Research on Post Evaluation of Road Passenger Line Intensive Transformation Based on Extension Matter-Element Method

Ting Pan, Yanfei Zhang, Yongqing Wang

***Abstract*— In recent years, intensive road passenger line has become a part of the construction of various cities. In this paper, in order to carry out a detailed evaluation of the operation of the line intensive transformation. Therefore, the post-evaluation system was established in this paper, including 13 indicators such as common bus network density, average travel time and traffic punctuality rate. The scoring method was used to determine the weight of the evaluation index. The euthenics and the extension matter-element method were used to establish the evaluation model. Thus, the already intensive road passenger line was post-evaluated by Zibo City at the end of 2015.**

***Index Terms*— Road passenger line, Intensive transformation, Post Evaluation, Extension Matter Element Method.**

I. INTRODUCTION

Traffic authorities and business lines of the enterprises did not timely after the transformation of passenger lines and the operation of the results of the summary and evaluation. Based on the extended matter-element method, the pull-off method is used to determine the weight of the evaluation index, a set of 13 indicators of the evaluation system is composed of three criteria for the evaluation of the road passenger line intensive reform of the post-evaluation system was established.

II. EXTENSION MATTER-ELEMENT METHOD

The extension system is a new discipline founded by Chinese scholar Cai Wen. Its system mainly includes three parts: extension theory, extension development and application of extension theory, extension method and extension engineering method [1] [2]. Extension theory as the basis of the latter two, the latter two as a practical application of the tool [3]. And the material-element extension method is based on the extension of the theory formed by the method, the specific concept is as follows.

A. Matter-element concept

Matter-element is used to describe the basic abbreviation of things, the expression is:

$$R(U, A, X) \qquad (1)$$

Where, U is the object (evaluation object), A is the feature name (index name), X is the specific value of the object (index value), U, A and X are called the three elements of the matter element R, A and X is a feature of a binary (called a matter). There is a close relationship between the three elements of matter-element, and there is a one-to-one relationship for the same object U, A and X, which can be expressed by $X = U(A)$ $(A_1, A_2, \cdots, A_n)$ and the corresponding magnitude $X = (X_1, X_2, \cdots, X_n)$, the matter element can usually be expressed as the following matrix form:

$$R = \begin{pmatrix} U & A_1 & X_1 \\ & A_2 & X_2 \\ & \mathrm{L} & \mathrm{L} \\ & A_n & X_n \end{pmatrix} = \begin{pmatrix} R_1 \\ R_2 \\ \mathrm{L} \\ R_n \end{pmatrix} \qquad (2)$$

In this formula, R is the matter-element to be evaluated, U is the grade of the thing to be studied, A is the name of the item to be evaluated at level U, and all the relevant feature names are listed. X represents the value of A at level U, which can be either a range of values (classical and threshing), or a specific value (matrix of matter to be evaluated)

B. Classic domain matter element

For the material element R_{oj} and U_{oj} that the division of the j evaluation level. If the respective characteristics of A corresponding X_{oji} all with the interval to represent the classic domain matter element can be determined, X_{oji} is the classic domain:

$$R_{oj} = R(U_{oj}, A, X_{oj}) = \begin{pmatrix} U_{oj} & A_1 & X_{oj1} \\ & A_2 & X_{oj2} \\ & \mathrm{L} & \mathrm{L} \\ & A_n & X_{ojn} \end{pmatrix} = \begin{pmatrix} U_{oj} & A_1 & \langle m_{oj1}, M_{oj1} \rangle \\ & A_2 & \langle m_{oj2}, M_{oj2} \rangle \\ & \mathrm{L} & \mathrm{L}\ \mathrm{L} \\ & A_n & \langle m_{ojn}, M_{ojn} \rangle \end{pmatrix} \qquad (3)$$

Where, $i = (1, 2, \cdots, n)$, j is the rating of the main body, the evaluation system established in this paper has five levels (ie, excellent, better, qualified, poor, very poor), so $j = 1, 2, 3, 4, 5$, m_{oji} is the lower limit of X_{oji}, M_{oji} is the upper limit of X_{oji}.

C. Section domain matter element

$$R_p = (U_p, A, X_{pi}) = \begin{pmatrix} U_p & A_1 & X_{p1} \\ & A_2 & X_{p2} \\ & \mathrm{L} & \mathrm{L} \\ & A_n & X_{pn} \end{pmatrix} = R_p = \begin{pmatrix} U_{oj} & A_1 & \langle m_{p1}, M_{p1} \rangle \\ & A_2 & \langle m_{p2}, M_{p2} \rangle \\ & \mathrm{L} & \mathrm{L}\ \mathrm{L} \\ & A_n & \langle m_{pn}, M_{pn} \rangle \end{pmatrix} \qquad (4)$$

Where, U_p is the whole of the evaluation level, and X_{pi} is the range of values taken by P for A_i (that is, the node of P). m_{Pi} is the lower limit of X_{Pi}, M_{Pi} is the upper limit of X_{Pi}, of course, the classic domain X_{ji} belongs to the section X_{Pi}.

D. To be assessed matter element

For the specific line intensive management U to be evaluated, according to the data of the collated and processed, the specific value X_i of each corresponding index can be obtained, and the matter element to be evaluated based on the object to be evaluated can be established:

$$R=\begin{pmatrix} U & A_1 & X_1 \\ & A_2 & X_2 \\ & \mathrm{L} & \mathrm{L} \\ & A_n & X_n \end{pmatrix} \qquad (5)$$

E. Associated functions

①Distance. This is different from the generalized distance, rather than the distance between two points, the range here is the distance from the domain of the domain, the classic domain, and so on. Assuming that x is any point on the real field $(-\infty,+\infty)$, $X_0=\langle a,b\rangle$ it is any interval on the real field, the distance is:

$$\rho(x,X_0)=\left|x-\frac{a+b}{2}\right|-\frac{(b-a)}{2} \qquad (6)$$

The distance from point x to interval X_0. In the specific application, the paper needs to establish the relationship between the two distance, one is the actual value of the index to be evaluated and the corresponding classic domain distance, as follows:

$$\rho(X_i,X_{oi})=\left|X_i-\frac{m_{oi}+M_{oi}}{2}\right|-\frac{M_{oi}-m_{oi}}{2} \qquad (7)$$

One is the actual value of the index to be evaluated and the distance from the domain is used to indicate the distance between the index to be evaluated and the level field, as follows:

$$\rho(X_i,X_{pi})=\left|X_i-\frac{m_{pi}+M_{pi}}{2}\right|-\frac{M_{pi}-m_{pi}}{2} \qquad (8)$$

②Associative function

$$K(X_i)=\begin{cases} \dfrac{-\rho(x_i,X_{oi})}{|X_{oi}|}, & x_i\in X_{oi} \\ \dfrac{\rho(x_i,X_{oi})}{\rho(x_i,X_{Pi})-\rho(x_i,X_{oi})}, & x_i\notin X_{oi} \end{cases} \qquad (9)$$

Indicates the degree of compliance between the i evaluation index A_i and the j rating level of the item to be evaluated. When $K_i(X_i)\ge 0$, X_i is X_{oji}, X_i is larger, indicating that X_i has the property of X_{oji}, the more usually the range of $\max K_i(X_i)$, the reaction is the membership of the material level, the opposite. $K(X_i)\le 0$, X_i does not belong to X_{oji}, the smaller the value, X_i distance away from the distance X_{oji}.

F. Comprehensive correlation

$$K_j(U)=\sum_{i=1}^{n} w_i K_j(X_i) \qquad (10)$$

Where, w_i is the determined weight of the index, $K_i(U)$ represents the degree to which U belongs to j, and if $K_j(U)$ is the maximum, then U belongs to j. In general, the degree of relevance of the evaluation object can be divided into three cases, the meaning of the table as shown in table 1

Table 1 Correlation degree meaning table

Correlation calculation	Whether the object to be evaluated is within this level	Whether it has the qualification to convert to that level	Result meaning
$K_i(U)>0$	yes	yes	The larger the value, the larger the degree of membership
$-1<K_i(U)<0$	no	yes	The larger the value, the larger the likelihood of conversion
$K_i(U)\le -1$	no	no	The smaller the value, the farther away from the level

III. Post-Evaluation System Established

The establishment of the road passenger line intensive reform effect post-evaluation system as shown in figure1

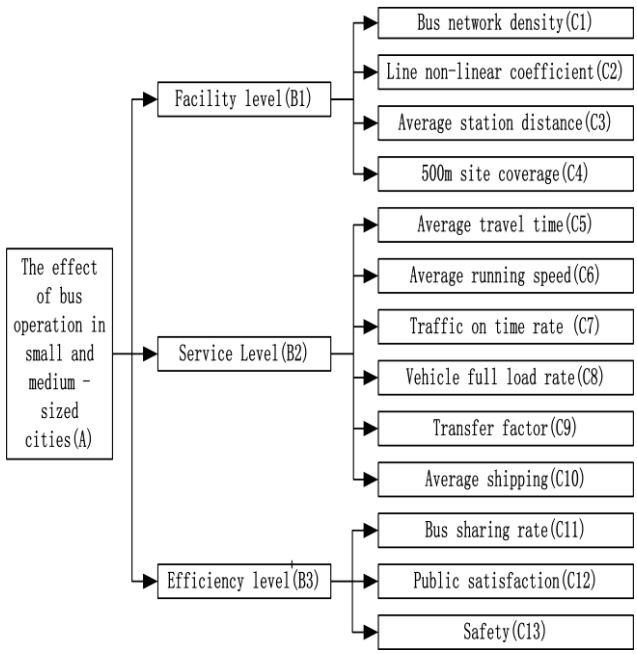

Fig.1. Flow chart

All indicators of the classification criteria as shown in table 2. [4] [5]

Table 2 Indicator level classification standard table

Index	Indicator range	Evaluation grade	Index	Indicator range	Evaluation grade
Bus network density C1	2-2.5km/km^2	Ⅰ	Driving standard point rate C7	1min	Ⅰ
	2.5-3km/km^2	Ⅱ		1-3min	Ⅱ
	3-4km/km^2	Ⅲ		3-5min	Ⅲ
	1-2km/km^2	Ⅳ		>5min	Ⅳ
Line non-linear coefficient C2	1.4	Ⅰ	Peak vehicle full load rate C8	95-100%	Ⅰ
	>1.4	According to the deviation of the decision		100%-105%	Ⅱ
				105%-110%	Ⅲ
				>110%,<95%	Ⅳ
Average station distance C3	500-800	Ⅰ	Transfer factor C9	1.3	Ⅰ
	300-500	Ⅱ		1.3-1.4	Ⅱ
	800-1000	Ⅲ		1.4-1.5	Ⅲ
	>1000	Ⅳ		>1.5	Ⅳ
500 m station coverage C4	95%	Ⅰ	Average cost C10	1 Yuan	Ⅰ
	85%-95%	Ⅱ		1-1.5 Yuan	Ⅱ
	75%-85%	Ⅲ		1.5-2 Yuan	Ⅲ
	<75%	Ⅳ		>2 Yuan	Ⅳ
Average travel time C5	0-20min	Ⅰ	Bus sharing rate C11	10%	Ⅰ
	20-30min	Ⅱ		5%-10%	Ⅱ
	30-40min	Ⅲ		3%-5%	Ⅲ
	>40min	Ⅳ		<3%	Ⅳ
Average running speed C6	20km/h	Ⅰ	Average running speed C6	10-15km/h	Ⅲ
	15-20km/h	Ⅱ		<10km/10	Ⅳ

A. Weight determination method

The n evaluation index of the corresponding evaluation of the main body is defined as $A=(A_1,A_2,\cdots,A_n)$. The initial observation value matrix $A=(A_1,A_2,\cdots,A_n)$ is constructed, and $A^*=[A_1^*,A_2^*,\mathrm{L},A_n^*]$ is obtained after the data is dimensionless. Then, the weight coefficient vector corresponding to each evaluation index is $w_i(i=1,2,\mathrm{L},n)$, and the weight vector matrix $W=[w_1,w_2,\mathrm{L},w_3]^T$ is established accordingly. Finally, the evaluation function of the evaluation object is $y_i=w_i gA_i^*$, if there is $Y=[y_1,y_2,\mathrm{L},y_n]^T$, then $Y=A^*\cdot W$.

As can be seen from the above equation, since A^* is the basic data to be known, the calculated value of Y is determined by the weighting factor. According to the mathematical principle, the matrix A^* is composed of n dimensional vector, the value of the vector of the dimensional vector can be understood as the value of the evaluation object, and the "grade scale-up method" , "As far as possible to distinguish between the differences between the evaluation indicators" principle, it is necessary through the weight coefficient W to achieve the evaluation of the degree of dispersion of the object to maximize the degree of dispersion, that is, the evaluation of the value of the maximum degree of Y dispersion is required. [6].

In summary, we can use the variance of Y to describe, through the calculation can be the following formula $s^2=(y_1-\bar{y})^2=w^T Hw$, where $H=A^{*T}A^*$ is a real symmetric matrix. Therefore, according to the principle of "grade scale-up method", the planning model of the weight coefficient of the evaluation index can be constructed $\max s^2=w^T Hw$, and the constraint condition is $w^T w=1,\ w>0$.

Theorem: If W take the standard eigenvector corresponding to the maximum eigenvalue $\lambda_{\max}$ of H, then $\max s^2=w^T Hw$ obtains the maximum value under the constraint condition: $\max s^2=w^T Hw$ [7].

Therefore, as long as the maximum eigenvalue corresponding to the largest eigenvector of the matrix H is calculated, and the normalization is carried out, the weight $W=(w_1,w_2,\mathrm{L},w_n)^T$ of the evaluation index is obtained, where $\sum_{i=1}^{n} w_i=1$.

IV. Zibo City 1 Bus Post-Evaluation

1)Through the collection of Zibo City 1 bus road passenger transport line intensive transformation of the relevant data, and the evaluation of the rating range and the actual value of the non-dimensional processing to be as shown in table 3.

2) The data and weights of all the indicators obtained by grad scale-up method are also shown in table 3.

Table 3 Data weight table

Criterion layer	Names of Index	Index value	Weights
Efficiency level	Bus sharing rate	4.7%	0.068
	Bus Satisfaction	83	0.167
	Safety	85	0.413
Service level	Average freight	1.25Yuan	0.077
	Vehicle punctuality	2min	0.020
	Average speed of vehicles	19.87	0.010
	Transfer factor	1.25	0.139
	Vehicle full load rate	55%	0.010
	Average travel time	15.6min	0.040
Facility level	Bus network density	2.2.km/km^2	0.034
	Line non-linear coefficient	1.71	0.005
	Average station distance	636 m	0.012
	500 m station coverage	76%	0.021

3) The physical domain of the classical domain is determined. According to the above method, the classical domain matrix is constructed with the benefit level criterion layer as an example, which corresponds to U_{01}, U_{02}, U_{03} and U_{04}, which are excellent, better, qualified and poor.

$$U_{01}=\begin{bmatrix} \text{Excellent} & \text{Bus sharing rate}A_1 & \langle 8\%,\ 10\% \rangle \\ & \text{Bus Satisfaction}A_2 & \langle 80,\ 100 \rangle \\ & \text{Safety}A_3 & \langle 80,\ 100 \rangle \end{bmatrix}$$

$$U_{02}=\begin{bmatrix} \textit{Better} & \text{Bus sharing rate}A_1 & \langle 5\%,\ 8\% \rangle \\ & \text{Bus Satisfaction}A_2 & \langle 60,\ 80 \rangle \\ & \text{Safety}A_3 & \langle 60,\ 80 \rangle \end{bmatrix}$$

$$U_{03}=\begin{bmatrix} \textit{Qualified} & \text{Bus sharing rate}A_1 & \langle 3\%,\ 5\% \rangle \\ & \text{Bus Satisfaction}A_2 & \langle 40,\ 60 \rangle \\ & \text{Safety}A_3 & \langle 40,\ 60 \rangle \end{bmatrix}$$

$$U_{04}=\begin{bmatrix} \textit{Poor} & \text{Bus sharing rate}A_1 & \langle 0,\ 3\% \rangle \\ & \text{Bus Satisfaction}A_2 & \langle 0,\ 40 \rangle \\ & \text{Safety}A_3 & \langle 0,\ 40 \rangle \end{bmatrix}$$

Service level and facilities level in turn corresponding to the establishment of four levels of classical domain matter element matrix, here no longer repeat.

4) Node domain matter matrix. According to the overall scope of the evaluation indicators, the construction of the road passenger line after the intensive transformation of the evaluation system of the domain element, with U_p to represent, as shown in the following formula:

$$U=\begin{bmatrix} \text{On the Intensive Effect of Road Passenger Line} & \textit{Bus sharing rate}A_1 & \langle 0,\ 10\% \rangle \\ & \textit{Bus Satisfaction}A_2 & \langle 0,\ 100 \rangle \\ & \textit{Safety}A_3 & \langle 0,\ 100 \rangle \\ & \textit{Average freight}A_4 & \langle 0,\ 3 \rangle \\ & \textit{Vehicle punctuality}A_5 & \langle 0,\ 6 \rangle \\ & \textit{Average speed of vehicles}A_6 & \langle 0,\ 20 \rangle \\ & \textit{Transfer factor}A_7 & \langle 1,\ 1.5 \rangle \\ & \textit{Vehicle full load rate}A_8 & \langle 95\%,\ 110\% \rangle \\ & \textit{Average travel time}A_9 & \langle 0,\ 40 \rangle \\ & \textit{Bus network density}A_{10} & \langle 1,\ 2.5 \rangle \\ & \textit{Line non-linear coefficient}A_{11} & \langle 1.4,\ 5 \rangle \\ & \textit{Average station distance}A_{12} & \langle 500,\ 1000 \rangle \\ & 500\ m\ \textit{station coverage}A_{13} & \langle 75\%,\ 100\% \rangle \end{bmatrix}$$

5) To determine the objective element matrix to be evaluated: the actual value of each evaluation index is obtained by data collection, collation and calculation. These values are substituted for the domain value of the membership element matrix, and finally the object element U is obtained. The process is as follows:

$$U=\begin{bmatrix} \text{On the Intensive Effect of Road Passenger Line} & \textit{Bus sharing rate}A_1 & \langle 4.7\% \rangle \\ & \textit{Bus Satisfaction}A_2 & \langle 83 \rangle \\ & \textit{Safety}A_3 & \langle 85 \rangle \\ & \textit{Average freight}A_4 & \langle 1.25 \rangle \\ & \textit{Vehicle punctuality}A_5 & \langle 2 \rangle \\ & \textit{Average speed of vehicles}A_6 & \langle 19.87 \rangle \\ & \textit{Transfer factor}A_7 & \langle 1.25 \rangle \\ & \textit{Vehicle full load rate}A_8 & \langle 55\% \rangle \\ & \textit{Average travel time}A_9 & \langle 15.6 \rangle \\ & \textit{Bus network density}A_{10} & \langle 2.2 \rangle \\ & \textit{Line non-linear coefficient}A_{11} & \langle 1.71 \rangle \\ & \textit{Average station distance}A_{12} & \langle 636 \rangle \\ & 500\ m\ \textit{station coverage}A_{13} & \langle 76\% \rangle \end{bmatrix}$$

6) Calculate the overall relevance as shown in table 4.

Table 4 Comprehensive correlation degree table

Grade	I	II	III	IV
Efficiency level	-0.05	-1.22	-1.36	-1.9
Service Level	0.29	-0.33	-0.09	-0.58
Facility level	0.16	0.07	0.07	0.02
Total degree of correlation	2.2	9.61	1.36	-6.11

Analysis of post-evaluation results: from the overall relevance of the situation: to be evaluated object U in the second level, then Zibo City 1 bus road passenger line intensive transformation effect is better.

V. CONCLUSION

A post-evaluation system suitable for the intensive transformation of the road passenger line is established on the basis of the actual situation of the road passenger line. And the scientific rationality of the post evaluation system is demonstrated through examples. The post evaluation system

also applies to post-evaluation of the intensive transformation of the road passenger line in other small and medium-sized cities.

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