Evaluating the satisfaction of passengers with different backgrounds for public transit

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Abstract

This paper presents a satisfaction evaluation method to give an insight into the relationships among passenger backgrounds, perceptions and satisfaction for public transit (PT) service. Firstly, we proposed a systematic evaluation system and deduced a calculation model to demonstrate the critical factors that affect passenger satisfaction. Secondly, a targeted survey was conducted among passengers in Maanshan. 680 passengers in total from 10 bus lines were chosen, from whom 520 questionnaires were effective. In addition, IBM SPSS statistics 19.0 version was introduced to calculate passenger satisfaction. The result shows that, passengers with different backgrounds and trip purposes have different perceptions and expectations of PT service. Moreover, the layout of bus stops and the quality of PT service exert an influence on passengers in some degree as well. Therefore, considering the limited urban resources in developing countries, these features should be taken seriously while implementing the relative schemes to improve PT service.
Keywords: service satisfaction, passenger background, questionnaire survey, binary logistic regression.

1 Introduction

Public transit (PT) is suffering the competitive pressure from private traveling tools in China. In the recent ten years, with an explosive increase in the private car ownership and utilization, the proportion of people who travel by bus has been decreasing continuously. Many research projects have been carried out on the purpose of enhancing the development of PT [1–4]. These researches try to improve the service quality and passenger satisfaction of PT so that PT will appeal to more passengers.

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Quality of service reflects the passenger's perception of PT performance [5]. Attributes which are used to describe this perception are heterogeneous with a wide range of quantitative and qualitative characteristics [6, 7]. Clearly, quantitative attributes are the characteristics that describe the performance of PT that can be directly observable [8], such as availability, capacity, cost, operational speed, dwell time, service intervals, number of accidents, punctuality, etc. [9, 10]. In contrast, qualitative attributes lie in identifying aspects of service quality which are difficult or impossible to measure directly. In reality, qualitative characteristics can be effectively obtained through the passenger's point of view [11], including reliability, security, comfort, company image, ease of use, etc [12–14]. All of these attributes play a role in determining the service quality of PT.

However, from the passenger's viewpoint, satisfaction of PT is relative and depends upon the objectives, means and results [15]; so, apart from the assessment of the service quality provided by PT, understanding the behavioral intentions of PT passengers is important, as well [16, 17]. Because passengers demand different levels of PT service, none of trip plans could meet all the travel needs. Additionally, as a typical developing country, it is difficult for China to implement all the optimized strategies or methods to ensure the priority of PT. Therefore, it is significant to evaluate satisfaction of passengers with different backgrounds [18]. Through those researches, PT managers can draw up better trip schemes for different passengers with different needs in order to improve satisfaction of PT service with limited resources. When PT resources are allocated optimally, the maximum degree of passenger satisfaction will be realized.

The rest of the paper is arranged as follows: Section 2 proposes an evaluation indicator system and deduces a calculation model to evaluate passenger satisfaction. Section 3 analyzes and discusses the collected data from the questionnaire survey. In Sections 4 and 5, discussion and conclusion are conducted. The acknowledgments are located in the final section.

2 Methodology

2.1 Construction of evaluation indicator system

Previous studies have shown that satisfaction of passengers for PT service varies from their backgrounds [19, 20]. For old people, they intend to choose the certain public vehicles with more convenience and better traffic accessibility due to some mobility problems. But for young people, they will attach more attention to the efficient transport because of huge pressure from life and work. As for people with different education backgrounds, those who are highly educated often pursue higher life quality and as a result they value riding comfort highly. In addition, passengers who have regular working hours will call for the higher punctuality rate.

Similarly, passengers with various trip purposes raise different demands on PT service. They will select the bus with higher reliability than comfort when

going to school or work. On the contrary, if they go out for shopping and entertaining, they will value comfort more than reliability. Consequently, the evaluation attributes like age, education, nature of the employment, trip purpose by transit and so on will be selected to analyze the perception of passengers with different backgrounds.

A number of both quantitative and qualitative attributes have been introduced to evaluate service quality of PT. However, not all of those attributes are necessary for the passengers. In evaluating wait time for PT, the average wait times can be measured. Average wait time has substantial correlation with the layout of bus stops, proper bus routes, transit capacity, and time intervals between subsequent buses, etc. The long waiting time and crowded conditions represent a poor service quality of PT from the passenger perspective. The bus stop is a designated place where the bus stops for passengers to board and leave. The spacing, location, design, and operation of bus stops significantly influence the performance of PT system and passenger satisfaction. In addition, dwelling time may be governed by boarding demand, alighting demand, and total interchanging passenger demands. Different from other attributes, security on PT is a relative matter. It includes the potential for being involved in a crash, slips and falls while negotiating stairs and other elements of the PT system. That is to say, security covers both the real chance and the perceived one of being the victim of a crime while using PT. Actually, passengers' perceptions of security, as well as actual conditions, should be brought into the mode choice decision.

On the whole, the evaluation indicator system is established in Table 1, which can be employed to study the dynamical relationships among passenger backgrounds, perception and satisfaction.

Table 1: Evaluation indicator system.

Evaluation category	Calculation indicators
Backgrounds of passengers	Age
	Education
	Employment
	Trip purpose
Perception of PT service	Average waiting time
	Bus stop location
	Dwelling time
	Security
Passenger satisfaction	Satisfaction

2.2 Model deduction

Passenger satisfaction is usually divided into satisfaction and dissatisfaction. In this case, $y_s = 1$ represents satisfaction while $y_s = 0$ denotes dissatisfaction. In addition, with the assumption that there could be a dynamical relationship

among the dependent variable y_s, other influencing factors (independent variable) a_i and an error term ε_i, the following equation can be obtained as follows:

$$y_s = \alpha + \beta a_i + \varepsilon_i \tag{1}$$

where, β is the regression coefficient, which represents the slope of the regression line, α is the regression constant representing the intercept of the regression line, ε are random variables representing errors in the relationship with mean of 0.

Suppose the critical point is defined as c (c = 0.5) and $P(y_s)$ is the probability of satisfaction. That is to say, when $P(y_s) > c$, passengers are satisfied with the service of PT. Otherwise, passengers will feel dissatisfied.

Consequently, the probability of satisfaction can be written as equation (2):

$$\begin{aligned} P(y_s = 1 \mid a_i) &= P[(\alpha + \beta_i a_i + \varepsilon_i) > 0.5] \\ &= P[\varepsilon_i > 0.5 - \alpha - \beta_i a_i] \\ &= P[\varepsilon_i > -\hat{\alpha} - \beta_i a_i] \\ &= P[\varepsilon_i \le \hat{\alpha} + \beta_i a_i] \\ &= F(\hat{\alpha} + \beta_i a_i) \end{aligned} \tag{2}$$

Here, $\hat{\alpha} = \alpha - 0.5$, F represents the cumulative distribution function of error term ε_i. Evaluation indicators of passenger satisfaction, which are categorical variables, do not conform to the normal distribution. If the regular regression model is applied, the connection between the dependent variable and other factors will not be described properly. In this study, assuming that the indicators conform to the logistic distribution, equation (3) is obtained:

$$F(\hat{\alpha} + \beta_i a_i) = \frac{1}{1 + \exp[-(\hat{\alpha} + \beta_i a_i)]} = \frac{\exp(\hat{\alpha} + \beta_i a_i)}{1 + \exp(\hat{\alpha} + \beta_i a_i)} \tag{3}$$

With equations (2) and (3), the probability of satisfaction p_s is given as follows:

$$p_s = P(y_s = 1 \mid a_i) = \frac{\exp(\hat{\alpha} + \beta_i a_i)}{1 + \exp(\hat{\alpha} + \beta_i a_i)} \tag{4}$$

As shown above, equation (4) is a nonlinear function, which is composed of different influencing factors a_i. The logistic regression model with eight independent variables can be obtained as equation (5):

$$p_s = P(y_s = 1 \mid a_1, a_2, \ldots, a_8) = \frac{\exp(\hat{\alpha} + \sum_{i=1}^{8} \beta_i a_i)}{1 + \exp(\hat{\alpha} + \sum_{i=1}^{8} \beta_i a_i)} \tag{5}$$

With the logarithm to equation (5), the linear function equation can be obtained:

$$\ln(\frac{p_s}{1-p_s}) = \text{logit}(y_s) = \hat{\alpha} + \sum_{i=1}^{8} \beta_i a_i \quad (6)$$

Here ln symbol refers to a natural logarithm and $\hat{\alpha} + \sum_{i=1}^{8} \beta_i a_i$ is the familiar equation for the regression line. $\hat{\alpha}$ and β_i ($i = 1 8$)could be calculated by maximum likelihood estimate [21].

With these complicated algebraic translations, the regression coefficients are not as easy to interpret. In equation (1), β_i represents 'the change in y_s with one unit change in a_i ' is no longer applicable. Instead, we have to translate the coefficient β_i with the exponent function. Also, as it turns out, when we do that we have a type of 'coefficient' that is pretty useful. This coefficient is called the odds ratio, which is equal to $\exp(\beta_i)$. So, if β_1 is 0.75, the odds ratio is approximately 2.12. It means that the probability that y_s equals 1 is likely about twice as the value of a_i which is increased one unit. In this way, an odds ratio of 0.5 indicates that y_s = 1 is half as likely with an increase of a_i by one unit. An odds ratio of 1.0 indicates there is no relationship between y_s and a_i .

3 Empirical application

3.1 Data collection

The proposed methodology was applied as an experimental case study about PT service in a medium-sized urban area called Maanshan. Maanshan is located on the south bank of the middle and lower reaches of the Yangtze River and bordering on Nanjing city. It is an industrial city with an area of more than 300 square kilometers and a population of roughly 800 thousand. The PT system of the city is composed of 656 buses and 42 transit lines, which offers service to 35% of the residents every day. The service of PT is available from 5:30 to 20:30 with the departure interval of 10 minutes.

The survey from Oct. 8 to Oct. 15, 2011 about PT service was sponsored by the Maanshan Road Traffic Institute (MRTI) and organized by Maanshan Public Transportation Company. It was the first time to conduct a face-to-face survey especially on the PT satisfaction within the whole city. During the investigation, the meanings of all the evaluation attributes were explained to each interviewee in advance in order to improve reliability of survey data. The survey, which consists of 680 passengers chosen at random from 10 bus lines, was carried out from 6:00 to 10:00 a.m. The questionnaire selected for the survey is presented in Table 2. These nine attributes pertain to research on the relationships among passenger backgrounds, perceptions and satisfaction of PT service. Based on the survey data, 520 out of 680 questionnaires were effective (shown in Table 2).

Table 2: List of selected variables.

Attributes	Question	Answer options	Survey data	Percent
Age	How old are you?	1. Up to 20 years	110	21.11%
		2. From 21 to 40 years	349	67.18%
		3. From 41 to 60 years	52	9.98%
		4. Over 60 years	9	1.73%
Education	What is your education level?	1. Primary school	13	2.50%
		2. Junior middle school	69	13.24%
		3. Senior middle school	151	28.98%
		4. Above Junior college	262	50.48%
		5. Else	25	4.80%
Employment	What kind of company your are working for?	1 State-owned enterprise	45	8.64%
		2. Government	64	12.28%
		3. Private enterprise	113	21.69%
		4. Else	301	57.93%
Trip purpose	What is your trip purpose by bus?	1. Go to work	128	24.57%
		2. Go to school	106	20.35%
		3. Shopping	154	29.56%
		4. Leisure and pleasure	36	6.91%
		5. Else	97	18.61%
Average waiting time	How long will you wait for bus on average?	1. Less than 10 minutes	184	35.32%
		2. About 10 – 20 minutes	249	47.98%
		3. About 20 – 30 minutes	67	12.86%
		4. Over 30 minutes	20	3.84%
Bus stop location	What do you think of the bus stop location?	1. Reasonable	35	6.72%
		2. Need change	485	93.28%
Dwelling time	What do you think of the average bus dwelling time?	1. Too long	72	13.82%
		2. Acceptable	364	70.06%
		3. Too short	84	16.12%
Security	Do you feel it is safe to take the bus?	1. Safe	222	42.61%
		2. Unsafe	298	57.39%
Satisfaction	What do you think of PT service?	1. Satisfied	343	66.03%
		2. Dissatisfied	177	33.97%

3.2 Data description

Corresponding percentage indicators of the interviewees' attitudes are shown in Figure 1.

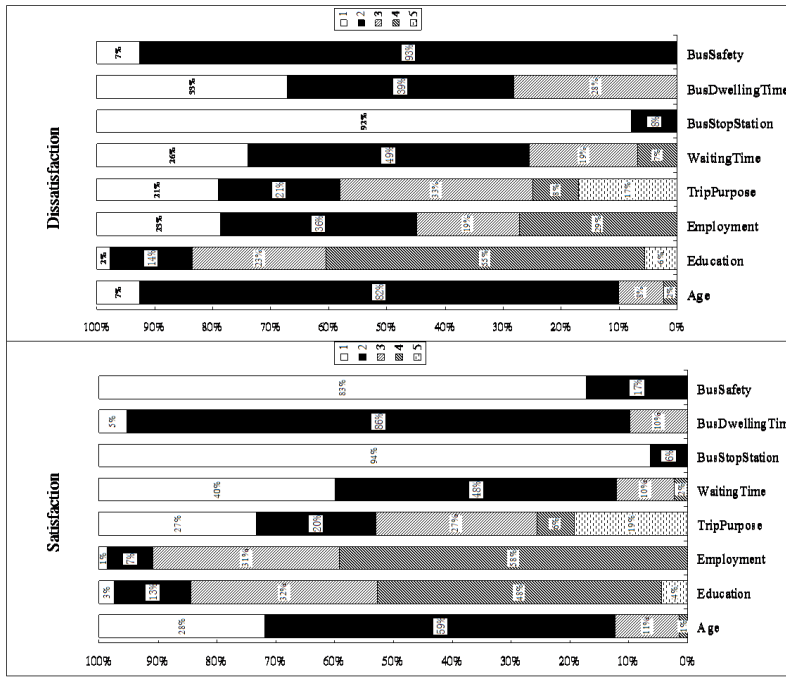

Figure 1: Statistics description (statistics with different categories 1, 2, 3, 4 and 5 are shown in Table 2).

As the data about the age distribution of interviewees shows, 89.29% of all respondents are adults less than 40 years of age. The largest percentage (67.18%) range is from 21 to 40. 21.11% are aged less than 20 years. 1.73% are over 60 years old and only 9.98% are from 41 to 60 years of age. Maybe the reason for this phenomenon is that the survey was conducted during morning rush hours. In addition, 50.48% of interviewees have an education background of junior, college or higher. This is followed by senior middle school passengers, with 28.98% of the total. Only 7.3% of interviewees have a low education background of primary school or lower.

As for the employment of interviewees, in morning peak, 79.62% of passengers work for private enterprises and 12.28% of them work for state-

owned enterprises. Only 8.84% of them work for government departments. However, during the morning peak hours, urban residents often take the bus for working, studying and shopping, accounting for 74.48% of the total. Only 6.91% of residents go out for leisure and pleasure. It means the life quality in Maanshan should be promoted because most of residents go out for the purpose of earning a living.

According to the survey, although the bus departs every ten minutes in Maanshan, average waiting time of passengers always fluctuates greatly owing to traffic delay, layout of stops and passenger flow distribution. The average waiting time of most bus routes lasts from ten minutes to twenty minutes, accounting for 47.98%. That is followed by the waiting time of less than ten minutes, with 35.32%. About 16.7% of bus routes need more than twenty minutes' waiting. Incredibly, passengers should spend more than thirty minutes waiting for a bus along several bus lines, although accounting for a small proportion, at just 3.4%.

Actually, about 93.28% of interviewees think the layout of bus stops is not reasonable, but 70.06% of them can tolerate the delay of PT service. 16.12% of interviewees complain about the too short dwelling time on account of the small passenger volume at some bus stops. On the contrary, 13.82% of them regard dwelling time as being a little bit long. What's more, 57.39% of interviewees feel it unsafe to take the bus.

Surprisingly enough, 66.03% of interviewees are satisfied with the PT service in Maanshan though the surveys about some other attributes of bus service were disappointing in the past months.

3.3 Data processing

In this subsection, IBM SPSS statistics 19.0 version is introduced to analyze the survey data. The calculation procedure is as follows: (1) Transform the categorical variable into dummy variable. (2) Set up the 'Classification cutoff' as 0.5 and 'Maximum Iterations' as 20. (3) Determine 'Include constant in model', 'Classification plots', 'Hosmer-Lemeshow goodness-of-fit' and 'CI for exp(B)'. (4) Select the Maximum likelihood estimate method to estimate the parameters. Hypothesis testing of calculation process is shown in Table 3.

Table 3: Omnibus and Hosmer-Lemeshow tests of model coefficients.

Different test method		Chi-square	df	Sig.
Omnibus text	Step	86.771	21	.000
	Block	86.771	21	.000
	Model	86.771	21	.000
Hosmer-Lemeshow Tests	Step	Chi-square	df	Sig.
	1	6.293	8	.614

The model coefficients are verified by the omnibus test in Table 3. The result of Chi-square test is 86.771. According to the value of significance level 0.05 and the degree of freedom 21, the obtained standard value of the Chi-square test is 32.671 (smaller than 86.771). In this condition, the number of degrees of freedom is the number of values in the final calculation of a statistic that are free to vary. As for Hosmer-Lemeshow Test, with the freedom degree 8 and the significance level 0.05, the standard value of the chi-square is calculated as 15.507. As seen from Table 3, the chi-square calculated value 6.293 is smaller than 15.507, which validates the model for the Hosmer-Lemeshow Test. The calculation results can be shown in Table 4.

Table 4: Calculation results.

Attributes	B	S.E,	Wald	df	Sig.	Exp (B)	95% C.I.for EXP(B)	
							Lower	Upper
Age	NA	NA	7.308	3	.063	NA	NA	NA
Age(1)	-.636	.809	.619	1	.431	.529	.109	2.582
Age(2)	-.059	.791	.006	1	.940	.943	.200	4.440
Age(3)	.535	.832	.414	1	.520	1.708	.334	8.722
Education	NA	NA	7.413	4	.116	NA	NA	NA
Education(1)	1.120	.812	1.901	1	.168	3.065	.624	15.065
Education(2)	.135	.546	.061	1	.804	1.145	.393	3.336
Education(3)	.756	.510	2.200	1	.138	2.130	.784	5.787
Education(4)	.183	.496	.137	1	.711	1.201	.455	3.176
Employment	NA	NA	5.819	3	.121	NA	NA	NA
Employment(1)	-.768	.393	3.816	1	.051	.464	.215	1.003
Employment(2)	-.328	.333	.974	1	.324	.720	.375	1.382
Employment(3)	.177	.299	.350	1	.554	1.194	.664	2.146
Trip Purpose	NA	NA	1.174	4	.882	NA	NA	NA
Trip Purpose(1)	.163	.347	.221	1	.638	1.177	.597	2.322
Trip Purpose(2)	.159	.346	.210	1	.647	1.172	.594	2.310
Trip Purpose(3)	.046	.311	.022	1	.882	1.047	.570	1.925
Trip Purpose(4)	-.255	.440	.336	1	.562	.775	.327	1.836
Waiting Time	NA	NA	14.121	3	.003	NA	NA	NA
Waiting Time(1)	1.360	.542	6.303	1	.012	3.894	1.347	11.256
Waiting Time(2)	.936	.529	3.132	1	.077	2.551	.904	7.195
Waiting Time(3)	.289	.577	.251	1	.616	1.335	.431	4.135
Bus Stop Station(1)	-.439	.411	1.141	1	.285	.645	.288	1.443
Bus Dwelling Time	NA	NA	22.263	2	.000	NA	NA	NA
Bus Dwelling Time(1)	.778	.358	4.720	1	.030	2.177	1.079	4.393
Bus Dwelling Time(2)	1.277	.274	21.686	1	.000	3.585	2.095	6.136
Security(1)	-.956	.208	21.074	1	.000	.385	.256	.578
Constant	-.997	1.025	.946	1	.331	.369	NA	NA

Column 'Sig.' is the statistical significance. Column 'df' is the degree of freedom. Column 'B' is status data, which illustrates the relation of satisfaction and different indicators. If the value is positive, it can be found that the indicator satisfies PT service. On the contrary, if the value is negative, it means the indicator cannot satisfy PT service. In column 'Exp(B)', the data is the odds ratio which indicates how much those indicators contribute to PT satisfaction. Column 'S.E.' represents the standard deviation of statistic results. Column 'Wald' represents the inspection results by Wald Test. Row 'Sig.' represents the significance level of data. And column '95% C.I.for EXP(B)' illustrates the fluctuation range of EXP(B) on the condition of 95% credibility.

4 Discussion

According to the calculation results of the model (Table 4), it is found that passengers in different age groups have different perceptions of satisfaction for PT service. All the status data of passengers younger than 40 years are negative, which means they are not satisfied with PT service. Specifically, passengers vary in age from 21 to 40, whose odds ratio value is 0.943, which means they have lower tolerance towards PT service. Therefore, on account of 89.29% of total passengers, bus managers should take the initiative to adjust their policies and try to meet the requirements of this group of people. PT will be more attractive only when satisfaction of passengers is fully improved. Despite 9.98% of all passengers, those whose age is over forty are satisfied with existing PT service, for their odds ratio value is 1.708. In fact, the elderly seldom take the bus in morning rush hours. In addition, old people can enjoy free bus ride, as they are subsidized by the local government the whole day except from 7:00 to 9:00 a.m. and from 17:00 to 19:00 p.m. in order to avoid huge travel demand in peak hours.

Considering the indicator of 'education attributes', it is obvious that passengers who possess higher education have higher tolerance and can understand the difficulties of transit service more easily. Actually, passengers' perceptions differ due to their different working units. The corresponding odds ratio value 0.720 of government department implies their slightly higher tolerance towards PT service. This phenomenon is related to their income and working conditions. In mainland China, government employees and state workers can take the special shuttle bus provided by their own companies as a benefit for work. However, passengers from private enterprises correspondingly have the positive rate of satisfaction, suggesting that they demand more PT service and cannot put up with the current PT service.

Moreover, customer perceptions vary in terms of their trip purposes. Those who go by bus with the purposes of working, studying and shopping, always have high expectations of PT service. On the one hand, they ask for more PT service, accounting for 74.48% of total passengers. On the other hand, the odds ratio values of these people are lower than 1, in which the value can be reduced to the minimum 0.638, which means that PT service is accepted at a low rate among these people and will be likely to be abandoned once they find an

alternative trip mode. In this condition, bus managers should therefore pay more attention to the travel demands of this group of passengers.

In terms of passengers' perceptions, most passengers are not satisfied with spending too much time in waiting for a bus. Average waiting time of most bus lines often fluctuates between ten minutes and twenty minutes, with 47.98% of the total. Many passengers have to wait for more than thirty minutes along some bus lines, with 3.4% of the total. Despite longer waiting time, passenger satisfaction will not decline sharply just because PT is the only choice for them. They are loyal to PT service and can bear much long waiting. Therefore, more measures should be taken to improve the reliability of PT service and attract more potential passengers, especially for some bus lines, which need too long waiting time.

Passengers will not be a pleased if the bus stop frequently, which suggests that the layout of traffic routes should take the location of the bus stop into account. Actually, frequent dwellings in morning rush hours upset passengers very much. It is also necessary to take steps to optimize the layout of bus lines.

Finally, the degree of satisfaction with the PT service can be considerably improved with high security on bus. 57.39% of interviewees feel it unsafe to take the bus. However, compared with other developing countries, China has a relatively good social security. That is to say, there is no necessary correlation between social security and sense of travel security of passengers.

5 Conclusion

In this paper, a systematic evaluation system and a calculation model for the passenger satisfaction are proposed. Based on a questionnaire survey, it can be concluded that passengers with different backgrounds and trip purposes have different perceptions and expectations on PT service. These key factors should be taken into account while improving the service quality of PT system. Considering the limited urban resources and different land functions in developing countries, an integrated and targeted plan about the transit route layout and operation management should be drawn up to raise the satisfaction of passengers and the efficiency of PT system.

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