

# Comprehensive Evaluation of Transport Channel Based on AHP Method

—As Chang-Zhu-Tan Urban Agglomeration for Example

Yishun Tian

School of Transport

Wuhan University of Technology

Wuhan, P.R.China

E-mail: athen2003@163.com

**Abstract**—Facing with the problems of both realizing development of the transportation and restraint of the environment and the resources, this paper analyzes current situation of transportation of Changsha-Zhuzhou-Xiangtan urban agglomeration and makes comprehensive evaluation on transport channel based on AHP. The evaluation indicators and methods provided the appraisal target and the method for the traffic department to make scientific decisions.

**Keywords**—Chang-Zhu-Tan Urban Agglomeration; Transport channel; AHP method; Evaluation

## I. INTRODUCTION

With acceleration of globalization, urban agglomeration facilitates the intensification of regional economic competition. In order to speeding up the construction of resource-conservation and environment-friendly society, National Development and Reform Commission have already consented to the decision of Changsha-Zhuzhou-Xiangtan urban agglomeration in December 2007. The regional economy of Changsha-Zhuzhou-Xiangtan urban agglomeration has been developed during those years. But it is inevitable that resources occupation, energy consumption

and environmental pollution disturbed robust development of regional economy and the improvement of people's living conditions[1].

## II. COMPREHENSIVE EVALUATION FOR TRANSPORT CHANNEL OF CHANGSHA-ZHUZHOU-XIANGTAN URBAN AGGLOMERATION

### A. Index data collection

Before the comprehensive evaluation of Changsha-Zhuzhou-Xiangtan urban agglomeration transport channel by Data Envelopment Analysis (DEA), we should selection decision unit according to the actual situation of Changsha-Zhuzhou-Xiangtan. We collected the following eleven main decision unit by the Changsha-Zhuzhou-Xiangtan urban agglomeration comprehensive transportation network characteristic, with Changsha-Zhuzhou-Xiangtan three major cities for node, combined with Channel identification results and on the basis of the main transportation channels trend. The selection of decision making units and numbers are shown in table 4.

TABLE I. THE SELECTION OF DECISION MAKING UNITS AND NUMBERS

number	Decision unit	Decision making unit location
1	Changsha West Channel	Changsha west through Ningxiang
2	Changsha East Channel	Changsha east through Liuyang
3	Changsha North Channel	Changsha north direction
4	Xiangtan West Channel	Xiangtan west through Xiangxiang
5	Xiangtan to Zhuzhou Channel	Xiangtan to Zhuzhou
6	Zhuzhou East Channel	Zhuzhou East through Liling
7	Changsha to Xiangtan Channel	Changsha to Xiangtan
8	Changsha to Zhuzhou Channel	Changsha to Zhuzhou
9	Xiangtan South Channel	South direction of Xiangtan
10	Zhuzhou South Channel	South direction of Zhuzhou
11	Liuyang and Liling South-North Channel	North-South channel through Liuyang and Liling

Establishment of evaluation index system structure was suitable for data envelopment method according to data collection and questionnaire survey and related statistical data after determine decision unit.

### B. Index Pretreatment

We should put the index pretreatment on index data standardization and the standardized processing in order to reflect

the real situation as far as possible. Preprocessing results are shown in Table 5.

TABLE II. INDEX PREPROCESSING RESULTS

Decision Unit	1	2	3	4	5	6	7	8	9	10	11
$X_{11}$	60	69	60	69	83	64	78	62	60	69	60
$X_{12}$	69	64	71	60	60	100	65	71	85	96	73
$X_{13}$	60	61	74	71	100	70	67	69	66	61	92
$X_{21}$	77	82	76	100	96	77	96	70	80	83	89
$X_{22}$	60	65	75	100	87	61	81	58	67	72	80
$X_{23}$	89	60	82	75	100	82	89	96	89	60	67
$X_{24}$	89	100	80	100	100	91	89	100	77	87	100
$X_{31}$	80	100	74	100	100	64	70	60	64	97	94
$X_{32}$	96	71	96	71	64	85	60	71	100	85	71
$X_{33}$	64	80	69	91	89	60	97	75	66	100	97
$X_{34}$	65	100	60	65	65	65	60	65	60	65	70
$Y_{11}$	70	68	67	73	83	73	70	71	72	95	100
$Y_{12}$	69	64	71	60	60	100	65	71	85	96	73
$Y_{13}$	89	100	83	79	89	82	60	92	90	90	89
$Y_{14}$	61	63	60	76	68	67	59	74	67	80	72
$Y_{21}$	63	72	64	70	77	64	61	64	60	67	62
$Y_{22}$	71	79	68	84	82	100	66	84	79	76	74
$Y_{23}$	78	98	100	69	87	60	62	93	63	80	71
$Y_{24}$	60	89	79	84	97	66	83	62	86	98	68

### C. DEA evaluation based on the AHP

#### 1) Determine the weight

According to the Changsha-Zhuzhou-Xiangtan urban agglomeration transport channel development influence analysis and relevant experts to issuing questionnaires, we get at all levels of judgment matrix are showed as follows, including judgment matrix of Infrastructure investment index in Table 6, transport channel structure index in Table 7, resources and environment

restriction in Table 8, transport efficiency indicators in Table 9, transportation service index in Table 10. Then build Comprehensive index system is showed in Table 11.

TABLE III. FACTORS OF JUDGMENT MATRIX OF INFRASTRUCTURE INVESTMENT INDEX

Factors	$X_{11}$	$X_{12}$	$X_{13}$	Priority Vector
$X_{11}$	1	3	1/2	0.4761
$X_{12}$	1/3	1	2	0.2442
$X_{13}$	2	1/2	1	0.2797

TABLE IV. FACTORS OF JUDGMENT MATRIX OF TRANSPORT CHANNEL STRUCTURE INDEX

Factors	$X_{21}$	$X_{22}$	$X_{23}$	$X_{24}$	Priority Vector
$X_{21}$	1	2	1/2	1/2	0.2178

$X_{22}$	1/2	1	1/3	1/3	0.2346
$X_{23}$	2	3	1	1	0.2693
$X_{24}$	2	3	1	1	0.2783

TABLE V. FACTORS OF JUDGMENT MATRIX OF RESOURCES AND ENVIRONMENT RESTRICTION

Factors	$X_{31}$	$X_{32}$	$X_{33}$	$X_{34}$	Priority Vector
$X_{31}$	1	1/3	1	1/4	0.1171
$X_{32}$	3	1	3	4	0.5773
$X_{33}$	1	1/3	1	1/2	0.1392
$X_{34}$	4	1/4	2	1	0.1664

TABLE VI. FACTORS OF JUDGMENT MATRIX OF TRANSPORT EFFICIENCY INDICATORS

Factors	$Y_{11}$	$Y_{12}$	$Y_{13}$	$Y_{14}$	Priority Vector
$Y_{11}$	1	2	5	4	0.5107
$Y_{12}$	1/2	1	3	3	0.2831
$Y_{13}$	1/5	1/3	1	1	0.0924
$Y_{14}$	1/4	1/3	1	1	0.1018

TABLE VII. FACTORS OF JUDGMENT MATRIX OF TRANSPORTATION SERVICE INDEX

Factors	$Y_{21}$	$Y_{22}$	$Y_{23}$	$Y_{24}$	Priority Vector
$Y_{21}$	1	3	1/2	1/4	0.2577
$Y_{22}$	1/3	1	3	3	0.2474
$Y_{23}$	2	1/3	1	1	0.1985
$Y_{24}$	4	1/3	1	1	0.2964

TABLE VIII. COMPREHENSIVE INDEX SYSTEM WEIGHT

Category	Target layer	Index layer	Weight
Input Index $X$	Infrastructure Investment ( $X_1$ )	Connectivity of Channel Transportation Network ( $X_{11}$ )	0.4761
		Social Applicability of Channel Transportation Network ( $X_{12}$ )	0.2442
		Intensity of Channel Transportation Network ( $X_{13}$ )	0.2797
	Transport Channel Structure ( $X_2$ )	Suitable Degree of Transportation Network ( $X_{21}$ )	0.2178
		Equilibrium Coefficient of Comprehensive Supply ( $X_{22}$ )	0.2346
		Matching Degree of Transport Capacity ( $X_{23}$ )	0.2693
		Transfer Time ( $X_{24}$ )	0.2783
	Resources and Environment Restriction ( $X_3$ )	Noise Effect ( $X_{31}$ )	0.1171
		Atmospheric Effects ( $X_{32}$ )	0.5773
		The Bearing Capacity of Land Resources ( $X_{33}$ )	0.1392
		The Bearing Capacity of Energy Resources ( $X_{34}$ )	0.1664

Output Index  $Y$	Channel Transportation Efficiency ( $Y_1$ )	Channel Passenger Turnover ( $Y_{11}$ )	0.5107
		Channel Passenger Density ( $Y_{12}$ )	0.2831
		Channel Transportation Speed ( $Y_{13}$ )	0.0924
		Safety Index ( $Y_{14}$ )	0.1018
	Channel Transportation Technology level ( $Y_2$ )	Channel Flow ( $Y_{21}$ )	0.2577
		Channel Capacity ( $Y_{22}$ )	0.2474
		Channel Saturation ( $Y_{23}$ )	0.1985
		Channel Traffic Flow Density ( $Y_{24}$ )	0.2964

### 2) Colligate index of decision making unit

Because the index that we can choose is more, using the DEA method for Changsha-Zhuzhou-Xangtan urban agglomeration transport channel for comprehensive evaluation is certain difficult. Therefore we need to select appropriate comprehensive index and use the comprehensive index to analysis on DEA. The comprehensive index method is as follows:

$$z_i^k = \sum_j w_{ij} \sigma_{ij}^k \quad (1)$$

$z_i^k$  on behalf of weight of the first  $i$  comprehensive index in the first  $k$  decision unit;  $w_{ij}$  means weight of the first  $i$  comprehensive index in the first  $j$  index;  $\sigma_{ij}^k$  presents value at comprehensive index  $i$  the  $k$  decision unit, which is made by standardized of  $j$  index.

According to the comprehensive index method and the front of the index of each branch, we can get the index system of comprehensive value as follows in Table 12.

TABLE IX. COMPREHENSIVE VALUE OF EACH DECISION UNIT INDEX

Decision Unit	1	2	3	4	5	6	7	8	9	10	11
$X_1$	62.20	65.54	66.60	67.36	82.14	74.47	71.75	66.16	67.78	73.36	72.13
$X_2$	79.58	77.10	78.49	93.27	96.08	78.49	88.65	82.54	78.54	75.34	84.03
$X_3$	84.51	80.47	83.68	76.18	71.86	75.73	66.32	69.27	84.40	85.17	77.15
$Y_1$	69.72	68.50	68.09	69.30	74.52	79.99	65.70	72.39	75.97	92.15	87.29
$Y_2$	67.07	83.93	76.58	77.41	86.15	72.71	68.96	74.11	73.00	81.00	68.53

### 3) Solving DEA model

We use DEA model with AHP restraint and by means of system analysis software to solve the value of decision making unit transport channel efficiency index  $\theta_j^*$ , the input index of the

slack variable  $s_j^-$ , output index of the surplus variable  $s_j^+$  and judgement index  $\lambda_j^*$ . The results can be seen in table 13.

TABLE X. THE RESULTS OF DEA MODEL SOLVING

Decision Unit	1	2	3	4	5	6	7	8	9	10	11
$\theta_{1j}^*$	0.89	0.98	1.00	0.95	0.94	0.97	0.99	0.96	1.00	1.00	1.00
Scale Effect	Rise	Rise	invariant	Rise	Rise	Rise	Rise	Rise	invariant	invariant	invariant
Slack Variable	12.7	10.8	0	0	0	0	10.2	7.2	0	0	0
	0	0	0	6.85	0	0	6.8	0	0	0	0
	0	0	0	0	0	4.36	0	0	0	0	0
Surplus Variable	0	0	0	6.1	0	0	0	5.4	0	0	0
Variable	0	0	0	0	9.4	0	0	0	0	0	0

We can see transport channel 3, 9, 10, 11 for DEA efficient and the rest of the decision units for non DEA efficient from the table according to DEA validity judgement theorem. That is to say, Changsha North Channel= Xiangtan South Channel= Zhuzhou South Channel= Liuyang and Liling South-North Channel> Changsha West Channel> Changsha East Channel> Xiangtan West Channel> Xiangtan to Zhuzhou Channel> Zhuzhou East Channel> Changsha to Xiangtan Channel>

Changsha to Zhuzhou Channel in Changsha-Zhuzhou-Xiangtan urban agglomeration transport channel of the relative efficiency. We can find out the difference between input and output index and achieve DEA efficient input and output index by calculating effective front face "projection" of the non DEA efficient decision unit. The specific conditions of Changsha-Zhuzhou-Xiangtan urban agglomeration transport channel's input and output deficit of each decision unit was shown in table 14.

TABLE XI. INPUT SURPLUS AND OUTPUT DEFICIT SITUATION

Decision Unit		1	2	3	4	5	6	7	8	9	10	11
Input Surplus	$\Delta x_1$	0	0	0	1.2	6.5	2.1	0	0	0	0	0
	$\Delta x_2$	0.31	0.24	0	0	2.4	0	0	0	0	0	0
	$\Delta x_3$	0.94	0.78	0	1.2	0	1.4	2.4	2.2	0	0	0
Output Deficit	$\Delta y_1$	10.2	9.8	0	0	1.4	1.3	11.5	10.8	0	0	0
	$\Delta y_2$	9.4	8.5	0	2.5	0	0	8.7	9.5	0	0	0

### III. RESULTS

Input surplus and output deficit provides direction for improving the channel service level, raising the level of technology and strengthening the internal rational configuration of decision unit. We can safely draw a conclusion combined with input surplus and output deficit situation and related index weight. The traffic conditions of main line are poor. The join between comprehensive transportation channel and comprehensive transportation hub is backward. The traffic hub's function of highway, railway, airport, waterways and so on in Changsha-Zhuzhou-Xiangtan Urban Agglomeration needs a further review. It is the lack of reasonable division and effective cohesion of different mode of transport which reduce the overall efficiency and service quality of the comprehensive transportation system. Railway, highway, shipping, aviation and other transportation modes are self-contained, each other is not closely linked[4], and they do not form a complementary organic whole. It is disconnection between the traffic hub city and traffic inside and outside. They didn't realize the effective cohesion.

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