Analysis of Influencing Factors on Rail Transit Passengers' Travel Route Choice in Suzhou

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After the opening of Line 4, the number of rail transit lines in Suzhou will increase to 3, and the number of transfer nodes will increase from 1 to 5. Rail transit passengers will face the choice of travel routes. This paper analyses the influencing factors of the choice of travel routes for rail transit passengers, and determines the correlation among the influencing factors and the weight of each influencing factor. According to the passengers' willingness to use Line 4 in the questionnaire survey, the transfer of passenger flow from Line 1 to Line 2 to Line 4 is predicted. By dividing the station areas of Line 1 and Line 2 to 11 zones, and establishing OD table, get different station area passengers' intention of transferring by Line 4.

Key Words: *rail transit passenger travel choice behavior, influencing factors of travel route selection, correlation analysis, the weight of the influencing factors*

1. INTRODUCTION

With the increasingly serious problem of urban road congestion, more and more cities begin to develop urban rail transit to alleviate the problem of urban road congestion, Suzhou is no exception. At present, Suzhou has officially operated rail transit lines 1 and 2. In mid and late April 2017, the trial operation of third rail transit line（Line 4） was ushered in. Compared with one transfer point when there are two lines, after the opening of Line 4, the number of transfer points will increase to 5, and the number of rail transit paths available for passengers will also increase. The change of passenger flow caused by the opening of Line 4 will directly affect the current operation plan and the adjustment of facilities and equipment of each line. In order to understand the passenger rail transit route choice behavior after the opening of Line 4 and to provide influence factor for passenger flow prediction of Suzhou rail transit. Therefore, it is necessary to study the influencing factors of passenger travel route choice before the opening of Line 4.

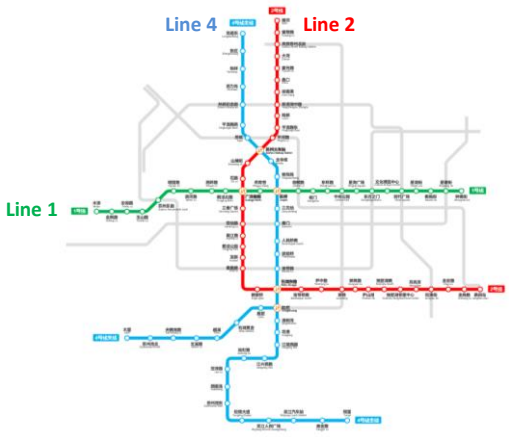

Fig 1. Route Map of Suzhou Rail Transit

2. INVESTIGATION OF INFLUENCING FACTORS

(1) Formulation of influencing factors

a. Individual basic attribute factors: gender, age, occupation, income, education level.
b. Personal travel attributes: Using frequency of rail transit, trip purpose, the estimation of trip distance, and the estimation of the trip time.
c. Ride factors: total travel time, transfer times, transfer waiting time, transfer distance, number of stations passed
d. Other factors: network familiarity and congestion.

(2) Implementation of the investigation

The survey of passengers' transfer intention in Suzhou Rail Transit is conducted in the form of questionnaires.

According to the data acquired by the Research Institute and the analysis methods to be adopted, the questionnaire content is designed. The main content of the questionnaire includes basic passenger information, passenger travel characteristics information, OD survey, using willingness survey of Line 4 under the condition of unchanged OD, investigation of influencing factors of each travel route choice, and route choice survey under hypothetical scenarios. A total of 800 questionnaires were distributed and 756 valid questionnaires were obtained after screening.

3. RELEVANCE ANALYSIS

There are three methods of correlation analysis, Pearson correlation analysis, Kendall correlation and Spearman correlation.

Pearson correlation:

It needs paired data, each pair of data is independent; the sample size is more than 30; the population of the two variables is normal distribution, or at least single peak distribution; the data is measured continuous data; there is a linear correlation; the influence of covariant factors is excluded.

Kendall rank correlation:

It is a method to express the correlation degree of multi-column hierarchical variables. The result is staggered coefficient, which is suitable for merging hierarchical data.

Spearman rank correlation:

Spearman rank correlation is a method to study the correlation between two variables based on rank data. Spearman rank correlation can be studied by Spearman rank correlation as long as the observed values of two variables are paired rank evaluation data or the rank data transformed from continuous variable observation data, regardless of the overall distribution form of the two variables and the size of the sample size.

Combined with the type of data obtained in this survey, this correlation analysis method decides to use Spearman grade correlation.

Table 1. The correlation between using frequency per week and acceptable transfer times

			acceptable transfer times	using frequency per week
Spearman's rho	acceptable transfer times	correlation coefficient	1	.097**
		Sig（bilateral）	.	0.007
		N	756	756
	using frequency per week	correlation coefficient	.097**	1
		Sig（bilateral）	0.007	.
		N	756	757

The confidence level (bilateral) was 0.01, the correlation was significant. There was a significant correlation between using frequency per week and acceptable transfer times. The positive correlation indicated that the more frequent the passengers used rail transit, the more likely they were to accept the larger transfer times.

Table 2. The correlation between network familiarity and acceptable transfer times

			acceptable transfer times	network familiarity
Spearman's rho	acceptable transfer times	correlation coefficient	1	−. 104**
		Sig（bilateral）	.	0. 004
		N	757	756
	network familiarity	correlation coefficient	−. 104**	1
		Sig（bilateral）	0. 004	.
		N	756	756

The confidence level (bilateral) was 0.01, the correlation was significant. It shows that there is a great correlation between subway familiarity and acceptable transfer times, and it is a negative correlation. That means the increase of familiarity with the network will reduce the maximum number of transfers acceptable to passengers.

In addition, the confidence between age, income and the number of acceptable transfers is greater than 0.5, which indicates that there is no correlation between age, income and the maximum number of acceptable transfers.

4. DETERMINING THE WEIGHTS OF THE INFLUENCING FACTORS

The weights of influencing factors in the choice of rail transit passengers' travel routes are determined mainly through the analysis of the ranking questions in the questionnaire. The method of calculating the score of each influencing factor after assignment is used to analyze the ranking questions, and the weight of each influencing factor

is obtained. The software used for analysis is SPSS20 and Excel. According to the order of the six spaces in the sorting questions, the scores are 10 points, 7 points, 5 points, 2 points, 1 point and 0 point from front to back.

$$\textit{The weights of influencing factors} = \frac{\textit{Number of choices for this influencing factor} \times \textit{Corresponding score}}{\textit{Total score of six influencing factors}}$$

Table 3. Weights of influencing factors of overall data

TOTAL DATA	weight
total travel time	0.215
transfer walking distance	0.184
transfer times	0.182
transfer waiting time	0.175
congestion degree	0.157
number of station passed	0.087

From the above table, it can be concluded that the total travel time has the largest weight, which is the most important factor affecting passenger's travel route choice. Next are the transfer walking time and the transfer times, the weights of the two factors are relatively close, and the number of stations passed has the lowest weight, which is the last factor to be considered, or the factor not included in the passenger's route choice.

Table 4. Weight of Influencing Factors under Gender Classification

GENDER	male	female
total travel time	0.218	0.212
transfer waiting time	0.182	0.169
transfer walking distance	0.175	0.192
transfer times	0.170	0.193
congestion degree	0.164	0.151
number of station passed.	0.091	0.083

It is noted that there are differences between men and women in terms of the number of transfers and waiting time. Males take the second place in waiting time, while females take the fourth place in waiting time, while females take the opposite position.

Table 5. Weight of Influencing Factors under Age

AGE	0~30	30~50	50~
total travel time	0.221	0.205	0.189
transfer times	0.182	0.194	0.098
transfer walking distance	0.172	0.203	0.254
congestion degree	0.165	0.135	0.188
transfer waiting time	0.164	0.197	0.190
number of station passed	0.096	0.067	0.081

It is noticed that the most important factor for passengers aged 0-50 is the total travel time, while the most important factor for people over 51 is the transfer walking distance. Age characteristics are largely reflected in the influencing factors of travel choice.

Table 6. Weight of Influencing Factors under Using frequency

Using Frequency	0~2 /week	3~10 /week	10~ /week
total travel time	0.209	0.213	0.229
transfer waiting time	0.187	0.169	0.167
transfer walking distance	0.178	0.195	0.172
transfer times	0.178	0.186	0.182
congestion degree	0.177	0.141	0.155
number of station passed	0.072	0.096	0.095

With the increase using frequency, the ranking of the weight of transfer times has steadily risen.

Table 7. Weight of Influencing Factors under Travel time

Travel Time	0~30 min	30~60min	60~min
total travel time	0.215	0.218	0.174
transfer times	0.183	0.180	0.206
transfer walking distance	0.182	0.192	0.171
transfer waiting time	0.174	0.176	0.174
congestion degree	0.157	0.157	0.183
number of station passed	0.089	0.079	0.091

There are obvious differences in the weights of influencing factors between passengers with total travel time of more than 60 minutes and those less than 60 minutes. Passengers with long travel time are most concerned about the transfer times, not the total travel time, at the same time, the proportion of congestion degree is higher, ranking second.

5. TRANSFER FORECAST OF LINE 4

Firstly, OD tables of rail transit stations are established.

In order to show the travel situation of different areas of rail transit more clearly, Line 1 and Line 2 are divided into 11 traffic districts.

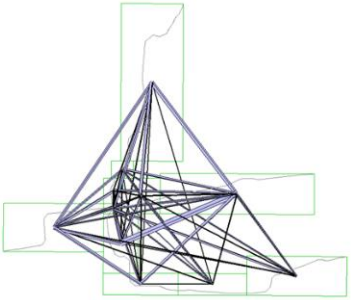

Fig 2. Desire line of zones

Through the question 12 in the questionnaire (passenger transfer route selection at the same origin and destination points after Line 4 is opened) percentage of transfer passenger flow in OD table is obtained.

Table 8. Percentage of transferred passenger flow in OD table

zone	1	2	3	4	5	6	7	8	9	10	11
1								100%		53%	70%
2						50%				33%	40%
3											
4						10%		12%			
5											
6									47%	13%	38%
7		100%							50%	100%	100%
8									60%	67%	67%
9						23%	22%	29%			
10	38%	29%				71%	100%	100%			
11	42%	73%				55%	80%	100%			

Table 9. Transect volume of line 2 zones

downgoing				upgoing		
Transferred	Forecast	Practice	zone	Practice	Forecast	Transferred
			1			
100%	105	105		70	70	100%
			2			
68%	97	142		115	89	77%
			3			
71%	111	156		162	136	84%
			4			
80%	156	194		169	126	75%
			5			
63%	65	103		95	52	55%
			6			
100%	49	49		48	48	100%
			7			
100%	30	30		28	28	100%
			8			

Table 10. Transect volume of line 1 zones

downgoing				upgoing		
Transferred	Forecast	Practice	zone	Practice	Forecast	Transferred
			9			
100%	129	129		95	95	100%
			4			
71%	144	203		182	147	81%
			10			
100%	109	109		145	145	100%
			11			

It can be seen that the percentage of transect volume transferred to Line 4 is the largest among Zone 5 and Zone 6, The transect volume between 9 and 4, 10 and 11, 1 and 2, 6 and 7, 7 and 8 will not be transferred to Line 4.

6. CONCLUSION

This paper mainly focuses on the study of passenger route choice behavior for the upcoming Suzhou Rail Line 4. After preliminary formulation of the possible influencing factors, the data are collected by questionnaire survey according to the factors considered and the analytical methods to be adopted. The data obtained are distributed comprehensively in time and passenger attributes, so it is feasible to use them for analysis.

In the data analysis stage, the author first chooses the appropriate correlation analysis method according to the type of data, and explores the correlation among the influencing factors.

Then, according to the ranking of the influencing factors given by passengers, the weights of each influencing factor are calculated, and then according to the different classification of passengers, the weights of influencing factors for different types of passengers' route choice are compared.

Finally, in order to explore the transfer intention of passengers in different station areas, the stations of Line 1 and Line 2 are divided into 11 traffic zones, and the desire lines between the zones are obtained by OD table. The practical transect volume and the predicted transect volume of each zone are calculated. Thus, the transfer of passengers from stations in different regions to Line 4 can be obtained.

APPENDIX

Questionnaire on Passengers Transfer Intention of Suzhou Rail Transit

Distinguished ladies/gentlemen:：

Hello! The purpose of this questionnaire is to find out the passengers' Intention to choose the transfer routes of Suzhou rail transit, so as to facilitate the formulation of the next rail transit planning and construction policy. No signature is required for this survey. Thank you for your cooperation.

Location：_____ Date：_____M____D Time：_____

Investigator：_____

The above is filled out by investigators.

Q1 Gender：(1)male (2)female

Q2 Age：(1) Age 20 and under (2)21-30 (3)31-40 (4)41-50 (5)51-60 (6)61 and over

Q3 Occupation：(1) Company employees (2) Government /public institution employees (3) Business managers/private entrepreneurs(4) Middle school students (5) college students (6) retirees (7) individual households / farmers (8) other ___(please specify)

Q4 Personal monthly income: (1) less than 2000 yuan (2) 2001-3000 yuan (3) 3001-5000 yuan (4) 5001-8000 yuan (5) 8001-10000 yuan (6) more than 10000 yuan

Q5 Educational level: (1) below senior high school (2) senior high school (including secondary and vocational schools); (3) junior college (4) undergraduate (5) master's degree or above

Q6 The number of times you take rail transit every week is (1 trip, 2 round trips):

(1) Few rides (2) 1-2 times (3) 3-5 times (4) 6-10 times (5) more than 10 times

Q7 The main purpose of your trip is:

(1) commuting (2) going to school / leaving school (3) going out for business / official work (4) going out for shopping / playing (5) shopping (6) other___ (please specify)

Q8 the distance from the origin to the destination is about. mile

Q9 the time from the origin to the destination is about_ minute

Q10 Boarding station_____line_____station

Q11 Get off station_____line_____station

Q12 After the opening of Line 4 of rail transit, the same starting and ending points, if you need to transfer, the transfer route is:

take_____line，transfer to line_____at_____station，transfer to line_____at_____station。

Q13 Your familiarity with Lines 1, 2 and 4 of Suzhou Rail Transit is as follows:
(1) Familiar with it, can accurately estimate the time needed for a trip
(2) Familiar with it, and can roughly estimate the time needed for a trip.
(3) Not familiar with, only know the situation of each line station
(4) very unfamiliar：
Q14 What is the maximum number of transfers you can accept during a trip?
(1) once (2) twice (3) more than three times
Q15 The priority of the factors affecting your choice of transfer station is:： ___>___>___>___>___>___
(1) total travel time (2) transfer times (3) transfer waiting time (4) transfer walking distance (5) congestion degree (6) number of stations passed
Q16 If there are multiple paths to choose from the same starting and ending point, which one would you choose according to the following different situations?
(1) Route 1 (2) Route 2 (3) Route 3

	total travel time	transfer times	transfer waiting time	transfer walking distance	congestion degree	number of stations passed
Route 1	24 mins	1	2 mins	50 miles	crowding	10
Route 2	28 mins	1	3 mins	80 miles	comfort	11
Route 3	20 mins	2	4 mins	100 miles	crowding	8

Finally, thank you for your support to the construction of Suzhou Rail Transit.

REFERENCE

[1]LIU Jian-feng, SUN Fu-liang, BAI Yun, XU Juan.. Passenger Flow Route Assignment Model and Algorithms for Urban Rail Transit Network. *Journal of Transportation System Engineering and Information Technology*, 1009-6744.2009.02.004
[2] Liu, X., Qu, H., Chien, S., Ran, B., Huang, M. Optimizing Route Choice Research in Rail Transit Network Based on Passenger Classification, *Journal of Transportation Engineering and Information*, 1672-4747.2016.04.013
[3] Raveau S, Munoz J C, De Grange L. A topological route choice model for metro. *Transportation Research Part A:* 45(2011) 138-147,
[4] Schmockera J.D, Bell M.G.H. and Kurauchi F. A quasi-dynamic capacity constrained frequency-based transit assignment mode. *Transportation Research part B.*, 42(2008) 925-945,

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