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FUZZY COMPREHENSIVE EVALUATION OF CONTAINER TRANSPORTATION MODES ALONG THE CHANGJIANG RIVER MAIN LINE AND ITS DELTA AREA

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ABSTRACT: The Changjiang River (Yangtze) is one of the fastest growth areas of container transportation in China. Rail, road and water transportation have competed against each other for container transportation in the Changjiang River main line and its delta area. It is of significance to assess these different transportation modes scientifically in order to organize container transportation efficiently in this area and make decision for integral plan and construction of transportation system in this area. This paper outlines application of fuzzy comprehensive evaluation to appraise different modes of typical direction of containers. Twelve assessment indexes were decided. Membership functions were formulated. Evaluation results indicated that road transportation was optimal mode in the Changjiang River delta area, however water transportation was the primary way in the Changjiang River main line.
KEY WORDS: container transportation mode; fuzzy comprehensive evaluation; assessment index; the Changjiang River main line and its delta area

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1 INTRODUCTION

The Changjiang River basin is one of the economic developed areas in China. A lot of products are exported in the area each year, and most of them are suitable for container traffic. It is predicted officially that container traffic volume will reach up to 7×10^6 TEUs in 2005 and 10×10^6 TEUs in 2010 (ZHANG, 2000).

Recently, there are three container transportation modes (CTM), including rail, road and water transport, in the Changjiang River main line and its delta area. Moreover, these three modes compete against each other in this area. It is of significance to assess these different transportation modes scientifically in order to organize container transportation efficiently in this area and make decision for integral plan and construction of transportation system in this area (ZHANG *et al*., 2002; ZHU *et al*., 1999).

Evaluation of CTM in the Changjiang River involving many quantitative and qualitative factors is a complicate work (WEI, 2002). It is difficult to consider the characteristics of transportation program in the view of cost and transit time only. Some important influential factors for decision-making, such as transportation availability and timeliness (LIN *et al*., 1993), environment condition (WILLIAM and ALAN, 1994), are difficult to be qualified with conventional evaluation method (BENJAMIN and WOLTER, 2002). For this reason, fuzzy comprehensive evaluation (ZHANG, 2000; HAN *et al*., 2001) is applied to appraising CTM of typical container flow in the Changjiang River main line and its delta.

According to the marketing investigation, the lines from Wuhan to Shanghai in the Changjiang River main line and from Hangzhou to Shanghai in the delta are selected as typical container flows (ZHANG, 1998). Some experts, government officers, shippers, carriers and freight agents were invited to join this evaluation.

2 ARITHMETIC STEPS OF FUZZY COMPREHENSIVE EVALUATION

Fuzzy comprehensive evaluation is the meta-synthesis

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of analytic hierarchy process (AHP) and fuzzy analysis. Arithmetic steps (LIU, 1998) of it are:

Step 1: Establishing the targets assemblage

$$O=\{O_i\},\ i=1, 2,\cdots, k$$

Step 2: Establishing the indexes set

$$U=\{U_i\}, i=1, 2,\cdots, n$$

Step 3: Defining the assessment set

$$V=\{V_i\},\ i=1, 2,\cdots, m$$

Step 4: Establishing the weight subset

$$A=\{A_i\}, i=1, 2,\cdots, n$$

where A_i is the weight of index U_i on set V. And

$$\sum_{i=1}^{n} A_i=1,\ 0<A_i<1$$

Step 5: Calculating the value of membership grade of each evaluating target to each index.

Step 6: Educing the evaluation matrix

$$\underset{\sim}{R}=[r_{ij}], i=1, 2,\cdots, k,\ j=1, 2,\cdots, n$$

where r_{ij} is the value of membership grade of target O_i to index U_j.

Step 7: alculating the evaluating result(matrix)

$$\underset{\sim}{B}=A\cdot\underset{\sim}{R}$$

3 ESTABLISHMENT OF ASSESSMENT INDEXES AND WEIGHTS

Having consulted expert team, 12 assessment indexes and assessment set were decided.These assessment indexes are: input-output ratio of corridor (U_1); transport cost of shipper (U_2); time of arrival (U_3); transport capacity of corridor (U_4); expansion capacity of corridor (U_5); unhindered degree of corridor (U_6); convenience and timeliness (U_7); safety (U_8); energy consumption (U_9); occupation of land (U_{10}); environment protection (U_{11}) (WILLIAM and ALAN, 1994); adaptability to war (U_{12}). Each index is classified into five levels. The assessment set is:

$V=\{V_1$ (the most important), V_2(more important), V_3 (important), V_4(less important), V_5(general)$\}$

According to experts measuring of the importance of each index, the weights of assessment indexes are determined as follows:

$$A=\{A_1(0.0958), A_2(0.0936), A_3(0.0979), A_4(0.0740), A_5(0.0729), A_6(0.0816), A_7(0.0881), A_8(0.0827), A_9(0.0849), A_{10}(0.0827), A_{11}(0.0827), A_{12}(0.0631)\}$$

4 FORMULATING MEMBERSHIP FUNCTION AND FUZZY EVALUATION MATRIX

Based on investigation and analysis, the value of membership grade of each transportation mode relative to index U_2 and U_3 can be described quantitatively by a set of formulate membership function (ZHANG , 2000) as following:

$$\mu(U_2)=\begin{cases}1-\sqrt{\dfrac{U_2}{15000}} & 0\leqslant U_2<15000\\ 0 & U_2\geqslant 15000\end{cases}$$

$$\mu(U_3)=\frac{1}{U_3} \qquad U_3>0$$

Other values of membership grade of each transportation mode relative to other indicators are calculated on the questionnaire for experts. Then, we can educe the evaluation matrix $\underset{\sim}{R}$, as follows:

The evaluation matrix $\underset{\sim}{R}$ of CTM along the Changjiang River main line (Wuhan–Shanghai)

	Rail	Road	Water
U_1	0.6750	0.5875	0.7500
U_2	0.6125	0.3072	0.6000
U_3	0.2000	0.5000	0.1667
U_4	0.6250	0.5875	0.8250
U_5	0.4750	0.4750	0.8000
U_6	0.7000	0.6000	0.7875
U_7	0.6625	0.8625	0.7250
U_8	0.7625	0.7375	0.7625
U_9	0.7250	0.4750	0.8000
U_{10}	0.4875	0.4750	0.8250
U_{11}	0.7250	0.7000	0.8000
U_{12}	0.4750	0.7000	0.8000

The evaluation matrix $\underset{\sim}{R}$ of CTM in the delta (Hangzhou–Shanghai)

	Rail	Road	Water
U_1	0.5625	0.6000	0.7000
U_2	0.7392	0.6806	0.8156
U_3	0.5000	0.9090	0.4000
U_4	0.7125	0.7125	0.7625
U_5	0.5125	0.5125	0.5875
U_6	0.6375	0.6625	0.6750
U_7	0.6375	0.8875	0.7125
U_8	0.7375	0.7625	0.7875
U_9	0.7000	0.6500	0.8000
U_{10}	0.5375	0.5125	0.8250
U_{11}	0.7375	0.7500	0.8000
U_{12}	0.4750	0.7500	0.8000

5 EVALUATION RESULTS

According to the theory of fuzzy comprehensive evaluation, the evaluation model is:

$$\underset{\sim}{B}=A\cdot\underset{\sim}{R}$$

The evaluation results can be gotten from matrix $\underset{\sim}{B}$ (Table 1).

Table 1 The evaluation results of CTM

	Rail	Road	Water
Along the Changjiang River main line (Wuhan–Shanghai)	(0.5928	0.5796	0.6977*)
In the Changjiang River delta (Hangzhou–Shanghai)	(0.6608	0.7025*	0.6990)

"*" is the optimal mode

The evaluation results show that road is the first mode to transport containers in the Changjiang River delta, however inland waterway transport predominates in the long distance transportation along the Changjiang River main line.

6 CONCLUSIONS

This study has demonstrated that fuzzy comprehensive evaluation provides a feasible and effective method to comprehensively appraise CTM. The evaluating results are reasonable.

Road has more advantage in short distance transport owing to its convenient shipment and a shorter delivery time, but is not fit for the large numbers of containers transporting in the long distance because of more expensive cost and the more damages to environment.

Container transportation has developed in inland waterway for some decades. It has already become primary way in the Changjiang River main line due to its perfect through transport service, low cost and less environment influence etc.

Rail does not bring the advantage of quick speed into full play because of the problems in connecting with ports and marine shipping, especially limited carrying capacity on the line. So, rail should focus on the through transport connecting to the other ways, perfect operation and facilities, and improve the quality of service as soon as possible.

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