INTERACTIVE STUDY ON THE RELATIONSHIP BETWEEN RESIDENCE AND CITY TRAFFIC SYSTEM BASED ON FUZZY LOGIC

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ABSTRACT

In order to study the influence of the choice of residence to urban traffic, a comprehensive evaluation model of urban residents' to choosing their residence is established. Due to the difficulty in quantifying many facilities around the residence, this paper obtained the fuzzification degree of the facilities' completeness around the the residential area by way of fuzzification means of the facilities' completeness. The fuzzy comprehensive evaluation model of each district in the city is put forward to ccombine with the residential price and the average income of urban residents. What's more, we simulated a medium-sized city, and verify the parameters of the model through MATLAB. Examples show that: A city which is of little poor facilities' completeness can lead some traffic jam to that of comparatively better facilities' completeness in certain degree. It is obvious that the choice of residence plays a significant role in urban traffic.

1. INTRODUCTION

The With the rapid development of Chinese economy and the increase of the urban population, a large amount of rural people swarm into cities and the city residential population is expanding gradually. All of the above lead to the sharp expansion of residence and a series of traffic problem. The residential selection and the city traffic system is a kind of nonmalignant interactive system. Once the residence is decided, different transportation will be established and it will affect the residents' selection to their residence in turn. Good choice of the residence can be convenient to the transportation of family shopping, entertainment and commuting, etc. From the perspective of the system, the good planning of residence can reduce the usage amount of urban motor vehicles fundamentally, reduce the distance for residents and reduce the requirements for transportation. Therefore, good residence is so important and necessary. Of course, a good traffic system can lead people to choose the residence and optimize the system between residence and city traffic. A city could have a more long-term development if it could deal with the relationship between urban residential land and urban transportation system.

Many domestic experts and scholars have made a deep study on the relationship between residential location and traffic system. Now the research results are mainly divided into two categories [1-7]: the mathematical programming model and the random utility model. The mathematical programming model mainly means that residents choose residence based on the principle of cost minimization maximization. This method is simple and has clear goal, but the city residents will think too much when choosing. Only a mathematical programming model would be difficult to cover all factors comprehensively. Therefore, there will be some certain deviation when using this mathematical programming model to simulate the choice of residential land. The random utility model is an extension of typical linear model. It means: fixed regression coefficient which is regarded as random variables is to describe the relationship between residence and traffic system. This model use a lot of indicators to describe the residence' features and generalize the fixed effect to random effect, considering a large number of individual factors. But the model ignores the interaction of different families, and does not reflect to optimize residents' choosing residential land. Due to many factors they think about, many urban residents could not choose their residence in a whole aspects, even have no idea about residence.

In order to make qualitative factors that are difficult to quantify accurately

reflect the important role it plays in choosing residence, this paper, will use fuzzy mathematics to deal with relative qualitative factors in qualified way, and discuss the choice of residence. Through the establishment of mathematical model, we want to conclude the fuzzy comprehensive evaluation to residence to study the influence of selection of residence to city traffic system.

2. Satisfaction evaluation model of household income and housing price to residence

Factors such as household income and housing price tend to be the first factor for urban residents to choose residence as a result of different housing prices and urban residents' household income of the city. If the average monthly income of the city family is P_j , The housing price of the target area i is N_i (among $0 < i \leq M$, expresses the total number of residence in the city) So the optional residential sets of a family must be (expresses the proportion that is to buy or rent the house in monthly average household income of the city). So we can get the satisfaction evaluation model of housing price to residence:

$$P_i = \frac{\gamma P_j - N_i}{\gamma P_j} \quad (1)$$

$$(0 \leq P_i < 1).$$

3. The fuzzy membership degree of facilities for completeness around residence

The facilities for completeness around residence plays an important role in the selection of the residential area. Residents will think a lot: school district housing. Hospital, shopping mall, park and other factors. Poor facilities for completeness around residence is not convenient to people's life. In other words, a good residence had better have a relative facility for completeness around residence.

Suppose that a facility for completeness around residence i is

$u_i = (u_i^1, u_i^2, u_i^3, u_i^4)$, (u_i^1, u_i^2, u_i^3 and u_i^4 denote scale evaluation of schools, hospitals, shopping malls). Schools and hospitals were set in a certain level in accordance with the provisions of the state standards. In this paper, the school and the hospital are divided into five grades. According to the district around the school or hospital grade, we define the fuzzy membership degree of facilities for completeness around residence. Its fuzzy language can be expressed as:

$$[\text{Class A}] = \frac{1}{1} + \frac{0.9}{0.9} + \frac{0.6}{0.8} + \frac{0.1}{0.7} \quad (2)$$

$$[\text{Class B}] = \frac{0.1}{1} + \frac{0.5}{0.9} + \frac{1}{0.8} + \frac{0.8}{0.7} + \frac{0.1}{0.6} \quad (3)$$

$$[\text{Class C}] = \frac{0.1}{0.8} + \frac{0.5}{0.7} + \frac{1}{0.6} + \frac{0.8}{0.5} + \frac{0.1}{0.4} \quad (4)$$

$$[\text{Class D}] = \frac{0.1}{0.6} + \frac{0.5}{0.5} + \frac{1}{0.4} + \frac{0.8}{0.3} + \frac{0.1}{0.2} \quad (5)$$

$$[\text{Class E}] = \frac{0.1}{0.4} + \frac{0.5}{0.3} + \frac{1}{0.2} + \frac{0.8}{0.1} \quad (6)$$

Therefore, we can obtain the fuzzy membership degree of facilities for completeness of the school $A(u_i^1)$ and the hospital $A(u_i^2)$ according to the above formula (2)-(6). The evaluation of shopping malls and parks is relative to these area. parks and other facilities for the evaluation with the area of these facilities related. Large shopping malls less than $1500 m^2$ or between 1500 to $7000 m^2$, or more than $7000 m^2$ will be divided like the following according to the business area of hypermarket, comprehensive supermarket and convenient store, the fuzzy membership degree of the consumption facilities for completeness can be expressed as:

$$A(u_i^3) = \begin{cases} \alpha_1 \left(\frac{\tilde{u}_i^3}{1500} \right)^2 & \tilde{u}_i^3 < 1500 \\ 1 - (1 - \alpha_1) \left(\frac{\tilde{u}_i^3 - 7000}{5500} \right)^2 & 1500 \leq \tilde{u}_i^3 < 7000 \\ 1 & \tilde{u}_i^3 \geq 7000 \end{cases} \quad (7)$$

$\tilde{u}_i^3$ means the operating area (The units was m^2) of consumption facilities of shopping malls around residence i . When $\alpha_1 = 0.8$, the fuzzy membership degree of consumption facilities for completeness of shopping malls around residence $A(u_i^3)$ is shown in Fig.1 :

Fig.1 The fuzzy membership degree change of the shopping center

From Fig.1 we can see : When $\alpha_1 = 0.8$; the operating area (The units was m^2) of consumption facilities of shopping malls around residence is less than $1500 m^2$, the fuzzy membership degree of consumption facilities

for completeness of shopping malls around residence increases with the increase of business area; When the operating area is up to $1500 m^2$, the consumption facilities could meet urban residents in a large degree, so the corresponding fuzzy membership degree is to 0.8. But when the operating area is between $1500 m^2$ and $7000 m^2$, the fuzzy membership degree rise relatively slow; When the operating area is more than $7000 m^2$, the fuzzy membership degree reaches 1.

According to the requirements of floor space of large parks, regional parks and small neighborhood parks, we divide the floor space of the researching park in the following way: more than $20 hm^2$, $2 hm^2 \sim 20 hm^2$ and $2 hm^2$ [8]. So the fuzzy membership degree of the leisure facilities for completeness of parks around the residence can be expressed as:

$$A(u_i^4) = \begin{cases} \alpha_2 \left(\frac{\tilde{u}_i^4}{2} \right) & \tilde{u}_i^4 \leq 2 \\ 1 - (1 - \alpha_2) \left(\frac{\tilde{u}_i^4 - 20}{18} \right)^2 & 2 < \tilde{u}_i^4 \leq 20 \\ 1 & \tilde{u}_i^4 \geq 20 \end{cases} \quad (8)$$

$\tilde{u}_i^4$ means the area covered (The units was hm^2) of leisure facilities of parks around residence i . When $\alpha_2 = 0.4$; the fuzzy membership degree of leisure facilities for completeness of parks around residence $A(u_i^4)$ is shown in Fig.2 :

Fig.2 The fuzzy membership degree change of the park

From Fig.2 we can see : when $\alpha_2 = 0.4$, the area covered (The units was hm^2) of leisure facilities of parks around residence is less than $2 hm^2$, the fuzzy membership degree of leisure facilities for completeness of parks around residence increases rapidly with the increase of business area; When the area covered is between $2 hm^2$ and $20 hm^2$, the leisure facilities rise relatively slow, and when the area covered is $5 hm^2$, it could almost meet the needs of most of the city's residents leisure and entertainment needs, the fuzzy membership degree was close to 0.6 ; When the area covered is more than $20 hm^2$, the leisure facilities will be very completed, the fuzzy membership degree reaches 1.

4 Comprehensive evaluation of the residence surrounding facilities

From the above, the matrix of relation R of level of the fuzzy membership of facilities for completeness of M community can be:

$$R = \begin{bmatrix} A(u_1^1) & A(u_1^2) & \cdots & A(u_1^M) \\ A(u_2^1) & A(u_2^2) & \cdots & A(u_2^M) \\ \vdots & \vdots & \vdots & \vdots \\ A(u_n^1) & A(u_n^2) & \cdots & A(u_n^M) \end{bmatrix} \quad (9)$$

Then we should determine whether the area has the above four infrastructure construction and conclude 0-1 line vector quantity

$$W = (w_{1i} \quad w_{2i} \quad \cdots \quad w_{ai}) \quad (10)$$

Among

$$w_{ai} = \begin{cases} 0 & \text{There were corresponding facilities around the district} \\ 1 & \text{There was no corresponding facilities around the district} \end{cases}$$

According to 0-1 line vector quantity W and matrix of relation R of the level of the fuzzy membership degree of facilities for completeness around residence matrix R , it can obtain various supporting satisfaction model facilities for completeness of each district :

$$A(u) = \frac{1}{4} W \cdot R$$

$$= \frac{1}{4} (w_{1i} \quad w_{2i} \quad \cdots \quad w_{ai}) \cdot \begin{bmatrix} A(u_1^1) & A(u_2^1) & \cdots & A(u_M^1) \\ A(u_1^2) & A(u_2^2) & \cdots & A(u_M^2) \\ \vdots & \vdots & \vdots & \vdots \\ A(u_1^4) & A(u_2^4) & \cdots & A(u_M^4) \end{bmatrix}$$

After calculation , we can get a line of satisfaction value of each district in the city:

$$A(u) = (A(u_1) \quad A(u_2) \quad \cdots \quad A(u_M)) \quad (11)$$

In a word, according to the average monthly income of the city family and the evaluation model P_i of each residence, combining with the satisfaction model facilities for completeness of each district $A(u)$, we can get the conclusion of ambiguous comprehensive evaluation model of satisfaction degree of each district:

$$Z_i = \alpha_3 p_i + \alpha_4 A(u_i) \quad (12)$$

α_3, α_4 means the weight of the model P_i and model $A(u)$ in the comprehensive evaluation (among $\alpha_3 + \alpha_4 = 1$).

5 Example

Fig.3 Simple traffic network

In Fig.3: A medium-sized city is divided into 17 residential areas and Residence 1 is the city center; each residence is connected by a . So we define that the free-flow speed of the two-way multilane which connect each district is equal to road width. The static date of simple traffic network in each residence is in Tab. 1.

Tab.1 Static date of simple traffic network

Road	1,2	1,4	1,6	1,8	2,3
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Length (<i>km</i>)	2	2.5	2.5	3	2.2	
Capacity (<i>veh</i> · <i>h</i> ⁻¹)	2000	2500	2000	1000	3000	
Free flow velocity (<i>km</i> · <i>h</i> ⁻¹)	30	40	30	10	50	
2,9	3,4	3,11	3,12	4,5	5,6	5,13
3.5	2.8	3.5	3	2	1.8	3.5
2000	3000	4000	4000	3000	2500	3500
30	50	60	60	50	30	60
5,14	6,7	7,8	7,15	7,16	8,9	9,10
3	2.5	2.5	3	2.8	3	2.8
3000	2000	2000	3000	4000	1500	3000
50	30	30	50	60	20	50
9,17	10,11	10,17	11,12	12,13	13,14	14,15
3.2	4	3	3.5	5	2.9	4.5
4000	4000	3500	4000	4000	4000	4000
60	60	60	60	60	60	60
15,16	16,17					
3.2	5					
3000	4000					
50	60					

Tab.2: The accommodation number of households in each residence, the proportion of high-income families in the area and the number and the distribution of destination in each family:

Tab.2.Static data of each residential location

Residential location		1	2	3	4	5
Family quantity		25000	16000	22000	18000	23000
High-income families/%		30%	25%	23%	23%	20%
Distribution of the main destination of the family	1	5000	2000	1400	1800	1400
	3	2000	1800	2500	1500	1200
	5	2000	500	1200	1500	2500
	7	1000	400	300	400	1100
	9	1000	1300	1000	300	300
	1、3	2000	2000	1200	1400	1000
	1、5	3000	400	900	1200	1500
	1、7	1000	500	300	400	1000
	1、9	1000	1200	800	500	300
	3、5	1000	500	1200	1300	1000
	3、9	900	1300	1300	500	300
	5、7	700	300	200	400	1400
	7、9	700	600	300	200	400
6	7	8	9	10	11	
15000	20000	15000	18000	12000	10000	
25%	22%	23%	20%	18%	18%	
2000	1000	1800	1200	500	600	
800	400	800	1000	800	1600	
1200	600	700	600	200	500	
1300	2000	1400	1000	800	300	
600	800	1600	2000	1500	800	
800	400	400	1200	600	1000	
1800	800	400	400	300	800	
1500	1600	1600	600	200	300	
600	500	1800	1500	800	800	
300	400	200	300	200	1000	
200	200	400	1400	900	800	
1500	1500	400	200	300	200	
600	1300	1400	1600	800	200	
12	13	14	15	16	17	
8000	9000	11000	10000	8000	8000	
12%	13%	15%	17%	14%	15%	
300	300	600	600	200	200	
2000	600	600	100	100	800	
800	1800	2000	900	1000	100	
200	300	800	1800	1400	800	
600	100	200	600	1200	1800	
300	400	600	200	100	300	
300	1000	700	600	200	100	
100	300	800	1000	300	300	
100	200	200	600	200	400	

800	800	1200	200	100	100
400	200	200	200	100	900
300	800	600	800	600	100
100	100	100	500	600	800

During the study, we focus on such aspects: housing prices all over the city, basic infrastructure such as education facilities such as schools, hospitals, shopping centers, parks or not its have or not around the residential area (National key schools and third A hospital are Class A according to the state regulations; The provincial key schools and third B Hospital are Class B; The city's key schools and third C hospitals are Class C; The county's key schools and Second grade Hospital are Class D; The general school and the first level hospitals are Class E).

Tab.3 Static data around the facilities in the residential location

Residential location		1	2	3	4	5	
Price ($yuan \cdot m^2$)		6000	5000	5500	4800	5200	
School	Have or not	1	1	1	0	1	
	Grade	B	D	C	*	B	
Hospital	Have or not	1	0	1	1	0	
	Grade	A	*	B	C	*	
Mall	Have or not	1	1	1	1	1	
	Selling area	8000	3000	5000	2500	6000	
Park	Have or not	1	1	1	1	1	
	Area covered	1.8	6	5	8	3	
6	7	8	9	10	11	12	13
5000	5300	4700	5200	4500	4500	4300	4300
0	1	0	1	0	1	0	1
*	C	*	C	*	E	*	E
1	0	1	1	1	0	1	0
D	*	D	C	D	*	E	*
1	1	1	1	1	1	1	1
5000	6000	1200	5000	1000	1500	600	7500
1	1	1	1	1	1	1	0
9	6	9	4	10	6	22	*
14	15	16	17				
4500	4500	4000	4300				
0	0	0	1				
*	*	*	E				
1	1	0	0				
E	D	*	*				
1	1	1	1				
800	1000	8000	1000				
1	1	0	1				
3	5	*	3				

Table.3 The business area and the area covered of the units were m^2 and hm^2 . During the study, the average monthly income of the urban cities was 10000 yuan, and the γ was 0.7. So from the above table, we get the satisfaction of the infrastructure and the fuzzy comprehensive evaluation about the residence in the city's commuting according to housing price and the having or not and the scale of the infrastructure around the residence and use MATLAB2009 simulated model.

Tab.4 Fuzzy evaluation of residence satisfaction

Residential location	1	2	3	4	5	
Price satisfaction	0.14	0.29	0.21	0.31	0.26	
School satisfaction	0.80	0.40	0.60	0	0.80	
Hospital satisfaction	1	0	0.80	0.60	0	
Mall satisfaction	1	0.89	0.97	0.87	0.99	
Park satisfaction	0.36	0.64	0.58	0.73	0.46	
Facilities evaluation	0.79	0.48	0.74	0.55	0.56	
Fuzzy synthetic evaluation	0.40	0.37	0.42	0.41	0.38	
6	7	8	9	10	11	12

0.29	0.24	0.33	0.26	0.36	0.36	0.39
0	0.60	0	0.60	0	0.20	0
0.40	0	0.40	0.60	0.40	0	0.20
0.97	0.99	0.51	0.97	0.36	0.80	0.13
0.78	0.64	0.78	0.53	0.81	0.64	1
0.54	0.56	0.42	0.68	0.39	0.41	0.33
0.39	0.37	0.37	0.43	0.37	0.38	0.37
13	14	15	16	17		
0.39	0.36	0.36	0.43	0.39		
0.20	0	0	0	0.20		
0	0.20	0.40	0	0		
1	0.23	0.36	1	0.36		
0	0.46	0.58	0	0.46		
0.30	0.22	0.34	0.25	0.26		
0.35	0.30	0.35	0.36	0.34		

Each value is round data. When involving ambiguous comprehensive evaluation value, we take $\alpha_3 = 0.6, \alpha_4 = 0.4$. As shown in Table 4:

Although the city center residence 1 has all sorts of facilities, its housing price is higher than other areas. So the fuzzy comprehensive evaluation is not the highest. The geographical location and the housing price of residence 8 are similar to residence 2, 4, 6, but the poor residential facilities of residence 8 make its fuzzy comprehensive evaluation slightly lower than the residence 2, 4, 6. High-income families living in residence 8 would choose to live in residential area 1, 9 which has relatively high fuzzy evaluation; Low-income families tend to live in residence 1, 7, 9 of complete facilities; Poor transportation in residence 8 would often cause urban traffic congestion. Building a school and expand the supermarket from 1200m^2 to 2000m^2 greatly reduce the ability of residents' transportation. Therefore, the managers can adjust to some appropriate measures according to the supporting facilities evaluation of urban residents as well as the fuzzy evaluation to the residence in order to optimize the urban space and traffic.

6 Conclusions

This paper mainly discusses the interactive relationship between the choice of residence and the transportation system based on the theory of fuzzy mathematics. By establishing the relationship model between the average income of urban residents and the housing price, we gain the satisfaction evaluation to the housing price in each residence from urban residents. Then, we gain the fuzzy comprehensive evaluation of each residence combining with the completeness of various facilities around the residence. At the same time, the managers can make reasonable improvement according to the deficiency in the evaluation of each district. It will be necessary for us to reduce travel traffic of city residents fundamentally and lead the residence and city traffic toward more benign development. Finally, I'd like to say that next step is to explore the influence of open district to the choice of the residence for city residents and city transportation.

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