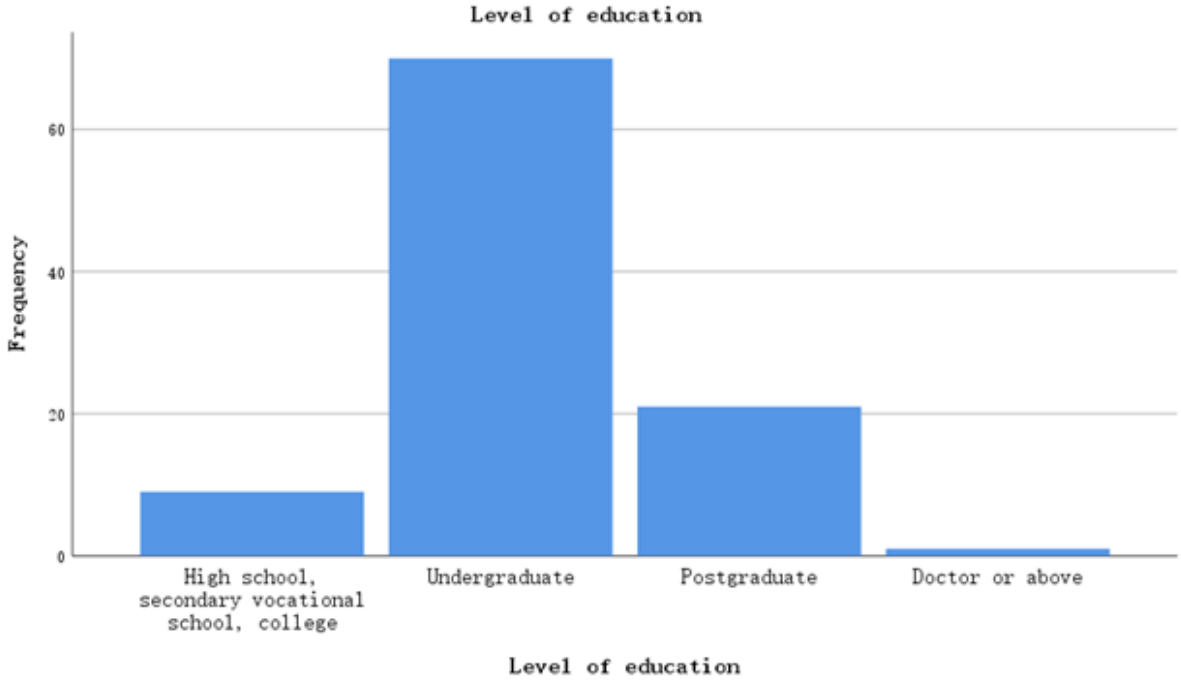
Note. This graph demonstrates that during the pandemic, the use of "bicycle highway" in Beijing recovered was relatively faster than that of subway. After May, the number of cyclists had broken the normal record before pandemic.

Graph 1



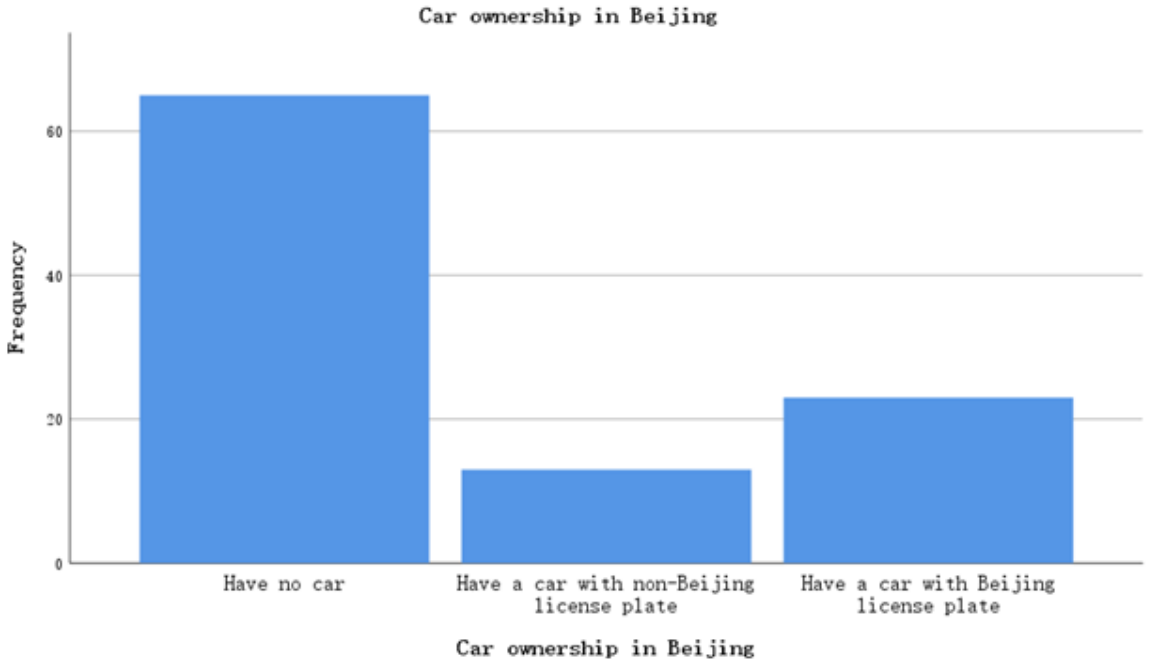
Note. This graph reflects the gender composition of commuters on the "bicycle highway".

Graph 2



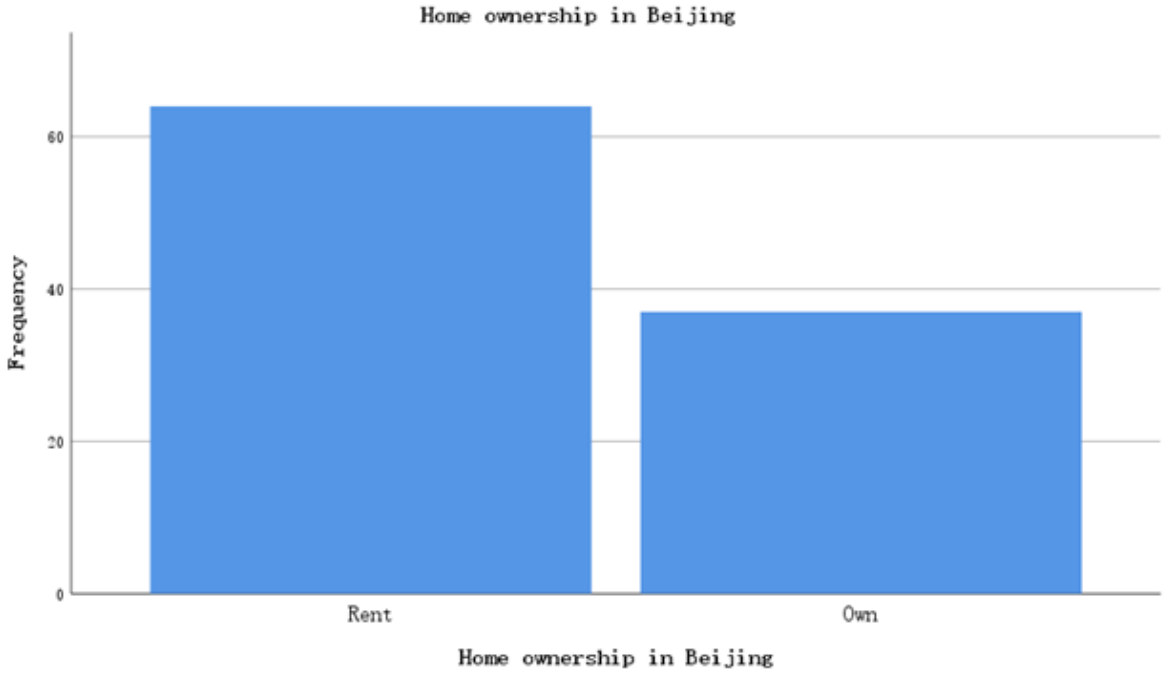
Note. This graph reflects different education levels of cycling commuters.

Graph 3



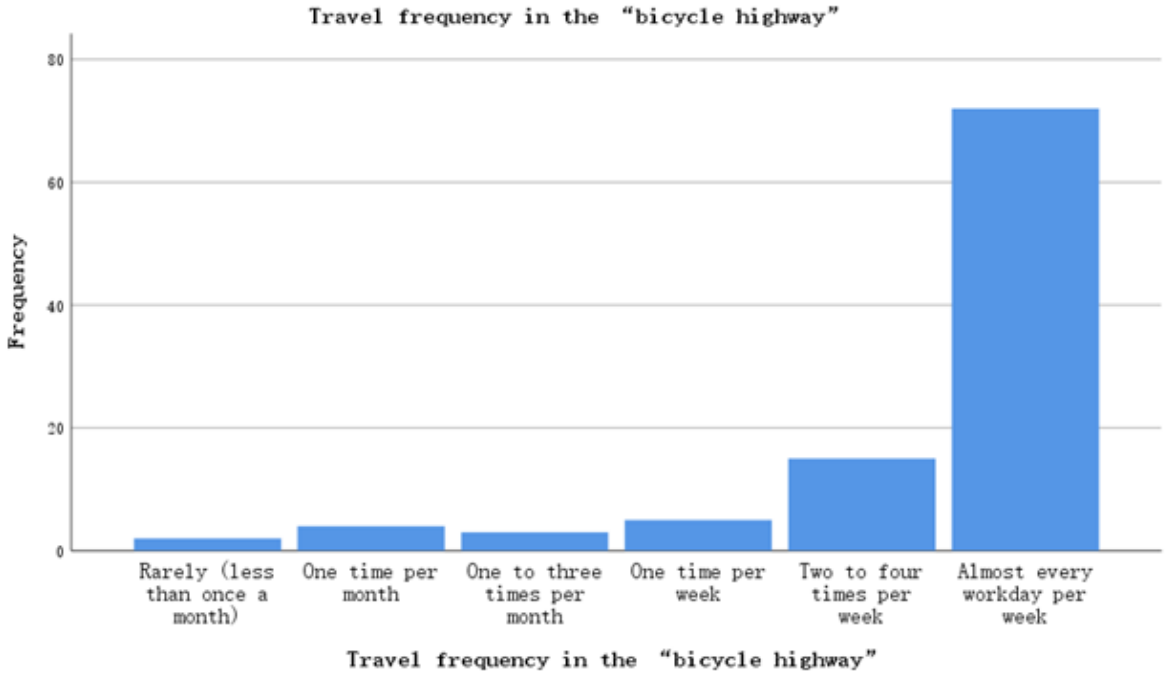
Note. This graph reflects the private cars ownership of commuters. The Beijing government has adopted a strict control over the car with a non-Beijing license plate.

Graph 4



Note. This graph reflects the housing purchase situation of cycling commuters.

Graph 5



Note. This graph represents commuters' willingness to participate in cycling commuting.

Table 1 Descriptive Statistics of Sample Characteristics

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Gender	101	1	2	1.26	.439
Level of education	101	3	6	4.14	.566
Car ownership in Beijing	101	1	3	1.58	.840
Home ownership in Beijing	101	1	2	1.37	.484
Travel frequency in the "bicycle highway"	101	1	6	5.41	1.185
Valid N (listwise)	101				

Table 2

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.909	.929	17

Table 3

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
I am satisfied with the level of comfort	67.2376	92.523	.702	.698	.901
I am satisfied with the level of safety	67.2079	91.446	.751	.732	.900
It can satisfy my needs of health improving	67.2079	90.866	.778	.736	.899
I am satisfied with the amenity facilities	67.2475	91.508	.773	.710	.900
I am satisfied with the commute time on this road	67.2277	91.038	.779	.743	.899
This is a place that makes me feel relaxed and happy	67.2574	91.233	.793	.706	.899

If this bicycle highway was torn down, I would feel sad	67.3069	91.355	.653	.568	.902
This road belongs to me, rather than being occupied by other means of transportation (such as private cars)	67.2277	90.458	.806	.771	.898
This road raises my awareness of green travel	67.1980	90.280	.805	.781	.898
It has a visually appealing architecture	67.5248	90.532	.723	.673	.900
It has beautiful sceneries	67.6634	90.466	.649	.577	.902
Is not overcrowded	68.3762	112.217	-.362	.297	.942
Is a great family-friendly place to be	67.7030	91.271	.602	.539	.904
I can always interact with my friends or colleagues	68.1683	91.561	.452	.520	.910
Has generally friendly people around	67.7129	90.927	.702	.619	.901
It meets my needs better than any other traffic modes	67.4059	93.364	.585	.474	.904
It has more diversity in activities (doing exercises,socializing,picking up kids etc.) than any traffic modes	68.0495	89.368	.605	.561	.904

Table 4

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.927
Bartlett's Test of Sphericity	Approx. Chi-Square	1175.572
	df	120
	Sig.	.000

Table 5 Factor Analysis of Survey Responses

Rotated Component Matrix[a]

	Component	
	1	2
I am satisfied with the commute time on this road	.856	.187
I am satisfied with the level of safety	.844	.149
I am satisfied with the amenity facilities	.816	.238
It can satisfy my needs of health improving	.815	.247
I am satisfied with the level of comfort	.790	.176
This is a place that makes me feel relaxed and happy	.742	.375
This road belongs to me, rather than being occupied by other means of transportation (such as private cars)	.732	.405
It has a visually appealing architecture	.725	.330
This road raises my awareness of green travel	.713	.438
It has beautiful sceneries	.608	.360
If this bicycle highway was torn down, I would feel sad	.585	.406
It meets my needs better than any other traffic modes	.558	.304
I can always interact with my friends or colleagues	.058	.883
It has more diversity in activities (doing exercises, socializing, picking up kids etc.) than any traffic modes	.313	.738
Is a great family-friendly place to be	.326	.724
Has generally friendly people around	.496	.618

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 3 iterations.

Table 6

Correlations

		Travel frequency in the "bicycle highway"	REGR factor score 1 for analysis 3	REGR factor score 2 for analysis 3	Gender	Level of education	Car ownership in Beijing	Home ownership in Beijing
Pearson Correlation	Travel frequency in the "bicycle highway"	1.000	-0.049	-0.271	-0.222	-0.055	0.011	-0.018
	REGR factor score 1 for analysis 3	-0.049	1.000	0.000	0.102	-0.016	0.119	0.220
	REGR factor score 2 for analysis 3	-0.271	0.000	1.000	0.169	-0.013	-0.201	-0.186
	Gender	-0.222	0.102	0.169	1.000	0.177	0.212	0.163
	Level of education	-0.055	-0.016	-0.013	0.177	1.000	0.228	0.214
	Car ownership in Beijing	0.011	0.119	-0.201	0.212	0.228	1.000	0.747
	Home ownership in Beijing	-0.018	0.220	-0.186	0.163	0.214	0.747	1.000
Sig. (1-tailed)	Travel frequency in the "bicycle highway"		0.314	0.003	0.013	0.293	0.458	0.430
	REGR factor score 1 for analysis 3	0.314		0.500	0.155	0.437	0.119	0.014
	REGR factor score 2 for analysis 3	0.003	0.500		0.046	0.450	0.022	0.031
	Gender	0.013	0.155	0.046		0.039	0.017	0.051
	Level of education	0.293	0.437	0.450	0.039		0.011	0.016
	Car ownership in Beijing	0.458	0.119	0.022	0.017	0.011		0.000
	Home ownership in Beijing	0.430	0.014	0.031	0.051	0.016	0.000	
N	Travel frequency in the "bicycle highway"	101	101	101	101	101	101	101
	REGR factor score 1 for analysis 3	101	101	101	101	101	101	101
	REGR factor score 2 for analysis 3	101	101	101	101	101	101	101
	Gender	101	101	101	101	101	101	101
	Level of education	101	101	101	101	101	101	101
	Car ownership in Beijing	101	101	101	101	101	101	101
	Home ownership in Beijing	101	101	101	101	101	101	101

Table 7

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	15.069	5	3.014	2.285	.052[b]
	Residual	125.287	95	1.319		
	Total	140.356	100			

a. Dependent Variable: Travel frequency in the "bicycle highway"

b. Predictors: (Constant), Car ownership in Beijing, REGR factor score 1 for analysis 3, REGR factor score 2 for analysis 3, Level of education, Gender

Table 8

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients			95.0% Confidence Interval for B		Correlations			Collinearity Statistics	
Model		B	Std. Error	Beta	t	Sig.	Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	6.235	0.867		7.191	0.000	4.514	7.956					
	REGR factor score 1 for analysis 3	-0.039	0.116	-0.033	-0.334	0.739	-0.270	0.192	-0.049	-0.034	-0.032	0.977	1.024
	REGR factor score 2 for analysis 3	-0.285	0.120	-0.240	-2.368	0.020	-0.523	-0.046	-0.271	-0.236	-0.230	0.913	1.095
	Gender	-0.472	0.277	-0.175	-1.700	0.092	-1.023	0.079	-0.222	-0.172	-0.165	0.887	1.127
	Level of education	-0.062	0.211	-0.030	-0.296	0.768	-0.480	0.356	-0.055	-0.030	-0.029	0.928	1.078
	Car ownership in Beijing	0.014	0.148	0.010	0.096	0.923	-0.279	0.308	0.011	0.010	0.009	0.854	1.171

a. Dependent Variable: Travel frequency in the "bicycle highway"

13. The complete questionnaire design

bicycle highway questionnaire.pdf