The Alternative Evaluation of Inter-city Railway in Regional Integrated Transport Corridor

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Abstract. First of all, Based on the analysis of traffic demand of inter-city channel and the function of the inter-city railway, the alternative evaluation system which include the factor of technical, economic and sustainable development is established. Then, the alternative evaluation method of inter-city railway in regional integrated transport corridor based on the fuzzy matter-element and discrete mutation is constructed. Finally, setting the chang-zhu-tan urban agglomeration as an example for analysis. The evaluation index system and evaluation method established in this paper has certain feasibility and practicability. And it has a certain guiding significance to promote the development of the inter-city railway and evaluation.

Introduction

With the economic globalization and regional integration, the development of the city is no longer confined to a single city, gradually formed in the central city as the core of urban agglomeration spatial units. The passenger transport demand between cities formed by the urban agglomeration economic ties has gradually come out, but conventional mode of transport can't load such traffic demand. Therefore, the planning and construction inter-city railway has become the urgent need of economic development.

The development of inter-city railway is also bound to have a certain impact, or a certain number of alternative on other mode of transportation in the regional integrated transport channels[1]. If we know the strength of the alternative, we can take measures to other corresponding measures on the mode of transportation.As a result, it has become a very critical and urgent issue to research how big is this alternative strength and how to evaluate alternative strength.

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Index system. Analysis the influence factors of the inter-city railway alternative, to get the alternative evaluation indexes in the comprehensive transport .The indexes is divided into two categories, qualitative and quantitative[2]. As shown in table 1.

Table 1 alternative evaluation index system

	Primary index layer	Secondary index layer	The index type
The Alternative Evaluation of Inter-city Railway in Regional Integrated Transport corridor	Social benefit indexes	Comfort	Qualitative
		Economy	Quantitative
		Security	Quantitative
	Technical indexes	Rapidity	Quantitative
		Accessibility	Qualitative
		Punctuality	Qualitative
	sustainable development	Occupation of land	Quantitative
		Environment pollution	Qualitative
		Development potential	Qualitative

This article set up the qualitative indexes which can be obtained by expert scoring or survey method.What's more ,rapidity of quantitative indicators measured in time, economy reference fares[3], and security according to the set values in table 2; Occupation of land index as shown in table 3.

Table 2 security index

Accident death rate (deaths per billion passenger miles)			
The inter-city railway	railway	Highway passenger	Private cars
0.1	0.1	0.2	2.6

Table 3 Occupation of land index

The occupation of land on Various modes of transport		
The inter-city railway	Both the railway	highway
40	25	32

Eevaluation method. Because involves index information has a certain ambiguity, this paper chooses fuzzy matter-element evaluation model to quantify the raw data processing[4]. In the calculation of weight, the discrete coefficient method is applied, which uses the mean square of each index of deviation to judge the discrete degree. Then, we can determine the weight of it. In addition, due to the size of the weight difference may be different levels of mutations in the evaluation index. So, the catastrophe theory is introduced for this sudden condition, to further improve the accuracy of the traditional fuzzy matter-element method.

Set the changzhutan intercity railway as an example

Calculation of evaluation indicators. The inter-city railway, railway, highway passenger transport and private cars is respectively set as M1, M2, M3, M4. Quantitative indicators are shown in table below[5]. As shown in table 4.

Table 4 Quantitative parameter values

Quantitative indicators	The inter-city railway M1	Both the railway M2	Highway passenger M3	Private cars M4
Rapidity C1 (unit: minutes)	24	40	55	65
Economy C2 (unit: RMB)	30	12	22	35
Security C3	0.1	0.1	0.2	2.6
Land C7 (unit: mu/km)	40	25	32	32

Combining with the analysis of the qualitative indexes, we adopt the method of investigation on the qualitative index score of each mode of transportation[6]. The investigation object are the passengers and private car owners. Survey sites are the railway station and long-distance bus terminal. Passengers score each transport mode and the evaluation results is shown in table 5:

Table 5 qualitative index score values

Qualitative indicators	The inter-city railway	Railway	Highway passenger	Private cars
Comfort C4	9.3	4.5	8	9.5
Accessibility C5	8.3	8	8.5	9.5
Punctuality C6	9.3	4	7	9.5
Environmental pollution C8	7	6.5	5	4
Development potential C9	9.5	7.5	6.5	4

The data processing of evaluation index. In this section, we will deal with the raw data of the four transport modes.

●Established the compound fuzzy matter-element.Based on the evaluation indexes of the original data, the compound fuzzy matter-element Rmn in table 6:

Table 6 The compound fuzzy matter-element Rmn

R*	M1	M2	M3	M4
C1	24	40	55	65
C2	30	12	22	35
C3	0.1	0.1	0.2	2.6
C4	9.3	4.5	8	9.5
C5	8.3	8	8.5	9.5
C6	9.3	4	7	9.5
C7	40	25	32	32
C8	7	6.5	5	3.5
C9	9.5	7.5	6.5	4

●Establish optimal-membership compound fuzzy matter-element.With the dimensionless method processing data,we can get the optimal-membership compound fuzzy matter-element[7].

$U_{ij} = (x_{ij} - \min x_{ij}) / (\max x_{ij} - \min x_{ij}.)$,i = 1,2,...,m, j is the bigger the better;

$U_{ij} = (\max x_{ij} - x_{ij}) / (\max x_{ij} - \min x_{ij})$,i = 1,2,...,m, j is the smaller the better.

In the above formula, max x_{ij} and min x_{ij} are respectively j th indicators of all the things. We can calculate the square of the difference of standard fuzzy matter-element and compound fuzzy matter-element. Then, difference square compound fuzzy matter-element is established. As shown in table 7.

Table 7 difference square compound fuzzy matter-element R*

R*	M1	M2	M3	M4
C1	0	0.1521	0.5776	1
C2	0.6084	0	0.1849	1
C3	0	0	0.0016	1
C4	0.0169	1	1	0
C5	0.64	1	0.4489	0
C6	0.0064	1	1	0
C7	1	0	0.2209	0.2209
C8	0	0.0196	0.3249	1
C9	0	0.1296	0.3025	1

Calculation of the weight. Use the formula of discrete coefficient method to calculate the weight[8]. As shown in formula (1),(2),(3),(4) The parameters of the calculation results are shown in table 8 below.

$$\bar{x}_j = \frac{1}{m}\sum_{i=1}^{m} x_{ij} \tag{1}$$

$$\delta_j = \sqrt{\frac{1}{m}\sum_{i=1}^{m}(x_{ij} - \bar{x}_j)^2} \tag{2}$$

$$D_j = \frac{\delta_j}{\bar{x}_j} \tag{3}$$

$$w_j = \frac{D_j}{\sum_{j=1}^{n} D_j} \tag{4}$$

Table 8 parameters of calculation weight

Evaluation indexes	Average	Mean square deviation	Dispersion coefficient	The whole weight
Rapidity C1	46	15.5081	0.3371	0.0981
Economy C2	24.75	8.6999	0.3515	0.1023
Security C3	0.75	1.0689	1.4252	0.4149
Comfort C4	7.825	2.0042	0.2561	0.0746
Accessibility C5	8.575	0.5629	0.0656	0.0191
Punctuality C6	7.45	2.2209	0.2981	0.0868
land C7	32.25	5.3092	0.1646	0.0479
Environmental pollution C8	5.5	1.3693	0.2490	0.0725
Development potential C9	6.875	1.9804	0.2881	0.0839

On the basis of calculating the whole weight of each index, we can continue to calculate local weight of secondary index layer.As shown in table 9.

Table 9 calculation of local weight

The total target layer	Primary index layer	Secondary index layer	Local weights
Evaluation of alternative	Social benefit index B1	Comfort C4	0.1260
		Economy C2	0.1729
		Security C3	0.7011
	Technical index B2	Rapidity C1	0.4810
		Accessibility C5	0.0937
		Punctuality C6	0.4253
	Sustainable development index B3	Occupation of land C7	0.2346
		Environmental pollution C8	0.3548
		Development potential C9	0.4105

Optimization of the mutations. By the structure of evaluation index system and mutation theory, there can be further optimization. Set the inter-city railway M1 as an example. The specific operation is as follows.

Optimization of Secondary index. Under the social benefit index B1 three secondary index of C4, C2 and C3 level dovetail mutations. The order of the weight and membership degree are C4, C2 and C3 accordly . So, X_{B1} is 0.1919. Simultaneously, X_{B2} is 0.1628,X_{B3} is 0.2346. In a word, $X_B=[x_{B1},x_{B2},x_{B3}]=[0.1919,0.1628,0.2346]$

Optimization of primary index. Through the Local weights of Secondary index cumulative, we can get the weights of primary index.It is $W_B=[W_{B1},W_{B2},W_{B3}]=[0.5917,0.2040,0.2042]$. Two primary index constitute cusp catastrophe ,and the result is $W_{B1}>W_{B3}>W_{B2}$.The order of importance is B1,B3,B2 orderly. Accordingly, the cusp catastrophe membership is $X_B=[X_{B1},X_{B3},X_{B2}]$. So, D1 is $[X_{B1},X_{B3},X_{B2}]$ $[W_{B1},W_{B3},W_{B2}]=0.5147$.So,the membership of M1(The inter-city railway) is 0.5147.

Closeness degree. The formula of closeness degree is

$$\rho H_i = 1-\sqrt{d_i} \tag{5}$$

pH_i is the closeness degree of i th mode of transport, d_i is membership of mutations.

Table 10 closeness degree and membership of mutations

	M1	M2	M3	M4
Membership of mutations di	0.5147	0.5263	0.6693	0.8919
Closeness degree pHi	0.2826	0.2745	0.1819	0.056

Conclusion

By the discrete coefficient and the index weight mutation model is established, and we calculate the mutation optimization indexes at all levels. Then ,we get the closeness degree of the inter-city railway, railway, highway passenger, private cars are 0.2826, 0.2745, 0.1819 and 0.056 orderly. Inter-city railway comprehensive rating score the highest in four kinds of transportation. This suggests that the intercity passenger channel in changsha-zhuzhou-xiangtan urban agglomeration has stronger alternative. In the process of raw data processing, optimal-membership of the calculation shows that the inter-city railway occupy obvious advantage in rapidity and security, also it has certain advantages in terms of comfort and punctuality. What's more, the environmental pollution is small and there is big development potential.

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References

[1] Priemus H, Zonneveld W, What are Corridors and What are The Issues, Introduction to Special Issue: The Governance of Corridors, Journal of Transport Geography, Vol.3, 167-177, 2003.

[2] Z.F.Lu, The Alternative Evaluation of Inter-city Railway in Regional Integrated Transport corridor, Railway Transportation and Economy, Vol.12, 76-80,2012.

[3] J.Xie, Analysis of the Features of all kinds of Transportation in Regional Integrated Transport corridor's Transportation Features, Transportation enterprise management,Vol.1,57-59.2011

[4] A.U.Wu, G.Q.Xiao, K.X.Cai, Fuzzy evaluation of fire risk, Fire Science, Vol .2, 99-105,2004.

[5] Y.H.Li, The Function Orientation of the Inter-city Rail Transit, The Railway Survey, Vol .5, 10-12. 2007,

[6] Y.G.Zhao, Study of Reasonable Division of Passenger Transport way in Regional Channel inter-city, Railway Transportation and Economy, Vol. 4,67-73, 2012,

[7] X.Q.Zhan, C.Liang, The Application of Fuzzy Matter-Element Model based on Entropy Weight in the Water Quality Comprehensive Evaluation, Journal of Water Conservancy, Vol.9,1057-1061,2005.

[8] Y.J.Pan, K.D.Liu, B.W.Zhang, Determination Method of Comprehensive Evaluation System of Objective Index Weight, Systems Engineering Theory and Practice, Vol.8,37-42, 2001.