Advances in Computer Science Research, volume 88
International Conference on Computer, Network, Communication and Information Systems (CNCI 2019)

Research on the Behaviour of Public Bicycles in Suzhou City

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Abstract. With the increasing environmental pollution, public transportation development is an urgent task. This paper mainly combines the characteristics of Suzhou's public bicycle system to conduct a sample survey of residents in Suzhou, focusing on the individual economic attributes (gender, age, occupation, income) and travel characteristics (travel distance, riding purpose, card reasons, cycling reasons, etc.). Secondly, this paper uses the binary logit model in SPSS software to get the main reasons that affect the residents' choice of public bicycle. The conclusion is: the factors affecting the choice of public bicycles mainly include travel distance, maximum acceptable riding time, whether you have a local account, whether you have a public bicycle card, whether you have used software to borrow a public bicycle, riding fees, monthly transportation fees, etc. At the same time, this paper also discusses the influencing factors of bus travelers and car travelers choosing public bicycles. It can provide some help for the development of public bicycle systems in the future.

Keywords: Public bicycle, choice behaviour research, binary logit model.

1. Introduction

With the acceleration of urbanization, the number of motor vehicles has gradually increased, traffic congestion, and environmental pollution has become more and more serious. Therefore, many countries have responded to the call for “Green commuting” and advocated the development of urban transport development models led by public transport. As a low-carbon and energy-saving green transportation mode, bicycles are more and more popular in major cities at home and abroad [1]. As a key city for economic development in Jiangsu Province, Suzhou is closely following the development trend of transportation construction. The public bicycles in Suzhou have been integrated into the daily life of the people and become a convenient of transportation for more and more people [2]. However, due to the lack of residents' attitude towards public bicycles and the quantitative analysis of the main factors affecting the choice of public bicycles, the current public bicycle use efficiency and service level are poor [3]. Therefore, on the basis of the current situation, this paper mainly studies the applicability of public bicycles under different factors such as different thresholds of use, distance, and transfer distance through the form of traffic travel investigation.

2. Traffic Choice Behaviour Theory

This paper is about the choice behavior of public bicycles. The subject is the different means of transportation chosen by each resident, that is, from any starting point A to any end point B, residents can choose the corresponding vehicle in different conditions (travel purposes, travel distance, etc.), which is a random selection process, so we can use discrete selection model to simulate the residents' choice behavior. The main research on whether chooses public bicycle is a dichotomous variable, so this paper mainly uses the binary logit model [4] [5].

Assuming that Y is a dependent variable of a dichotomous variable, having two values of 0 and 1, and the following linear relationship exists between the dependent variable Y and the independent variable X :

However, since the direct establishment of the model between Y and the independent variable X leads to the contradiction and heteroscedasticity of the left and right ends, so we use the effect model instead, assuming that U_i^0 is the utility of the individual i don't choose this mode of transportation, U_i^1 is the utility of the individual choosing this mode of transportation:

$$U_i^0 = X_i B^0 + \varepsilon_i^0 \quad (1)$$

$$U_i^1 = X_i B^1 + \varepsilon_i^1 \quad (2)$$

$$U_i^1 - U_i^0 = X_i (B^1 - B^0) + \varepsilon_i^1 - \varepsilon_i^0 \quad (3)$$

Let $U_i^1 - U_i^0 = y_i^*$, use $y_i^* = X_i B + \varepsilon^*$ to study the binary logit model [6].

Therefore, y_{ik} is assumed that the $i(i \in I)$ traveler selects the $k(k \in K)$ travel mode. $y_{ik} = 1$ indicates that the traveler chooses this mode, and $y_{ik} = 0$ indicates that the traveler does not choose the travel mode. Suppose there is a linear relationship with the independent variable in theory, i.e.

$$y_{ik}^* = \alpha_0 + \alpha_1 x_{i1} + \cdots + \alpha_m x_{im} + \varepsilon_k \quad (4)$$

α_0: Constant term, also known as intercept;

α_m: Pending parameter;

x_{im}: Independent variables (including personal socioeconomic attributes: gender, age, and occupation, etc. and personal travel characteristics: riding purpose, travel distance, etc.);

ε_k: Random items, satisfied with the Logistic distribution;

Therefore, the conditional probability that the nth person chooses j mode is

$$p(y_{ik} = \frac{1}{x_{ik}}) = p[(\alpha_0 + \alpha_1 x_{i1} + \cdots + \alpha_m x_{im} + \varepsilon_k) > 0] = \frac{\exp(\alpha_0 + \alpha_1 x_{i1} + \cdots + \alpha_m x_{im} + \varepsilon_k)}{1 + \exp(\alpha_0 + \alpha_1 x_{i1} + \cdots + \alpha_m x_{im} + \varepsilon_k)} \quad (5)$$

In order to investigate the influence of the change of each unit's independent variable on the choice of dependent variable, it is defined as Odds Ratio (OR), which is mainly used to investigate the sensitivity analysis of public bicycle selection [3].

$$OR = \frac{\exp(\alpha_0 + \alpha_1 x_{i1} + \alpha_i (x_{ik} + 1) \cdots + \alpha_m x_{im} + \varepsilon_k)}{\exp(\alpha_0 + \alpha_1 x_{i1} + \alpha_i x_{ik} + \cdots + \alpha_m x_{im} + \varepsilon_k)} \quad (6)$$

3. Survey Description

The main content of the questionnaire includes the following three aspects:
Personal economic attributes of the traveler: including the gender, age, income, and occupation of the respondent. There are two options for gender setting. The age is divided into 11 levels, and each option is divided into four options. The occupation setting is 14 options; the monthly income is set at 8 levels.

Traveler's travel characteristics: including departure and destination (for getting travel distance), walking time from departure point to public bicycle rental point, riding time, whether there is a local account, whether there is a public bicycle card, whether you have used software to borrow a public bicycle, the acceptable rental price, the purpose of cycling, the reason for cycling, the reason for getting the bicycle card, the monthly transportation fee, etc.

Other aspects: Investigating the proportion of different modes by travelers at different travel distances (0-12 km) to consider the sharing rate of various modes of transportation; considering the connection of walking time from the starting point to public bicycle rental and riding time, we get a three-dimensional scale map of the walking time and the riding time.

The questionnaire is divided into SP survey and RP survey. And it has two parts: the online questionnaire and the actual questionnaire. In the online questionnaire, 110 questionnaires were finally collected. In terms of the actual questionnaire, the survey was conducted from March 11 to March 25, 2017 for a total of 2 weeks. The survey sites were concentrated in Guanqian Street, Leqiao and Times Square in Suzhou. We got 433 questionnaires including 43 invalid questionnaires. Finally, we collected 500 valid samples.

4. Analysis of the Behaviour of Public Bicycles in Suzhou

4.1 Analysis of Resident Travel Characteristics

The resident travel characteristics involved in the survey include travel distance, walking time from the departure point to the public bicycle rental point, riding time, rental price, riding purpose, riding reason, transportation fee and so on. This paper mainly considers travel sharing rate under different travel distances and the connection between walking time and riding time.

4.1.1 Travel Sharing Rate under Different Travel Distances

From Fig. 1, we can know that the sharing rate curve of public bicycles tends to rise and then decrease with the increase of travel distance. In 0-2km, the proportion of public bicycles is increasing, and the distance is relatively stable in 2-3km, then it gradually declines over 3km. This is because within 1km travel distance, residents are more willing to choose to walk. Bus, car and other modes of transportation are more convenient and fast in more than 3 kilometers. The advantage of walking is concentrated in 0-1km. Private bicycles and public bicycles are similar, but it is more convenient than public bicycles to accept, so the sharing rate is higher than public bicycles within 0-6km. According to the 2016 annual report on road traffic development, the traffic volume of electric bicycles in Suzhou should be the highest, but the survey location is mainly concentrated in the bus station and the subway, so the proportion of electric bicycles is relatively low. The optimal travel distance of buses, cars and subways tends to be more than 6km.

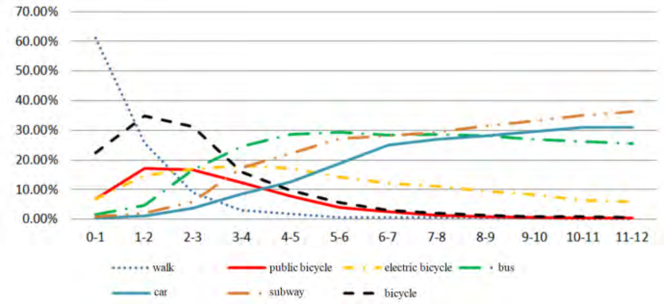

Fig. 1 Travel sharing rate under different travel distances (km).

4.1.2 The Connection between Walking Time and Riding Time

Fig. 2 is a comparison of the sample values by the cubic function (cubic polynomial interpolation) in MATLAB software, indicating the residents' choices for walking to public bicycle time and riding time. As can be seen from Fig. 2 , the red area represents a larger proportion, and the blue area represents a smaller one. When the walking time is less than 5 minutes, the riding time peaks at 10-20 minutes, indicating that the 5-minute walking time combined with the 10-20 minute riding time is the best mode for residents to choose a public bicycle.

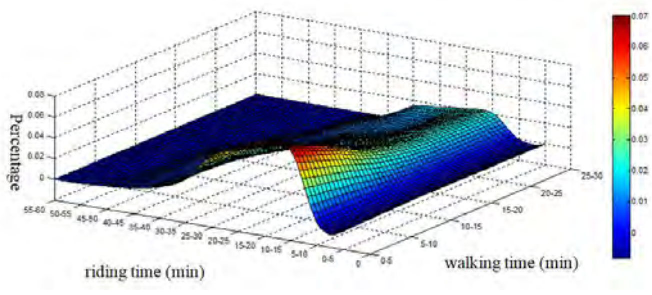

Fig. 2 The connection between walking time and riding time (min).

4.2 Analysis of the Residents' Behaviour Choosing Public Bicycles

This study used SPSS software to estimate the parameters of the binary logit model. Table 1 shows model estimation results of the residents. The variables in the final equation include travel distance (x_0), maximum acceptable riding time (x_1), whether you have a local account (x_2), whether you have a public bicycle card (x_3), whether you have used software to borrow a public bicycle (x_4), riding cost (x_5), the monthly transportation fee (x_6), one hour free (riding reason) (x_7).

Table 1 Variable in the equation of public bicycle.

	B	S.E.	Wals	df	Sig.	Exp(B)
travel distance	-0.081	0.028	8.604	1	0.003	0.922
maximum acceptable riding time	0.366	0.112	10.584	1	0.001	1.442
whether you have a local account	1.059	0.398	7.058	1	0.008	2.882
whether you have a public bicycle card	5.045	0.564	80.014	1	0.000	155.175
whether you have used software to borrow a public bicycle	5.164	0.536	92.800	1	0.000	174.791
riding cost	-0.315	0.157	4.037	1	0.045	0.730
the monthly transportation fee	-0.224	0.101	4.910	1	0.027	0.799
one hour free (riding reason)	1.032	0.469	28.506	1	0.028	2.808
constant	-3.922	0.735	28.506	1	0.000	0.020

The positive correlation variables are sorted according to the degree of influence: whether you have used software to borrow a public bicycle > whether you have a public bicycle card > whether you have a local account > one hour free (riding reason) > the maximum acceptable riding time. Firstly, the rate of people who used the software to borrow cars and have public bicycle cards is definitely higher, so they are significant factors. Secondly, from Exp(B), the ratio of residents with local accounts riding public bicycles is 2.882 times that of no local accounts. And considering the one-hour free feature of public bicycles, the ratio of residents choosing public bicycles has risen to 2.808 times. For every 10 minutes of maximum acceptable riding time, the ratio of residents choosing public bicycles is increased by 1.442 times, indicating that residents who are willing to ride longer are more willing to choose public bicycles;

The negative correlation variables are sorted according to the degree of influence: riding cost > monthly transportation fee > travel distance. With each additional level of riding cost, the ratio of residents choosing a public bicycle will drop to 0.73. The higher traffic cost per month for residents, the fewer times there are public bicycles. For each additional level, the probability of riding is reduced to 0.799. The farther the distance is, the more residents are less willing to ride a public bicycle, which is also in line with the short-distance travel of public bicycles.

So the fit model is:

$$P = \frac{1}{1+\exp(-3.922-0.081x_0+0.366x_1+1.059x_2+5.045x_3+5.164x_4-0.315x_5-0.224x_6+1.032x_7)} \quad (7)$$

The above model is about the influencing factor of the probability of public bicycle selection on the whole. Next, we will consider the factors influencing their choice of public bicycles in different travel modes.

Table 2 shows the results of the binary logit model estimation for bus travelers choosing public bicycles. The variables in the final equation include travel distance (x_0),whether you have a local account (x_1), monthly transportation fee (x_2), card for emergency needs (x_3), destination near (riding reason) (x_4), one hour free (riding reason) (x_5), environmental protection (riding reason) (x_6), age (x_7), monthly income (x_8).

Table 2 Variable in the equation of bus travelers.

	B	S.E.	Wals	df	Sig.	Exp(B)
travel distance	-0.161	0.041	15.602	1	0.000	0.852
whether you have a local account	0.945	0.389	5.915	1	0.015	2.573
monthly transportation fee	-0.476	0.158	9.097	1	0.003	0.621
card for emergency needs	1.287	0.464	7.694	1	0.006	3.624
destination near (riding reason)	1.109	0.390	8.077	1	0.004	3.030
one hour free (riding reason)	0.907	0.462	3.854	1	0.050	2.478
environmental protection (riding reason)	1.227	0.461	7.077	1	0.008	3.409
age	-0.564	0.212	7.045	1	0.008	0.569
monthly income	-0.240	0.135	3.183		0.074	0.787
constant	2.619	0.732	12.803	1	0.000	13.717

The positive correlation variables are sorted according to the degree of influence: card for emergency needs > environmental protection (riding reason)> destination near (riding reason)> whether you have a local account > one hour free (riding reason): From Exp(B), the ratio of bus travelers with local account choosing public bicycle is 2.573 times that of no local account. If the destination is closer, the ratio of bus travelers choosing public bicycles has risen to 3.03 times. Taking into one-hour free feature of public bicycles, the ratio of bus travelers choosing public bicycles has risen to 2.478 times. Also, the ratio of bus travelers using public bicycles will rise to 3.409 times according to the advantages of public bicycle environmental protection.

The negative correlation variables are sorted according to the degree of influence: age > monthly transportation fee > monthly income > travel distance: from Exp(B), the farther the travel distance is, the less the bus travelers are willing to choose public bicycle travel. And for every one kilometer of travel distance, the probability of selection drops to 0.852. The higher the traffic cost per month for bus travelers, the fewer the number of public bicycles will be used. The probability of riding decreases to 0.621 for each level of increase. For every 6 years of age for bus traveler, the probability of choosing public bicycles drops to 0.569. For each level of monthly income, the probability of selection drops to 0.787.

Therefore, in the future development of public bicycles, for transferring some of the bus travels to public bicycles, the government should take advantage of the one-hour free, environmentally friendly and short-distance travel of public bicycles to increase the density of public bicycle rental points in large shopping malls and tourist attractions, so that residents can more easily pick up vehicles and increase the public bicycle system. Mostly, the government can increase the public bicycle system to expand the age range and income level of public bicycle users.

So the fit model is:

$$P = \frac{1}{1+\exp(2.619-0.161x_0+0.945x_1-0.476x_2+1.287x_3+1.109x_4+0.907x_5+1.227x_6-0.564x_7-0.240x_8)} \quad (8)$$

Table 3 shows the binary logit model estimation results for car travelers choosing public bicycles. The variables in the final equation include whether you have a local account (x_0), go to work (riding purpose) (x_1), one hour free (riding reason) (x_2), unlike buses that need to wait (x_3).

Table 3 Variable in the equation of bus travelers.

	B	S.E.	Wals	df	Sig.	Exp(B)
whether you have a local account	1.629	0.600	7.360	1	0.007	5.096
go to work (riding purpose)	1.728	0.653	7.007	1	0.008	5.631
one hour free (riding reason)	1.490	0.699	4.541	1	0.033	4.437
unlike buses that need to wait	1.155	0.598	3.737	1	0.053	3.174
constant	-2.103	0.533	15.544	1	0.000	0.122

The positive correlation variables are sorted according to the degree of influence: go to work (riding purpose) > whether you have a local account > one hour free (riding reason) > unlike buses that need to wait: from Exp (B), the ratio of car riders riding public bicycles with a local account is 5.096 times that of no local accounts. Considering the one-hour free feature of public bicycles, the ratio of car travelers choosing public bicycles has risen to 4.437 times. Considering that public bicycles are unlike buses that need to wait, the probability that a car traveler uses a public bicycle rises to 3.174 times. The car travelers choose public bicycle to work is 5.631 times that for other purposes, this may be because there are more morning peak motor vehicles, which is likely to cause road congestion. Some residents with cars will switch to public bicycles to connect with other public transportation.

Therefore, in the future development of public bicycles, to transfer some car trips to public bicycle trips, the government mainly uses the advantages of public bicycles about one hour for free, unlike buses that need to wait and strengthen public bicycle rental points near bus stops and subway stations to seamlessly connect various public transportation modes.

So the fit model is:

$$P = \frac{1}{1+\exp(-2.103+1.629x_0+1.728x_1+1.490x_2+1.155x_3)} \quad (9)$$

5. Conclusion

This study uses the travel mode selection model (binary logit model) to deeply explore the characteristics of public bicycles' choice behavior from the perspective of the individual's personal attributes and travel characteristics. Firstly, this paper simulates residents' interaction time between walking time and riding time through MATLAB software, it can be seen that 5 minutes walking time with 10-20 minutes of riding time is the best mode for residents to choose public bicycles. Secondly, this paper uses the SPSS software model to analyze the behavior characteristics of public bicycles. It can be seen that the factors affecting the choice of public bicycles are environmental protection, destination near, riding cost, monthly transportation fee, travel distance, etc. For bus travelers, the factors that influence bus travelers to choose public bicycles mainly include travel distance, monthly transportation fee, age, monthly income, etc. For car travelers, the factors that influence car travelers to choose public bicycles mainly include go to work (riding purpose), unlike buses that need to wait, etc. In the future development of public bicycles, for transferring some of the bus travels to public bicycles, the government should take advantage of the one-hour free, environmentally friendly and short-distance travel of public bicycles to increase the density of public bicycle rental points in large shopping malls and tourist attractions, so that residents can more easily pick up vehicles and increase the public bicycle system. Mostly, the government can increase the public bicycle system to expand the age range and income level of public bicycle users. For transferring some of the car travels to public bicycles, the government can use the advantages of public bicycles about one hour for free, unlike buses that need to wait and strengthen public bicycle rental points near bus stops and subway stations to seamlessly connect various public transportation modes.

Acknowledgments

The completion of the thesis is attributed to many people's support and encouragement. First and foremost, I want to extend my heartfelt gratitude to my supervisor, Associate Professor Zhang Yong, whose patient guidance, valuable suggestions and constant encouragement make me successfully complete this thesis. Also, I would like to express my sincere gratitude to all the classmates who have taught me in study. My thanks also go to the authors whose books and articles have given me inspiration in the writing of this paper. Last but not least, I would like to express my special thanks to my parents, whose care and support motivate me to move on and make me want to be a better person.

References

[1]. Wei Z, Yuqi P, De W, Research progress on bicycle travel behavior and decision-making, Urban research, No. 01, pp. 50-55, January 2013.

[2]. Tingting Y, Fei S, “Progress and Prospects of Public Bicycle Research at Home and Abroad”, Northern economy, No. 4, 2014, pp. 20-22.

[3]. Bing L, “Research on Urban Public Bicycle Choice Behavior”, Xi'an, June 2013.

[4]. Jun C, Chunyan L, Xiaodong Z, “Improvement and verification of binary logit model for resident travel generation prediction”, Journal of Wuhan University of Technology, vol. 33, No. 5, 2009, pp. 1008-1011.

[5]. Chi P, Shengchuan Z, “Research on Commuting Behavior of Residents in Dalian Based on Logit Model”, Traffic information and security, vol. 30, No. 3, 2012, pp. 25-28.

[6]. Qiyu L, Huiying L, Junbo C et.al, “Research on Urban Public Bicycle Rental Behavior Based on Binary Logit Model”, Western Transportation Technology, No. 3, 2015, pp. 85-89.