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Analysis of Satisfaction Degree of Senior-Friendly Public Transit: A Case Study in Shanghai

FENG Suwei, CHEN Xueci, ZHANG Xue, SUN Yuhan

Shanghai University of Finance and Economics, Shanghai 200433, China

Abstract: Elderly people are facing challenges such as decreased stamina, limited mobility, lack of senior-friendly services, and gaps in using digital services. A key issue in the current transportation policy development is to promote the improvement of senior-friendly public transit facilities. Based on survey data collected in Shanghai, this paper uses an exploratory factor analysis method to categorize mobility difficulties for the elderly into three types: general mobility difficulties, public transit mobility difficulties, and digital gap difficulties. Crucial measures include improving public transit services and making public transit more senior-friendly. In addition, the paper uses a three-factor theory to analyze survey data on satisfaction degree regarding public transit services. In order to assess the priority for improvement of the three types of factors, the attribute variables affecting satisfaction are classified as basic factors, excitement factors, and performance factors. Finally, the paper proposes countermeasures and suggestions to enhance senior-friendliness in public transit from several perspectives: improving the comfortableness of travel conditions, strengthening the construction of hardware facilities for bus transit, and raising service awareness among bus drivers. **DOI:** 10.13813/j.cn11-5141/u.2022.0403-en

Keywords: senior-friendly transportation; public transit service; age-friendly; satisfaction; three-factor theory; digital gap; Shanghai

0 Introduction

Traffic disadvantage refers to the obstacles encountered by individuals in obtaining a series of transportation services and opportunities, which is related to the geographical location and mobility of the individuals, as well as the travel restrictions encountered by the individuals in physical, social, and psychological aspects [1]. We can identify the types and scope of traffic disadvantaged groups by evaluating the travel difficulty of individuals, such as people with physical or cognitive disabilities, the elderly, single parents, and people without vehicles, and focus on the disadvantaged position of these groups in travel and possible mobility difficulties. G. Currie [2] structured traffic disadvantage indicators with multiple characteristics such as income, employment, car ownership, and health status, which expanded the definition range of traffic disadvantaged groups. Due to their weakened physiology and function and decreased activity ability, the elderly are generally faced with various difficulties such as insufficient physical strength, inadequate public transit services, and digital gaps during their travels by means of walking and public transit. Therefore, the elderly belong to a special category of traffic disadvantaged groups, and current transportation policies for the elderly need to speed up the improvement of relevant senior-friendly transportation modes and facilities and eliminate the travel barriers of the elderly [3].

For the mobility difficulties of the elderly, this paper first uses exploratory factor analysis (EFA) to decompose them into three types: general mobility difficulties, public transit mobility difficulties, and digital gap difficulties. Then, the mobility difficulties of the elderly are identified through questionnaires to explore the key types of mobility difficulties. Finally, in order to solve the public transit mobility difficulties, important attribute variables are divided into three categories, namely, basic factors, excitement factors, and performance factors, which is realized by establishing the senior-friendly satisfaction evaluation indicators of public transit services for the elderly and using the three-factor theory, and policy suggestions are proposed to improve the senior-friendly public transit services.

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First author: FENG Suwei (1969–), female, from Yangzhou, Jiangsu Province, PhD, associate professor and PhD supervisor of the School of Public Economics and Management, Shanghai University of Finance and Economics, director of the Center for Transportation Economy and Policy Research of the Institute of Public Policy and Governance, Shanghai University of Finance and Economics, and her main research direction is transportation economy and policy. E-mail: fsuwei@mail.shufe.edu.cn

1 Types of mobility difficulties for the elderly

General mobility difficulties refer to the situation that the elderly cannot travel independently or need help due to their physiological conditions. Compared with other age groups, it is found that the travel frequency, travel time consumption, and travel distance of the elderly decrease with age, and the purpose of their travel changes from survival-oriented to life-oriented [4–5]. With the growth of age, the elderly gradually give up transportation modes with high physical requirements [6]. Therefore, travel inconvenience caused by physical decline, mobility inconvenience, and even physical defects is the first type of mobility difficulties that the elderly have to face.

Public transit mobility difficulties refer to the low service level, inadequate senior-friendly improvement, and failure to provide travel information in time in public transit, and they are not conducive to the daily travel activities of the elderly. In terms of travel mode, the elderly tend to prefer buses and walking and rarely choose urban rail transit with complex travel processes as a means of transportation. For example, compared with other transportation modes, the elderly in Kunming prefer to travel by bus [7]. However, the current public transit services cannot meet the simple and convenient travel demands of the elderly, and there is a lot of room for improvement of senior-friendly facilities. The study found that the bus transit system in Shanghai has problems such as unclear route planning and high distance between the ground and the bus pedals, and some urban rail transit systems have problems such as unclear route signs and long transfer distances [8]. These problems related to the improvement of senior-friendly public transit bring the second type of mobility difficulties for the elderly.

The third type of mobility difficulties for the elderly is related to the rapid popularization of smartphone applications in the information age. The rapid development of intelligent technology in the information age has made the digital gap more common, and daily trips involve smart technology applications such as taking buses by scanning codes with mobile phones, taking taxis by using APPs, and showing one's health code. In terms of travel, the elderly often prefer to use simple means to get traffic information, such as telephones, easily recognizable maps, symbols, etc. [9]. L. Philip et al. [10] found that differences in skills in information and communication technology (ICT), education, personal attitudes towards the Internet, and other aspects will lead to differences in Internet use. The individual differences of the elderly in these aspects affect their use of information products, and due to the insufficient supply of senior-friendly information services, they cannot receive timely responses and help when they encounter obstacles in travel. The third type of mobility difficulties formed by the digital gap reduces the travel experience and happiness of the elderly.

2 Satisfaction and three-factor theory

Customer satisfaction is an important indicator of service quality in many industries. In the field of public transit, the identification of attribute variables that affect passenger satisfaction can provide targeted strategies for operating agencies to improve the service quality of public transit [11–12]. The elderly's satisfaction with public transit services is positively related to the level of public transit services. High satisfaction usually indicates a better senior-friendly level of public transit services. Therefore, taking Shanghai as an example, this paper uses the passenger satisfaction survey to analyze the elderly's views on public transit services, so as to point out the direction for senior-friendly improvement.

The three-factor theory was inspired by the motivator-hygiene theory (also known as the two-factor theory [13]) of the American behavioral scientist Frederick Herzberg [14]. It divides service quality attributes into three categories: basic factors, performance factors, and excitement factors (in Fig. 1). Among them, the relationship between the basic factors and customer satisfaction is asymmetric. When the overall attribute performance is poor, the basic factors will have a significant impact on the overall satisfaction. In other words, poor performance will lead to reduced customer satisfaction, and good performance will not help to increase the overall satisfaction. The relationship between the performance factors and customer satisfaction is linear and symmetrical, and the performance factors have a significant impact on satisfaction under good or poor performances. The excitement factors also have an asymmetric relationship with customer satisfaction, which will have a significant impact when the overall attribute performance is great. In other words, good performance will help to improve customer satisfaction, and the failure to meet expectations will not negatively affect satisfaction.

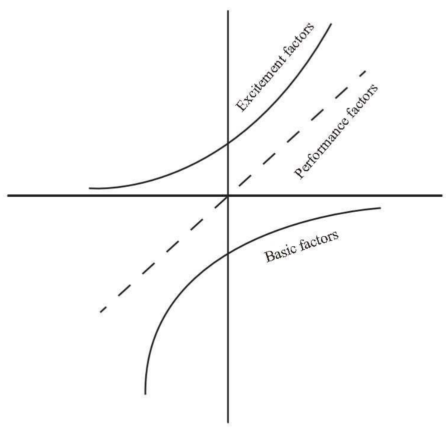

Fig. 1 Schematic diagram of the three-factor theory

The three-factor theory is widely used in research on public service satisfaction, and it is realized mainly by regression methods such as the importance grid and dummy variable. Lai H. J. et al. [15] first introduced the theory into the study of transportation service satisfaction and proved that there was a nonlinear relationship between the service quality of the bus rapid transit (BRT) system and satisfaction. Zhang et al. [16] used the three-factor theory to identify attribute variables affecting the service quality of buses, BRT, and vans. By evaluating the service satisfaction of the public transit system (buses, BRT, and subways) of Guangzhou, Cao et al. [17] found that operators of public transit should improve the comfort level of bus services and BRT. As the dummy variable method can clearly identify whether there are type differences and structural changes in samples [18], it is often used to test the impact of attribute variables of different factors on satisfaction. Wu et al. [11] used the three-factor theory and the dummy variable method to determine the key aspects in improving bus and BRT services and discussed the asymmetric impact of performance factors on the satisfaction of BRT trunk lines.

To sum up, it is urgent to determine the improvement priority of different types of mobility difficulties for the elderly, so as to provide a basis for formulating national and local policies. In the meantime, for other specific types of mobility difficulties, it is also necessary to find the direction of senior-friendly improvement, for which the three-factor theory has provided an analysis tool.

3 Identification of key mobility difficulty types for the elderly

3.1 Questionnaire design

This study conducted a questionnaire survey in Shanghai from January to February 2021 to analyze the types and manifestations of mobility difficulties of the elderly in Shanghai, as well as their opinions on the improvement of senior-friendly public transit and service levels. The survey involves both online and offline work. The online work collected data by issuing questionnaires to families with the elderly through a questionnaire survey platform called WJX, and the offline work conducted actual interviews by selecting typical activity sites for the elderly, such as parks, hospitals, and community service points. A total of 614 valid questionnaires were collected, including 252 offline ones (41%) and 362 online ones (59%). The survey data show that: 1) 45–49 year-olds account for 3%; 50–54 year-olds account for 16%; 55–59 year-olds account for 16%; 60–64 year-olds account for 21%; 65–69 year-olds account for 16%; 70–74 year-olds account for 13%; 75–79 year-olds account for 7%; Over 80 year-olds account for 8%. 2) 57% of the elderly live in the central urban area, and 43% of them live in the suburb. 3) The daily travel frequency of most elderly people is 1–2 times$\cdot$d^{-1}, with the main purposes being daily shopping, leisure and entertainment, medical treatment, etc. 4) Common travel modes (multiple choices) are walking (81%), buses (87%), subways (19%), while the elderly traveling by other transportation modes such as self-driving, taxis, and bicycles are less than 10%.

The contents of the questionnaire identifying the types of mobility difficulties for the elderly are shown in Table 1. They mainly refer to the traffic disadvantaged indicators proposed by A. Delbosc et al. [19], and the questionnaire measures the mobility difficulty degree of the interviewees by means of self-assessment with the help of traffic rating questions. Meanwhile, according to the issue of using intelligent technology by the elderly in their travels mentioned in the *Implementation Plan for Effectively Solving the Elderly's Difficulties in Using Intelligent Technology*, the questionnaire considers the digital gap as a new traffic disadvantage for the first time. It performs measurement by a 5-point system of the Likert scale, which ranges from very inconsistent (1 point) to very consistent (5 points).

Table 1 Contents of the questionnaire on types of mobility difficulties

Items	Questionnaire contents
V1	Able to bear daily transportation expenses effortlessly
V2	Able to reach the destination quickly
V3	Able to find appropriate transportation tools at any time to meet your travel needs
V4	Able to travel independently when you want to go out
V5	Able to walk around safely
V6	Able to get on and off public transit independently, such as buses, subways, etc.
V7	Able to choose public transit conveniently at night (after 19:00), such as buses, subways, etc.
V8	Able to choose public transit on weekends conveniently, such as buses, subways, etc.
V9	Public transit (such as buses, subways, etc.) for daily travel can operate smoothly
V10	Able to quickly obtain the information of waiting time and route of public transit that you need to take
V11	Easy access to public transit stations, such as bus stops and subway platforms
V12	You feel safe when traveling alone and will not be stolen or attacked
V13	You need help when you take public transit
V14	Able to find free time when you want to go out
V15	You need help on the way
V16	Able to quickly use your mobile phone to book car-hailing
v17	Able to use your mobile phone to scan codes and purchase public transit tickets, such as subway tickets
V18	Able to skillfully use your mobile phone to show your health code in public places, without affecting your travel

Source of data: V1–V5 are from Ref. [19], and V16–V18 are contents added by this paper.

3.2 Reliability and validity analysis of the questionnaire scale

3.2.1 Reliability analysis

Reliability analysis measures whether the scale meets the internal consistency. In this paper, Cronbach's Alpha is used for reliability analysis. If Cronbach's Alpha (i.e. the reliability coefficient) is greater than 0.8, the scale is very reliable. First, the reliability coefficient of each scale is calculated through SPSS24.0, and then the corrected item-total correlation (CITC) value and the reliability coefficient after deleting items are calculated, so as to determine whether each scale meets the internal consistency. After calculation, the reliability coefficient of the questionnaire is 0.964, which indicates that the scale has good reliability. The statistical scale of reliability analysis is shown in Table 2, where the CITC value of the questionnaire data meets the requirement of more than 0.5, which indicates that the setting of each item in the scale is positive, and the reliability of the questionnaire is favorable. In the meantime, the reliability coefficient values after deleting items are less than or equal to the reliability coefficient of 0.964 of the overall scale, which indicates that the reliability of the data obtained from the scale designed in this paper is high.

3.2.2 Validity analysis

Validity analysis analyzes the validity of the questionnaire scale. This paper uses factor analysis to measure the validity of the questionnaire. There are two conditions to judge whether the factor analysis method can be used: 1) The KMO (Kaiser-Meyer-Olkin, an indicator used to compare the simple correlation coefficient and partial correlation coefficient among variables) value is greater than 0.70. 2) The significance of Bartlett's test of sphericity is less than 0.05. The test results of the questionnaire scale show that the KMO value is 0.959, which is greater than 0.70, and the significance of Bartlett's test of sphericity is less than 0.05, indicating that the questionnaire scale is suitable for factor analysis.

The principal component analysis method is used to extract three common factors with their initial eigenvalues greater than 1. Table 3 shows the total variance explained by principal component analysis. It shows that the interpretation rate of the total variance of the three extracted common factors is 74.279%. It is an ideal state when the interpretation rate of the total variance is above 90%, but it is generally difficult to be achieved. It is an excellent state when the rate is 80%–90%, and a general state exists when the rate is 60%–70%, but it is acceptable, especially in the field of social sciences, and it can be used as reference information for further explanation. Since the interpretation rate of the total variance of the three common factors is more than 60%, we can consider that the validity of the questionnaire scale is positive.

Table 2 Statistical scale for reliability analysis

Items	Scale mean value after deleting items	Scale variance after deleting items	CITC	Reliability coefficient after deleting items
V1	54.81	235.977	0.750	0.962
V2	54.99	233.578	0.793	0.962
V3	55.00	231.279	0.798	0.961
V4	54.91	230.721	0.787	0.962
V5	54.90	234.974	0.748	0.962
V6	54.75	229.939	0.807	0.961
V7	55.08	234.834	0.739	0.962
V8	55.19	234.089	0.798	0.962
V9	55.15	236.495	0.754	0.961
V10	55.17	237.135	0.771	0.962
V11	54.98	238.342	0.720	0.963
V12	55.03	232.681	0.778	0.962
V13	54.96	230.469	0.813	0.960
V14	54.91	232.012	0.794	0.962
V15	54.92	235.982	0.782	0.962
V16	55.17	239.948	0.667	0.963
V17	55.18	238.620	0.646	0.964
V18	55.20	237.198	0.725	0.960

Table 3 Total variance explained by the principal component analysis method

Components	Initial eigenvalues			Loading of extracted quadratic sum			Loading of rotated quadratic sum		
	Total	Variance percentage/%	Cumulative percentage/%	Total	Variance percentage/%	Cumulative percentage/%	Total	Variance percentage/%	Cumulative percentage/%
1	11.215	62.308	62.023	11.215	62.308	62.308	6.526	36.257	36.257
2	1.238	6.877	68.690	1.238	6.877	69.185	3.888	21.599	57.856
3	1.032	5.733	74.279	1.032	5.733	74.918	3.071	17.06	74.918
4	0.533	2.963	77.397						
5	0.477	2.649	80.141						
6	0.459	2.549	82.757						
7	0.376	2.090	84.972						
8	0.374	2.077	87.079						
9	0.324	1.799	88.904						
10	0.306	1.702	90.633						
11	0.281	1.559	92.287						
12	0.244	1.358	93.663						
13	0.236	1.310	95.000						
14	0.214	1.190	96.211						
15	0.201	1.119	97.293						
16	0.178	0.989	98.304						
17	0.170	0.942	99.220						
18	0.142	0.786	100.000						

3.3 Identification of key mobility difficulty types

The coordinate rotation in factor analysis can make the description of the observed variables on the main factors more concentrated, so as to identify the key types of mobility difficulties. From the rotated component matrix in Table 4, we can see that 18 items in the questionnaire on the mobility difficulties for the elderly are divided into three categories of factors, and the load of each category of factors is higher than 0.5, so they can be classified. Factor 1 includes 11 items, i.e., V1, V2, V3, V4, V5, V6, V11, V12, V13, V14, and V15. Factor 2 contains four items, i.e., V7, V8, V9, and V10, and factor 3 has items of V16, V17, and V18.

Table 4 Rotated component matrix

Items	Rotated load matrix		
	Factor 1	Factor 2	Factor 3
V3	0.787		
V5	0.750		
V12	0.746		
V11	0.733		
V4	0.731		
V14	0.715		
V1	0.714		
V13	0.712		
V2	0.705		
V6	0.671		
V15	0.639		
V9		0.803	
V7		0.783	
V8		0.778	
V10		0.768	
V17			0.846
V16			0.832
V18			0.800

The load of factors in Table 4 is 0.639–0.846. Generally speaking, the item can be included in the factor if the load is greater than 0.5. EFA is further conducted on 18 items to condense them into three typical characteristic problems, and the groups of samples are classified into corresponding groups of difficulties. Then, the typical characteristics of each group of difficulties are obtained through differentiation analysis (in Table 5). The information extracted through factor 1 mainly involves the fact that the elderly cannot travel independently or need help due to physiological reasons, as well as some common problems in travel, and they belong to general mobility difficulties. The information extracted through factor 2 is problems related to public transit, and it belongs to public transit mobility difficulties. The information extracted through factor 3 is related to the use of intelligent technology by the elderly, which belongs to digital gap difficulties. The three types of mobility difficulties for the elderly are independent and have different characteristics (in Table 6).

Table 5 Contents contained in extracted factors

Category of factors	Contents in factors
Factor 1	V1: able to bear daily transportation expenses effortlessly
	V2: able to reach the destination quickly
	V3: able to find appropriate means of transportation at any time to meet your travel needs
	V4: able to travel independently when you want to go out
	V5: able to walk around safely
	V6: able to get on and off public transit independently, such as buses, subways, etc.
	V11: easy access to public transit stations, such as bus stops and subway platforms
	V12: you feel safe when traveling alone and will not be stolen or attacked
	V13: you need help when you take public transit
	V14: able to find free time when you want to go out
	V15: you need help on the way
Factor 2	V7: able to choose public transit at night (after 19:00) conveniently, such as buses, subways, etc.
	V8: able to choose public transit on weekends conveniently, such as buses, subways, etc.
	V9: public transit (such as buses, subways, etc.) for daily travel can operate smoothly
	V10: able to quickly obtain the information of waiting time and route of public transit that you need to take
Factor 3	V16: able to quickly use your mobile phone to book car-hailing
	V17: able to use your mobile phone to scan the code and purchase public transit tickets, such as subway tickets
	V18: able to skillfully use your mobile phone to show your health codes in public places, without affecting your travel

Table 6 Types of mobility difficulties for the elderly

Category of factors	Types of mobility difficulties	Characteristics of mobility difficulties
Factor 1	General mobility difficulties	Unable to travel independently or in need of help, and some common problems in travel
Factor 2	Public transit mobility difficulties	Difficulties in taking public transit
Factor 3	Digital gap difficulties	Difficulties in using intelligent technology in travel

To sum up, the questionnaire scale used in this paper has good reliability and validity and can be used for the following research.

4 Satisfaction evaluation of senior-friendly public transit services

4.1 Descriptive statistics of satisfaction

General mobility difficulties, as the first type, are mostly the description of the physical difficulties of the elderly and attempt to improve the physical fitness of the elderly through public policies. Limited by the current scientific and medical conditions, it is difficult to completely change them in a short time, and low feasibility and strong uncertainty of the results will be obtained. Digital gap difficulties, as the third type, involve information provision, and they are only used as an auxiliary measure to improve accessibility. The ultimate policy goal is to ensure the smooth travel of the elderly. Since the travel of the elderly in cities of China mainly depends on walking and public transit, it is crucial to find strategies to improve the public transit mobility difficulties, which belong to the second type. Therefore, the second part of the questionnaire focuses on senior-friendly satisfaction with public transit services. The descriptive statistics of the elderly's satisfaction with public transit services in Shanghai are shown in Table 7.

Table 7 Descriptive statistics on the satisfaction of senior-friendly public transit services in Shanghai

Attribute variables	Mean value	Standard deviation	Minimum value	Maximum value
Overall evaluation of public transit services	4.149	1.627	1	5
Walking distance	3.558	0.824	2	5
Waiting time	3.588	1.096	1	5
Transfer distance	3.591	0.970	1	5
Transfer times	3.666	1.097	1	5
Optional lines	3.768	0.927	2	5
Speed of travel	2.558	1.030	1	5
Bus priority	2.387	1.004	1	5
On-time rate of departure and arrival	3.558	0.972	1	5
Vehicle interval	3.649	1.079	1	5
Smooth vehicle operation	2.378	0.972	1	5
Full load rate in vehicles	2.417	1.061	1	5
Number of seats	2.218	0.956	1	5
Barrier-free facilities of vehicles	2.528	1.029	1	5
Waiting service facilities	2.254	1.130	1	5
Driver's service attitude towards the elderly	2.456	1.114	1	5
Reasonable setting of lines	3.655	0.993	1	5
Reasonable setting of stations	3.815	0.936	1	5
Facilities of electronic navigation and voice broadcasting system	2.497	1.182	1	5
Intelligent transfer query system	2.412	1.111	1	5
Ticket price	3.541	1.116	1	5
Daily travel cost	3.674	1.106	1	5

4.2 Recoding of attribute variables

The dummy variable regression method in the three-factor theory is used to identify the effective factors to improve the satisfaction of public transit services and prioritize them. The attribute variables are recoded into two mutually exclusive dummy variables, namely, high performance and low performance. As shown in Table 8, the three types of options of high-performance dummy variables, i.e., very satisfied, satisfied, and general, are recoded as 1, with the rest recoded as 0. The very dissatisfied level of the low-performance dummy variable is recoded as 1, with the rest recoded as 0. The reason why the dissatisfied rather than the middle value of the five-point scale, namely, general, is used as a reference category is that among the 21 attribute variables, the mean value of 10 indicators is less than 3.0. In other words, nearly half of the attribute variables in the satisfaction evaluation do not reach the average level. Since many projects of senior-friendly public transit services in Shanghai are still under construction, the standards of reference categories are lowered to prioritize the improvement of attribute variables more accurately.

Table 8 Recoding of attribute variables of public transit services

Satisfaction	High-performance dummy variable	Low-performance dummy variable
Very satisfied	1	0
Satisfied	1	0
General	1	0
Dissatisfied	0	0
Very dissatisfied	0	1

4.3 Regression analysis

The ordered Probit model is used to regress the satisfaction of each attribute variable and the overall satisfaction after the dummy variable calibration. If the regression results show that the regression coefficient of the low-performance dummy variable of a certain attribute variable is significant, while that of the high-performance dummy variable is not significant, then it is a basic factor, and the attribute variable will affect the satisfaction evaluation results only at a low level. If the regression coefficient of the high-performance dummy variable of a certain attribute variable is significant, but that of the low-performance dummy variable is poor, then it is an excitement factor, and it will affect the overall satisfaction only when the performance is good. In other words, it will affect the satisfaction evaluation result only when the attribute reaches a higher standard. If the two dummy variable coefficients of a certain attribute are significant, then it is a key performance factor. If two dummy variables of a certain attribute both are not significant, then it is a non-significant performance factor. This paper uses the p value of 0.05 as the critical significance level, and the regression results are shown in Table 9.

4.4 Factor screening

The reliability of each attribute variable is determined according to the p value and its confidence comparison in Table 9. In view of this, the basic factors, excitement factors, and performance factors are screened out from the regression results, and the mean value and ranking are calculated (in Table 10). Among the studied 21 attributes, the basic factors include barrier-free facilities of vehicles and speed of travel. Excitement factors include bus priority, waiting time, and number of seats. Performance factors include smooth vehicle operation and waiting service facilities.

4.5 Determination of factor improvement priority

Among the 21 attribute variables, first, the performance of waiting service facilities and smooth vehicle operation in performance factors is poor, ranking the 20th and 19th, respectively, namely, the second and third from the bottom, so the two attributes should be the first priority for improvement. Secondly, the two basic factors barrier-free facilities of vehicles and speed of travel should be placed in the second

Table 9 Regression results and statistical parameters of attribute variables of public transit services

Attribute variables	Regression coefficient	Standard deviation	t value	p value	95% confidence interval		Significance
Walking distance (high)	−1.122	0.779	−1.440	0.150	−2.650	0.405	
Walking distance (low)	0	0	0	0	0	0	
Waiting time (high)	1.974	1.183	1.670	0.095	−0.345	4.293	*
Waiting time (low)	0.040	4.753	0.010	0.993	−9.276	9.356	
Transfer distance (high)	1.113	1.069	1.040	0.298	−0.982	3.208	
Transfer distance (low)	1.028	8.588	0.120	0.905	−15.805	17.861	
Transfer times (high)	0.286	0.879	0.320	0.745	−1.438	2.009	
Transfer times (low)	0.613	4.231	0.140	0.885	−7.681	8.906	
Optional lines (high)	0.048	1.347	0.040	0.972	−2.593	2.688	
Optional lines (low)	0	0	0	0	0	0	
Speed of travel (high)	−0.292	0.350	−0.830	0.405	−0.978	0.395	
Speed of travel (low)	−1.000	0.478	−2.090	0.036	−1.936	−0.064	**
Bus priority (high)	0.515	0.282	1.820	0.068	−0.038	1.069	*
Bus priority (low)	0.093	0.371	0.250	0.802	−0.634	0.819	
On-time rate of departure and arrival (high)	−0.097	0.841	−0.110	0.909	−1.745	1.552	
On-time rate of departure and arrival (low)	1.419	1.712	0.830	0.407	−1.936	4.774	
Vehicle interval (high)	−0.052	0.792	−0.070	0.948	−1.604	1.501	
Vehicle interval (low)	1.697	2.314	0.730	0.463	−2.839	6.233	
Smooth vehicle operation (high)	0.799	0.396	2.010	0.044	0.022	1.576	**
Smooth vehicle operation (low)	−0.707	0.330	−2.140	0.032	−1.353	−0.061	**
Full load rate in vehicle (high)	0.320	0.359	0.890	0.373	−0.383	1.023	
Full load rate in vehicle (low)	−0.717	0.465	−1.540	0.123	−1.629	0.194	
Number of seats (high)	−1.000	0.377	−2.660	0.008	−1.738	−0.262	***
Number of seats (low)	0.055	0.326	0.170	0.867	−0.584	0.693	
Barrier-free facilities of vehicle (high)	−0.455	0.392	−1.160	0.246	−1.222	0.313	
Barrier-free facilities of vehicle (low)	1.111	0.431	2.580	0.010	0.266	1.956	***
Waiting service facilities (high)	−0.760	0.348	−2.190	0.029	−1.442	−0.079	**
Waiting service facilities (low)	−0.595	0.360	−1.650	0.099	−1.301	0.111	*
Driver's service attitude towards the elderly (high)	−0.086	0.321	−0.270	0.789	−0.714	0.543	
Driver's service attitude towards the elderly (low)	0.082	0.393	0.210	0.834	−0.688	0.853	
Reasonable setting of lines (high)	−0.739	1.453	−0.510	0.611	−3.587	2.109	
Reasonable setting of lines (low)	1.373	4.869	0.280	0.778	−8.169	1.916	
Reasonable setting of stations (high)	−0.318	0.884	−0.360	0.719	−2.050	1.414	
Reasonable setting of stations (low)	−1.665	7.160	−0.230	0.816	−15.699	12.369	
Facilities of electronic navigation and voice broadcasting system (high)	0.155	0.316	0.490	0.625	−0.465	0.774	
Facilities of electronic navigation and voice broadcasting system (low)	−0.149	0.344	−0.430	0.664	−0.823	0.524	
Intelligent transfer query system (high)	−0.109	0.334	−0.330	0.744	−0.764	0.546	
Intelligent transfer query system (low)	0.177	0.343	0.520	0.605	−0.495	0.850	
Ticket price (high)	1.148	1.449	0.790	0.428	−1.693	3.989	
Ticket price (low)	0.080	2.235	0.040	0.972	−4.301	4.460	
Daily travel cost (high)	−0.668	1.097	−0.610	0.543	−2.818	1.482	
Daily travel cost (low)	0.800	2.482	0.320	0.747	−4.064	5.665	

Variable mean value	4.149	Standard deviation of variables	1.627
Pseudo R^2	0.033	Number of samples	362.000
Chi-square value of likelihood ratio	41.053	Prob > chi2	0.424, original assumption accepted
Akaike information criterion (AIC)	1 281.075	Bayesian information criterion (BIC)	1 456.199

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

priority. From the perspective of performance ranking, their positions at the 13th and 12th are in the middle, which are better than those of the bus priority and number of seats in the excitement factors (18th and 21st, respectively), but the low performance of the basic factors will have a significantly negative impact on satisfaction. Therefore, after comprehensive consideration, the two basic factors are set as the second priority. Finally, the excitement factors that will have a positive impact on satisfaction under high performance, namely, bus priority, waiting time, and number of seats, are classified into the third priority (in Table 11).

Table 10 Classification and satisfaction ranking of attribute variables of public transit services

Attribute variables	Types	Satisfaction mean value	Satisfaction ranking
Barrier-free facilities of vehicles	Basic factor	2.528	13
Speed of travel	Basic factor	2.558	12
Bus priority	Excitement factor	2.387	18
Waiting time	Excitement factor	3.588	8
Number of seats	Excitement factor	2.218	21
Smooth vehicle operation	Performance factor	2.378	19
Waiting service facilities	Performance factor	2.254	20

Table 11 Priorities of attribute improvement factors of public transit services

First priority (performance factors)	Second priority (basic factors)	Third priority (excitement factors)
Smooth vehicle operation Waiting service facilities	Barrier-free facilities of vehicles Speed of travel	Bus priority Waiting time Number of seats

So far, this paper calculates and determines the factor improvement priorities of attribute variables by using the three-factor theory and relevant quantitative regression methods, which clarifies the improvement direction for improving the public transit services for the elderly. The inadequacy of the above analysis is that the priority setting of improvement factors only aims to improve the satisfaction of senior-friendly public transit services, without considering the cost of improvement and the difficulty of implementation, and more factors need to be taken into account before specific implementation.

5 Conclusion

In the context of an aging society, it will help to make accurate decisions, improve travel accessibility, and enhance the quality of life by identifying the types of mobility difficulties for the elderly and the priorities for improvement. This paper introduces the digital gap as a new traffic disadvantage into the mobility difficulties for the elderly and uses EFA to identify three types of mobility difficulties, namely, general mobility difficulties, public transit mobility difficulties, and digital gap difficulties. In addition, the three-factor theory is used to screen out the basic factors, excitement factors, and performance factors from 21 attribute variables that affect public transit services and to set improvement priorities.

The research results show that the improvement direction of senior-friendly public transit services includes three aspects: 1) improving the comfort level of bus taking, such as improving waiting service facilities, strengthening the design of waiting booths (installing seat armrests, increasing seat width, etc.), as well as providing the first-mile service from going out to getting on vehicles according to the feeble characteristics of the elderly. 2) Strengthening the construction of hardware facilities of buses, such as increasing the update of barrier-free facilities of vehicles and equipping the intelligent transfer query system with the voice broadcast function. 3) Improving the service awareness of bus drivers, keeping the bus running at a steady speed, and intensifying professional training for service personnel. The research ideas and relevant conclusions of this paper can provide a reference for Shanghai and other cities to cope with population aging, improve the life quality of the elderly, and improve senior-friendly public transit services. In addition, the research can be improved by expanding the number of samples and making them more representative in spatial distribution.

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