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FACTORS OF PERCEIVED WAITING TIME AND IMPLICATIONS ON PASSENGERS' SATISFACTION WITH WAITING TIME

ABSTRACT

In order to explore the influence factors on perceived waiting time, a multiple linear regression model has been used to quantitatively describe the relationship between perceived waiting time and various factors. The model is established with 234 data, which is surveyed with questionnaire at three stops in Harbin, China. The results show that several certain factors ("trip purpose - where to", "presence of a companion - whether one has a companion or not", "having a timing device - whether one has a timing device or not", "riding frequency - how many times one takes one line per week" and "waiting behaviour - what one does while waiting for a bus") have significant influence on perceived waiting time, which confirms previous findings and supports transferability of results. The significance of "waiting mood - how about the mood while waiting for a bus" and "reserved waiting time - how long one will wait" are confirmed for the first time in this study. In contrast to previous studies, "waiting time interval - for how long in one day" is a negative variable and socioeconomic variables are non-significant. And it is found that the relationship between perceived waiting time and passengers' satisfaction with the waiting time follows a decreasing exponential distribution. With this model, the variation trend of the section, where passenger satisfaction value is larger than 0 is obviously steeper than the section smaller than 0. Such result proves that passenger mood with short waiting time is more sensitive than with longer waiting time. And the borderline perceived waiting time, distinguishing satisfied from dissatisfied passengers is proven to be 7.87 minutes when assignment interval of satisfaction is (-25.25], when satisfaction is positive (larger than 0), the accuracy being 70.30%, while the accuracy is 82.71% for negative satisfaction (less than 0).

KEY WORDS

perceived waiting time; linear regression model; passenger satisfaction with waiting time; borderline perceived waiting time;

1. INTRODUCTION

Urban conventional bus transportation provides sustainable and fair service at a low travel cost for passengers; however, the share in Harbin, Heilongjiang Province is far lower than private cars, which is mainly attributed to crowded traffic in rush hour, unstable headway and poor vehicle interior comfort. Moreover, Psarros et al. [1] found that the abovementioned reasons would lead to low passengers' satisfaction with waiting time. Some scholars have pointed out that the key to improving the attraction of public transportation was the improvement of passenger perception [2]. In recent years, traffic planners have increasingly focused on improving service quality and passengers' satisfaction in the design and improvement stage of public transportation systems [3, 4].

The passenger perceptions of bus service can be described in terms of passengers' satisfaction with waiting time, and it is affected by many factors. Hensher [5] identified two factors, waiting environment service quality and information service quality. Then Stopher et al. [6] extended this research and found that the most influential factors were punctuality rate of buses' arrival, walking time from the origin to destination bus stop, and service facilities of the bus stop. Wen et al. [7] used variable stepwise elimination and determined that the predominant factors were passengers' waiting time and passenger waiting behaviour. Das and Pandit [8] proved that shortening of passenger waiting time could indirectly improve passenger satisfaction and ultimately improve bus capacity. While the time cost indicated that customers preferred to wait rather than to pay for more frequent service, the management's goal was to provide the most suitable service for passengers, thus a more frequent bus timetable was necessary. However, this brought high costs;

otherwise, management had to use other means to make passengers more satisfied in their waiting time [9]. Therefore, based on the perspective of time cost, the perceived waiting time is a relatively important factor for passenger satisfaction. Friman and Gärling [10] established a mathematical model to explore the relationship between passengers' satisfaction and the frequency of major accidents; similarly it is feasible to explore only one important correlated variable which is the perceived waiting time, for passenger satisfaction.

Van Hagen and Galetzka [11] found that passengers' perceived waiting time was often greater than the actual waiting time and that the perception deviation is larger when the actual waiting time is shorter, and then the passengers' negative emotions such as irritability and restlessness grow, and this also influences the passengers' travel quality. Psarros et al. [1] used the continuous time risk model to explore the factors that influence the perceived waiting time and found that "age", "trip purpose" and "travel time" had effects. They also found that the elderly and group trips for work or school would automatically extend the perceived waiting time, and in the morning peak the travel population would automatically shorten the perceived waiting time. Studies have indicated that real-time information could reduce the passenger perceived waiting time, thus Watkins et al. [12] presented a multiple linear regression model including real-time information, riding frequency, peak time and other factors to forecast the waiting time. Hui et al. [13] indicated that passenger psychological changes could be improved in the process of waiting for buses, which would affect the perceived waiting time from two aspects (real-time arrival information and a comfortable waiting environment) and attract passengers' attention. Other passenger factors, such as waiting behaviour and the presence of companions, could produce a deceptive effect and reduce passenger perceived waiting time, while negative emotions could make passengers overestimate their waiting time [11].

At present, the majority of studies on perceived waiting time and passenger satisfaction only used the influencing factors in establishing the related models and they did not take into account the specific relationship between the perceived waiting time and the passenger satisfaction. However, the findings of many scholars indicated that the perceptions of waiting time directly influenced the evaluation of bus service quality, which meant that there was a relationship between the perceived waiting time and passenger satisfaction. At the same time, the results on the influencing factors of perceived waiting time are not uniform. Therefore, this paper will consider more factors to create a model of influencing factors of perceived waiting time and construct a relationship model between perceived waiting time and passenger satisfaction. And because of the limitation of research condition, only bus transport was studied.

This paper is organized as follows. In Section 2 the detailed survey scheme is introduced. In Section 3 a multiple linear regression model is applied for fitting the influence factors of passenger perceived waiting time. In Section 4, the relationship between perceived waiting time and passenger satisfaction based on the exponential distribution model is discussed in detail and results are provided to validate the performance of the proposed approach. Finally, the conclusion and the future work will be presented.

2. SURVEY

2.1 Stop selection principles

Too many bus lines or too few passengers will affect the efficiency of survey and accuracy of the sample. It is necessary to comply with the following three principles in the process of selecting the bus stops. Firstly, the selected stops cannot serve too many lines. It is best that there are no more than three lines. Waiting passengers could reasonably infer the bus arrival time and estimate whether they have enough time to conduct the survey at the stops. Secondly, passenger arrival should be random which can improve the reliability of the sample data. The third is that the stop must have essential demand to some extent in order to guarantee a sufficient sample size in the finite investigation time.

2.2 Surveyed stops

Based on the above selection principles, three stops were selected in Harbin, Heilongjiang Province, China, and a total of ten lines were involved. The basic bus service information of surveyed stops and involved lines are shown in *Table 1*.

2.3 Investigation

Factors of perceived waiting time and passenger satisfaction were surveyed through administering a questionnaire. In addition to passenger basic information, such as gender, occupation and education, the following questions were also assessed in the questionnaire.

1) Having a timing device: Whether you have a timing device or not?
2) Presence of a companion: Whether you have companions or not?
3) Travel purpose: Where you are going? Home, working place, school, shopping or other?
4) Riding frequency: How many times do you ride this line per week?
5) Walking time: How long did it take if you walk to your destination from the surveyed stop instead of riding a bus?

Table 1 – Basic information of surveyed stops

Stop number	Line quantity in service	Basic information of involved lines				
		Line number	Average headway/min	Length/km	Amount of sites along line	Average speed/km/h
1	3	1	9	16.7	32	25
		2	7	22.0	37	25
		3	9	22.7	39	25
2	3	4	9	17.1	31	25
		5	8	16.7	32	25
		6	5	21.9	41	25
3	4	7	5	10.7	21	25
		8	6	13.0	26	25
		9	5	18.9	37	25
		10	7	27.6	47	25

6) Reserved waiting time: How long is the maximum time that you would be willing to wait?
7) Waiting behaviour: What are you doing in the process of waiting for the bus?
8) Waiting mood: What is your mood now? Very easy, easy, no feeling, anxious or very anxious?
9) Passenger perceived waiting time: What do you think how long did you wait?
10) Satisfaction grade: Please fill out the waitingtime to meet every satisfaction grade, they are very satisfied, satisfied, no feeling, unsatisfied and very unsatisfied (e.g. how many minutes for "very satisfied" do you think?).

In the survey, three minutes were needed on the average for passengers to finish one questionnaire. The investigation was done in time intervals of 7:00–9:00, 12:00–13:00 and 16:30–18:30 on May 18, 2014. There were six investigators that were divided as three groups and each group was in charge of one bus stop. All members had been trained in advance. The investigation was done with nice weather conditions and 40, 20 and 40 questionnaires were distributed, respectively, from the earliest time interval to the last one. All the questionnaires were filled by passengers with the help of trained investigators. The three groups conducted the survey on the same day and obtained 300 questionnaires eventually.

2.4 Statistical results

There were 300 questionnaires distributed in this survey, from which the unfinished and unreliable questionnaires were removed, and 234 were valid. The statistical sample data characteristics are shown in *Table 2*.

As shown in *Table 2*, the gender ratio is close to 1:1. The number of passengers having a timing device is much larger than those without. The proportion of taking "home" and "work or school" as travel purpose is close to 70%, which is likely to be related to the longer survey time in the morning and evening rush hours. The ratio of riding frequency is close to 1:1:1, and this variable represents the degree of familiarity with bus service. Over 75% passengers will walk more than 30 minutes if they choose walking rather than taking a bus, which illustrates that the travelling of most people is long-distance. Reserved waiting time is related to the waiting mood when the perceived waiting time is longer than their reserved time passengers seem to become anxious.

3. INFLUENCE FACTORS OF PERCEIVED WAITING TIME

3.1 Model

In order to synthesize discrete and continuous variables and quantitatively describe the weights of all factors, meanwhile linear regression model is generally selected for psychological behaviour research. Thus eventually a multiple linear regression model was used to explore the various influence factors of perceived waiting time. The model could be described as $y=\beta_0+\beta_1x_1+\beta_2x_2+...+\beta_nx_n$ where y is the perceived waiting time, minute, $x(i=1,2,...,n)$ is the influence factors, and $\beta_k(k=0,1,...,n)$ is the coefficient.

In order to determine the parameters for modelling, it is necessary to transfer the variables with qualitative description into the quantitative data. So every variable with qualitative description is described as one or zero; for example, if the passenger's "travel purpose" is "home", then the value of variable "travel purpose: home" is one and vice versa other variables in the group of "travel purpose" are zeros, e.g. "travel purpose: working or school" is zero. Among these, "gender" "occupation" "education" "having a timing device" "presence of a companion" "travel purpose" "riding frequency" "waiting behaviour" "waiting mood" and "waiting time interval" use the abovementioned assignment method. While "walking time" and

Table 2 – Descriptive statistics of the sample

Variable	Categories	Amounts	Percentage
Gender	Male	121	51.70%
	Female	113	48.30%
Occupation	Students	83	35.50%
	Office workers	94	40.20%
	Retired	49	30.0%
	Other	8	3.30%
Education	Junior high school and below	35	14.90%
	Senior high school	97	41.50%
	Undergraduate or specialized	72	30.80%
	Master's or above	30	12.80%
Having a timing device	Yes	208	88.89%
	No	26	11.11%
Presence of a companion	Yes	89	38.03%
	No	145	61.97%
Travel purpose	Home	62	26.50%
	Work or School	97	41.45%
	Shopping or Entertainment	50	21.37%
	Other	25	10.68%
Riding frequency (per week)	1–5	78	33.33%
	6–10	80	34.19%
	>10	76	32.48%
Walking time/min	≤20	12	5.13%
	21–30	45	19.23%
	31–40	56	23.93%
	41–50	57	24.36%
	51–60	37	15.81%
	>60	27	11.54%
Reserved waiting time/min	≤5	32	13.68%
	6–10	121	51.71%
	11–15	49	20.94%
	16–20	21	8.97%
	>20	11	4.70%
Waiting behaviour	Using electronic equipment	73	31.20%
	Chatting with companion	71	30.34%
	Nothing	88	37.61%
	Other	2	0.85%
Waiting mood	Very easy	14	5.98%
	Easy	51	21.79%
	No feeling	80	34.19%
	Anxious	60	25.64%
	Very anxious	29	12.39%
Waiting time interval	Morning peak	85	36.32%
	Off-peak	48	20.51%
	Evening peak	101	43.16%

"reserved waiting time" are originally quantitative data, the raw survey data are satisfactory.

3.2 Parameters of the model and analysis

SPSS software was chosen to fit linear regression model. These survey variables are likely to be related, which is the concept of multicollinearity. The variable with multicollinearity should be removed. So the method of eliminating backwards was chosen to eliminate unsuitable variables. The results are shown in *Table 3*. Significant level should be less than 0.05 for significant variables.

Table 3 shows the results excluding the variables with multicollinearity. The "occupation" variable did not appear in it, which suggests that it is a variable with multicollinearity. And according to significant level, it is obvious that "gender" "education" and "walking time" have less significance and "having a timing device" "presence of a companion" "trip purpose" "riding frequency" "waiting mood" "waiting behaviour" "waiting time interval" and "reserved waiting time" have good significance.

In order to improve the precision of the model, the paper eliminates the less significant variables in *Table 3*. The model was refitted and the results are shown in *Table 4*.

Perceived waiting time can be described by Equation 1:

$$y = 7.604 - 1.526x_{WT} - 1.474x_{WC} + 1.545x_{TP} + \\ + 1.054x_{RF} + 0.894x_{RW} - 0.027x_{RW} \\ - 1.104x_{BC} + 1.781x_{MA} + 2.866x_{MW} \quad (1)$$

Table 3 shows that the perceived waiting time is well correlated with "waiting mood", which indicates that poor mood will extend the perceived waiting time. "Trip purpose for work or school" and "morning peak" are positively correlated with perceived waiting time.

Table 3 – Estimation results after eliminating variables with multicollinearity

Variable	Standard coefficient	
	B	Sig.
(Constant)	8.403	0.000
Gender: Female	-0.485	0.436
Education: Master's or higher	-0.752	0.460
Having a timing device	-0.526	0.048
Presence of a companion	-1.502	0.033
Travel purpose: work or school	1.744	0.041
Riding frequency: >10 times/week	1.056	0.044
Walking time	-0.017	0.351
Reserved waiting time	0.027	0.023
Waiting behaviour: chat with companion	-1.056	0.049
Waiting mood: anxious	1.864	0.016
Waiting mood: very anxious	3.005	0.003
Waiting time interval: morning peak	1.094	0.039
Waiting time interval: evening peak	0.537s	0.029

Table 4 – Estimation results after eliminating variables with less significance

Variable	Standard coefficient	
	B	Sig.
(Constant)	7.604	0.000
Having a timing device x_{WT}	-1.526	0.047
Presence of a companion x_{WC}	1.474	0.050
Travel purpose: work or school x_{TP}	1.545	0.041
Riding frequency: >10 times/week x_{RF}	1.054	0.048
Waiting time interval: morning peak x_{TM}	0.894	0.047
Reserved waiting time x_{RW}	0.027	0.036
Waiting behaviour: chat with companion x_{BC}	-1.104	0.042
Waiting mood: anxious x_{MA}	1.781	0.014
Waiting mood: very anxious	2.866	0.003

"Riding frequency" is positively correlated with perceived waiting time. The passengers riding a bus with higher frequency may have a better understanding about the arrival time of the bus, enabling a shorter waiting time. "Having a timing device" is a negatively correlated variable which shows that if the stops are equipped with clocks or real-time information board, passenger perception of waiting time will decrease. "Presence of a companion" is a negatively correlated variable. It can relieve the passenger tension and reduce the perception of waiting time. A positive correlation was found between "reserved waiting time" and perceived waiting time, which means that the longer a passenger's reserved waiting time is, the larger is the perceived deviation.

"Trip purpose", "with companion", "riding frequency" and "waiting behaviour" were found having significant influences on the perceived waiting time. The result was in line with the previous model [1, 11, 12]. Several studies proposed that "waiting mood" and "reserved waiting time" may influence perceived waiting time, and this paper verified the significant influence of these factors [9, 13]. In addition, one study has shown that education, occupation, and other basic factors have significant influences on perceived waiting time [1]. However, these relationships in this research were not proven, which is possibly caused by different environment and sample limitation, for example, urban traffic land is more compact and urban residential population is more intensive in China than those in foreign countries.

4. PASSENGER SATISFACTION WITH WAITING TIME

4.1 Quantitatively described waiting satisfaction

The level of satisfaction was divided into five grades: very satisfied, satisfied, no feeling, dissatisfied, very dissatisfied. According to question 10 in section 2.3, every surveyed passenger filled in an acceptable waiting time for different grades of satisfaction, and the waiting time interval from "very satisfied" to "very dissatisfied" was 0-50 min. In order to explore the quantitative relationship between waiting time and passenger satisfaction, the qualitative descriptions of the five moods have been converted into quantitative descriptions. Fifty was selected as the width of assignment range, and finally (-25, 25] was chosen as the assignment range to be consistent with the symmetry distribution regularity of the satisfaction grade. Each grade corresponded to 234 samples, in order to improve precision of model, this paper ascertained 10 sets of values through dividing the lower and upper limits. The assignment method is shown in *Table 5*.

To simplify things, integer values in each interval were randomly selected for corresponding passenger satisfaction. There were 234 samples input into MATLAB. The software could realize discrete data serialization, and the relation curve was obtained when data were imported and the result is shown in *Figure 1*.

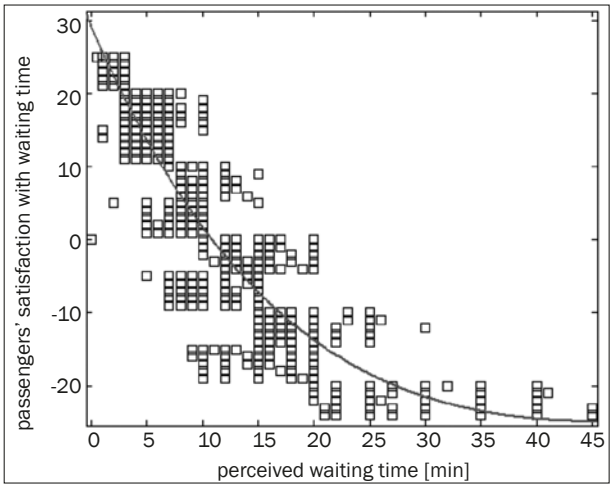

Figure 1- Scatter diagram of the 234-sample data Scatter diagram perceived waiting time

Table 5 – Value intervals corresponding to different grades of satisfaction

Waiting satisfaction grade		Value interval
Very dissatisfied	The lower	(-25,-20]
	The upper	(-20,-15]
Dissatisfied	The lower	(-15.-10]
	The upper	(-10,-5]
No feeling	The lower	(-5,0]
	The upper	(0,5]
Satisfied	The lower	(5,10]
	The upper	(10,15]
Very satisfied	The lower	(15,20]
	The upper	(20,25]

The curve indicates the input data points fitted curve. According to the curve shape, an exponential distribution model is used to describe the relationship between perceived waiting time and passengers' satisfaction with waiting time. The basic form of the model is $y = y_0 + Ae^{-x/t}$ where y_0, A, and t are the calibration parameters.

Because every satisfaction grade value is selected at will, the model parameters are not unique. The calibration parameters will change with different satisfaction value intervals. However, the model form is unique, no matter how to assign a value, the relationship between perceived waiting time and passenger satisfaction follows a decreasing exponential distribution.

With the exponential distribution model, the sample data were fitted again, the result of data fitting is shown in *Figure 2*.

When the assignment interval of passenger satisfaction with waiting time is (-25, 25), passenger waiting satisfaction is described in Equation 2:

$$y = -25.79 + 50.90e^{-T/11.57} \quad (2)$$

where is the value of passenger waiting satisfaction; is the perceived waiting time, min.

As shown in *Figure 2*, six demarcated points (A, B, C, D, E and F) in the horizontal coordinate axis demonstrate satisfaction value of 25, 15, 5, -5, -15, -25 for the waiting time, respectively. That is, the time interval between A and B indicates the "very satisfied" region in this model.

4.2 Model characteristics and significance

As shown in *Figure 2*, when the perceived waiting time increases, passenger satisfaction with waiting decreases and their waiting mood deteriorates.

When passenger satisfaction is "very satisfied" or "satisfied" the approximate range of the corresponding perceived waiting time interval is (A, C); when passengers' waiting satisfaction is "very dissatisfied" or "dissatisfied" the approximate range of the corresponding perceived waiting time is (D, F). The latter range is significantly larger than the former, which indicates passengers are more likely to be dissatisfied when the perceived waiting time exceeds expectations. The trend of the part of passengers' waiting satisfaction values which is larger than 0 is obviously steeper than when the part of the satisfaction value is less than 0, which explains that passengers moods with short waiting time are more sensitive than with longer waiting time.

Satisfaction can be divided into two levels (satisfied and dissatisfied) with the dividing point 0. In Equation 2, when satisfaction is 0, the perceived waiting time is 7.87, and this time is the borderline value for satisfaction and dissatisfaction. When the perceived waiting time is less than 7.87 minutes, passengers may be satisfied; on the contrary when it is longer than 7.87 minutes, the passengers may be dissatisfied.

In order to verify the accuracy of the borderline value, 234 samples are divided into satisfaction and dissatisfaction with the standard of 7.87 minutes, and the results are compared with the actual satisfaction level. The comparison results are shown in *Table 4*.

Taking the reference point of 7.87 minutes as the standard, the number of "satisfaction" responses is 101, and out of these, there were 71 of "satisfaction" in the actual survey, so when satisfaction is positive (larger than 0), the accuracy is 70.30%. When satisfaction is negative (less than 0), the accuracy is 82.71%, which is larger than it is positive. That is probably because the range of perceived waiting time for

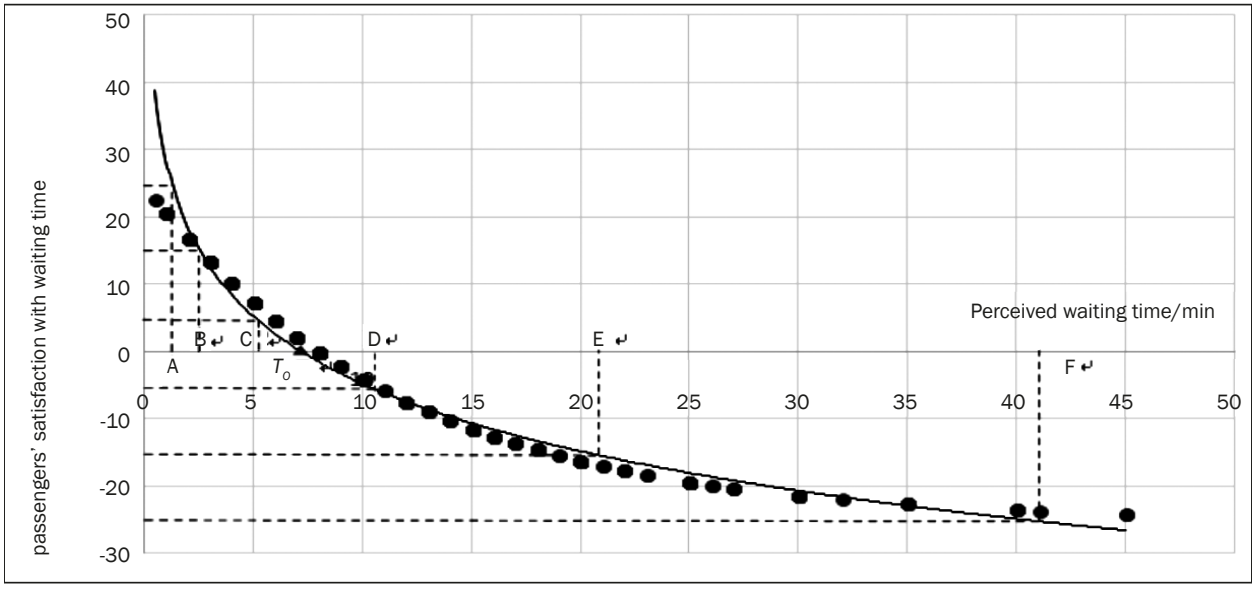

Figure 2 – Results of data fitting

negative satisfaction is significantly larger than that of positive satisfaction, so the number of passengers in the negative satisfaction group is larger than in the positive satisfaction group.

5. CONCLUSION

This study found that passengers perceived waiting time is in positive correlation with "trip purpose," "riding frequency," "waiting mood," "waiting time interval," and "reserved waiting time" and is in negative correlation with "having a timing device," "presence of a companion," and "waiting behaviour". The perceived waiting time can be further improved according to these influencing factors; moreover, the perceived waiting time directly affects the passenger satisfaction with waiting time. The perceived waiting time and passenger satisfaction follow the exponential distribution, the passenger waiting satisfaction decreases as perceived waiting time increases. With this model, taking 7.87 minutes as the critical point, when the perceived waiting time is less than 7.87 minutes, the passenger is satisfied, while when the perceived waiting time is longer, the passenger is dissatisfied. And the proportion of the model results consistent with sample is 70.30% when passenger satisfaction is satisfied, while the proportion is 82.71% when the passenger satisfaction is dissatisfied.

Passenger satisfaction with the waiting time directly affects the evaluation of bus service. In order to increase the attractiveness of public transportation, it is essential to improve passenger satisfaction. Thus, the key is to reduce passengers' perceived waiting time. According to the perceived waiting time model, if passengers are in a good mood and choose positive waiting behaviour, such as the use of portable electronic devices or peer communication, the perceived waiting time will be reduced. A timing device can also reduce the perceived waiting time. Managers can improve the service level of public transportation by providing real-time information or facilities equipped to measure time at the stop. Thus, passenger satisfaction with waiting time and the evaluation of the service quality of public transportation can be improved.

This study still has some limitations. Factors of perceived waiting time are not comprehensive, sample size is limited and sample structure remains to be improved, etc.

In this paper, the perceived waiting time model did not consider the impact of real-time information, and some scholars have suggested that passenger perceived waiting time is likely to be equal to actual waiting time when real-time information is available [2]. In addition, the relationships among perceived waiting time, waiting satisfaction, and the choice of travel mode is a direction for future research.

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公交乘客感知等待时间的影响因素及其与等车满意度之间的关系

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摘要：为了定量分析影响感知等待时间的各方面因素，选用多元线性回归模型进行分析。以黑龙江省哈尔滨市无实时信息提示公交站点调查得到的234个样本数据为基础，构建了感知等待时间影响因素模型。结果显示出行目的、有同行的伙伴、有时间计量工具、出行频率和候车行为感知等待时间有显著影响，这和现有的其他学者的研究一致。而现有的研究中并没有涉及到候车情绪和预留等待时间，本文研究发现这两个因素与感知等待时间也具有显著相关性。与现有研究成果不一致的是，候车时段与感知等待时间负相关，年龄、职业等乘客自身的社会经济属性指标并不具有显著相关性。同时本文研究发现感知等待时间与乘客等车满意度服从负指数分布，并且满意度大于0时的变化趋势明显陡于满意度小于0的部分，这说明乘客在候车时间较短时情绪更加敏感。本文发现等车时间为7.87分钟是划分满意度正负的分界值，当感知等待时间小于7.87分钟时，满意度为正；当感知等待时间大于7.87分钟时，满意度为负。

关键词：感知等待时间；多元线性回归模型；等车满意度；临界感知等待时间

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