Appraisal of Logistics Enterprise Competitiveness on the Basis of Fuzzy Analysis Algorithm

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Abstract: In the paper, we set up an appraisal index system of enterprise competitiveness integrated with enterprise reality in China. Whether a certain enterprise's concrete index by using fuzzy analysis algorithm is weak or strong can be derived from sending out questionnaires to experts for them to investigate and mark scores. In the paper a comprehensive fuzzy appraisal model on competitiveness is set up. The fundamental model and thinking of two-level comprehensive fuzzy appraisal of competitiveness is given by using fuzzy mathematical method on the basis of the index system of competitiveness and the identification of competitiveness. We take a logistics enterprise in Heilongjiang (Enterprise A) for empirical analysis. The outcome agrees with the reality, which verifies the model's validity. [The Journal of American Science. 2005;1(2):82-89].

Key words: fuzzy analysis; logistics enterprises; competitiveness

1 Foreword

Under the situation of the trend of present economic globalization enhancing day by day and China's entry to WTO, the competition environment logistics enterprises facing has changed a lot in China. Domestic and regional competition turns into global competition; common cost and scale competition into ability-acquisition and creativity competition. That requires logistics enterprises in China to improve their service quality, explore management innovations, improve management level and strengthen the competitive power, to parallel international market and become part of the world economy market.

Fuzzy analysis is a kind of semi-quantitative analysis method applying to a multi-factor incident, which is not appropriate to quantitative analysis. It can express some kind of qualitative description and people's judgment in quantitative form by the way of membership to determine the risk level of system in fuzzy figuring. The method can check and reduce people's subjective influence to some extent, and thus the analysis gets more scientific. Appraisal on enterprise's competitiveness is a typical comprehensive multi-index and multi-level problem, which is affected by many factors, most of which are uncertain. The index determining has qualitative and subjective color, namely fuzzy. Therefore it's appropriate to apply fuzzy algorithm theory to such kind of questions by quantitative description. In the paper we adopt multi-level fuzzy analysis algorithm to appraise logistics enterprise competitiveness.

2 Setting up Model of Fuzzy Algorithm Appraisal

2.1 Setting up Appraisal Index System

To make the appraisal of logistics enterprise competitiveness correct and effective, we set up multi-factor appraisal index system by dividing factors, which affect the designing plan of logistics centre into two levels according to their attributes. The appraisal index is as follows:

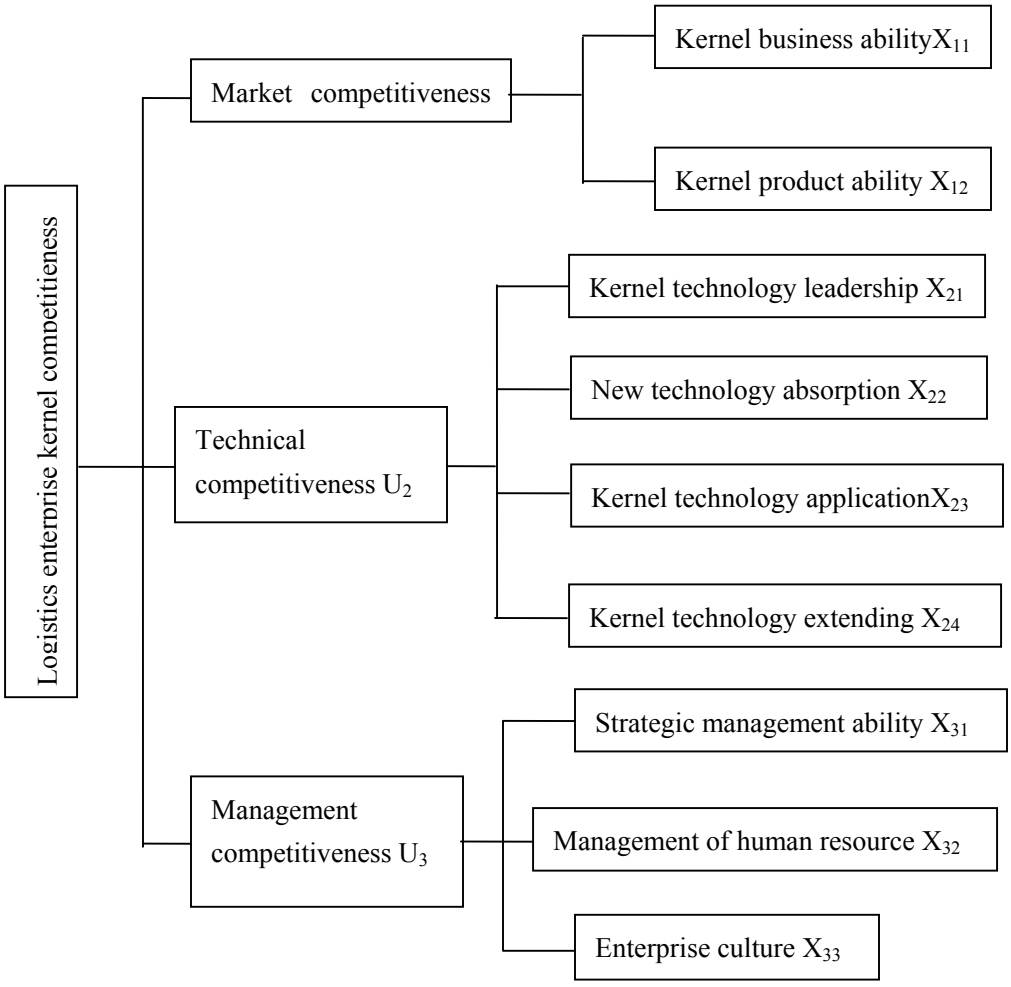

Figure 1. Appraisal Index of Logistics Enterprise Competitiveness

2.2 Setting up Appraisal Model

We can set up the comprehensive model of enterprise competitiveness appraisal. The concrete procedure is as follows:

(1) Suppose U is factor set

$U=\{U_1, U_2, U_3\}$,

where

$U_1=\{X_{11}, X_{12}\}$

$U_2=\{X_{21}, X_{22}, X_{23}, X_{24}\}$

$U_3=\{X_{31}, X_{32}, X_{33}\}$

V is appraisal set.

$V=\{Y_1, Y_2, Y_3, Y_4\}=\{$strong, semi-strong, average, weak$\}$.

(2) Weight number

We can get the weight number vector of X_{ij} to U_i, N_i ($i=1, 2, 3$) by expert's comprehensive appraisal and AHP method,

where $N_1=[N_{11} \quad N_{12}]$

$N_2=[N_{21} \quad N_{22} \quad N_{23} \quad N_{24}]$

$N_3=[N_{31} \quad N_{32} \quad N_{33}]$.

Additional, we can get r_{ijt} which stands for the degree of X_{ij} subjective to Y_t by fuzzy statistics and we form a vector set R_i ($i=1, 2, 3$)

$$R_1=\begin{bmatrix} r_{111} & r_{112} & r_{113} & r_{114} \\ r_{121} & r_{122} & r_{123} & r_{124} \end{bmatrix}$$

$$R_2=\begin{bmatrix} r_{211} & r_{212} & r_{213} & r_{214} \\ r_{221} & r_{222} & r_{223} & r_{224} \\ r_{231} & r_{232} & r_{233} & r_{234} \\ r_{241} & r_{242} & r_{243} & r_{244} \end{bmatrix}$$

$$R_3=\begin{bmatrix} r_{311} & r_{312} & r_{313} & r_{314} \\ r_{321} & r_{322} & r_{323} & r_{324} \\ r_{331} & r_{332} & r_{333} & r_{334} \end{bmatrix}$$

Considering main factors of competitiveness being emphasized, we take operator as M（*， v），then

$$B_t = N_t \bullet R_t = [b_{i1} \quad b_{i2} \quad b_{i3} \quad b_{i4}]$$

(3) Second level appraisal

Like the above, we get the weight number of C to A by expert's marking and AHP method.

$$C = [C_1 \quad C_2 \quad C_3]$$

Besides, we can also get b_{ij} which stands for the degree of U_t subjective to Y_t and we form a judgment matrix

$$R = \begin{bmatrix} B_1 \\ B_2 \\ B_3 \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} \\ b_{21} & b_{22} & b_{23} & b_{24} \\ b_{31} & b_{32} & b_{33} & b_{34} \end{bmatrix}$$

Then we get second level appraisal vector

$$B = C \bullet R = [b_1 \quad b_2 \quad b_3 \quad b_4]$$

where $b_t = c_1 \cdot b_{1t} \vee c_2 \cdot b_{2t} \vee c_3 \cdot b_{3t}$.

(4) Appraisal judgment

We get $B' = [b_1' \quad b_2' \quad b_3' \quad b_4']$ by reducing $B = [b_1 \quad b_2 \quad b_3 \quad b_4]$ to unity. Then we can judge the enterprise competitiveness according to the maximum membership principle.

3 Empirical Analysis

The above analysis founds the theory basis for empirical analysis of logistics enterprise competitiveness appraisal. Now we analyze the competitiveness appraisal of a logistics enterprise in Heilongjiang province empirically by applying fuzzy analysis algorithm.

3.1 Competitiveness Identification

3.1.1 Investigation and Calculation of Index Weight Number

According to the above, we should make sure competitiveness index weight number before appraising a certain enterprise in setting up an appraisal model. For this sake, we invite 12 specialists including senior executives in industry, experts in academic circle and other people to appraise the importance among indexes by AHP method associating with internal attributes of competitiveness.

(1) Calculating on the weight number of market competitiveness, management competitiveness and technology competitiveness to enterprise competitiveness.

According to the investigation, the appraisal outcome of 5 experts in Group A and 7 in Group B is shown by Table 1.

Table 1. Table of Index Weight Number Appraisal of AHP Method

	Market competitiveness		Technical competitiveness		Management competitiveness		Sequencing vector	
	A	B	A	B	A	B	A	B
Market competitiveness	1	1	1	1	0.5	1	0.25	1
Technical competitiveness	1	1	1	1	0.5	1	0.25	1
Management competitiveness	2	1	2	1	1	1	0.5	1

The sequencing vector in Table 1 is derived from judgment matrix of AHP method by the way of square root law. Its concrete procedure is as follows.

① Numbers multiplied in every line one by one, then above

② Reduction to unity of the above outcome as vector to get the estimated sequencing vector

Other index sequencing vector's calculating is the same, so we leave out the concrete procedures.

The procedure of estimating judgment matrix consistency in Table 1 is as follows.

① The transposed matrix of judgment matrix is right multiplied by sequencing vector to get a new vector.

$$[0.25 \quad 0.25 \quad 0.5]\begin{bmatrix} 1 & 1 & 2 \\ 1 & 1 & 2 \\ 0.5 & 0.5 & 1 \end{bmatrix} = [0.75 \quad 0.75 \quad 1.5]$$

② Every number in the new vector is divided by every according number in sequencing vector to get another vector.

$$\left[\frac{0.75}{0.25} \quad \frac{0.75}{0.25} \quad \frac{1.5}{0.5}\right] = [3 \quad 3 \quad 3]$$

③ The total by summing every number in the vector divided by the number of to get an approximate value for the maximum character root λ_{max}.

$$\lambda_{max} = (3+3+3)/3 = 3$$

④ Calculating the compatibility index C.I.

$$\text{C.I.} = (\lambda_{max} - n)/(n-1) = (3-3)/(3-1) = 0$$

⑤ Calculating the random compatibility ratio C.R

$$\text{C.R.} = C.I./R.I. = 0/0.58 = 0$$

Finally, we judge the matrix compatibility. The judgment matrix has satisfactory consistency because of C.R.=0〈0.1.

The weight number consistencies of other judgment matrixes are done as the above procedure. Though they are not given, the calculating outcomes show that judgment matrixes are of comparatively satisfactory consistency.

Out of 12 experts, 5 get the judgment outcome as Table 1 and 7 as Table 2. We can work out the according index weight number 0.3：0.3：0.4 i.e., the weight numbers of market competitiveness, technology competitiveness and management competitiveness to enterprise competitiveness are 0.3，0.3，0.4 respectively. Then we get C = ［0.3　0.3　0.4］.

(2) Calculating weight numbers of kernel business capability and kernel product capability to market competitiveness.

According to the investigating outcome, the appraisal outcome of 2 experts in Group A, 8 in Group B and 2 in Group C is shown by Table 2.

Table 2. Table of Index Weight Number Appraisal of AHP Method

	Kernel business ability			Kernel product ability			Sequencing Vector		
	A	B	C	A	B	C	A	B	C
Kernel business ability	1	1	1	2	1	0.5	0.67	0.5	0.33
Kernel product ability	0.5	1	2	1	1	1	0.33	0.5	0.67

We can calculate the according index weight numbers as follows:

$$\frac{0.67\times 2 + 0.5\times 8 + 0.33\times 2}{12} = 0.5$$

$$\frac{0.33\times 2 + 0.5\times 8 + 0.67\times 2}{12} = 0.5$$

namely, weight numbers of kernel business capability and kernel product capability to market competitiveness are 0.5、0.5 respectively. Then we get N_1＝[0.5　0.5].

(3) Calculating weight numbers of the degree of kernel technology leadership, new technology absorption ability, kernel technology application ability and kernel technology extending ability to technology competitiveness.

According to the investigation, the appraisal outcome of 12 experts is shown by Table 3, i.e. the weight numbers are 0.3、0.2、0.2、0.3 respectively. Thus we get N_2＝[0.3　0.2　0.2　0.3].

(4) Calculating weight numbers of strategic management ability, human resource management ability and enterprise culture to management competitiveness

According to the investigation, the appraisal outcome of 6 experts in Group A and 6 in Group B is shown by Table 4.

Table 3. Table of Index Weight Number Appraisal of AHP Method

	Kernel technology leadership	New technology absorption	Kernel technology application	Kernel technology extending	Sequencing vector
Kernel technology leadership	1	2	2	1	0.3
New technology absorption	0.5	1	1	0.5	0.2
Kernel technology application	0.5	1	1	0.5	0.2
Kernel technology extending	1	2	2	1	0.3

Table 4. Table of Index Weight Number Appraisal of AHP Method

	Strategic management ability		Management of human resource		Enterprise culture		Sequencing Vector	
	A	B	A	B	A	B	A	B
Strategic management ability	1	1	2	1	2	1	0.5	0.33
Management of human resource	0.5	1	1	1	1	1	0.25	0.33
Sequencing vector	0.5	1	1	1	1.	1	0.25	0.33

Accordingly we get the weight numbers as follows:

$$\frac{0.5 \times 6 + 0.33 \times 6}{12} \approx 0.4$$

$$\frac{0.25 \times 6 + 0.33 \times 6}{12} \approx 0.3$$

$$\frac{0.25 \times 6 + 0.33 \times 6}{12} \approx 0.3$$

i.e. weight numbers of strategic management ability, human resource management ability and enterprise culture to management competitiveness are 0.4、0.3、0.3 respectively. Thus we get N_3=［0.4 0.3 0.3］.

3.1.2 Identification of Concrete Index for Logistics Enterprise A's Competitiveness

Experts are invited to appraise enterprise competitiveness identification to get the maximum scores of identification, besides they have appraised index weight numbers.

According to the investigation, the appraisal outcome of 8 experts in Group A and 4 in Group B is shown by Table 5.

Table 5. Table of Appraised Maximum Scores of Competitiveness Identification of AHP Method

	advance		malleability		historical dependence		value		Sequencing vector	
	A	B	A	B	A	B	A	B	A	B
advance	1	1	2	2	1	2	1	1	0.286	0.333
malleability	0.5	0.5	1	1	0.5	1	0.5	0.5	0.142	0.167
historical dependence	1	0.5	2	1	1	1	1	0.5	0.286	0.167
value	1	1	2	2	1	2	1	1	0.286	0.333

The according index weight numbers are

$$\frac{0.286\times 8+0.333\times 4}{12}\approx 0.30$$

$$\frac{0.142\times 8+0.167\times 4}{12}\approx 0.15$$

$$\frac{0.286\times 8+0.167\times 4}{12}\approx 0.25$$

$$\frac{0.286\times 8+0.333\times 4}{12}\approx 0.30$$

i.e. the identifications of competitiveness are that the maximum scores of advance, malleability, historical dependence and value are $0.3\times 100=30$, $0.15\times 100=15$, $0.25\times 100=25$ and $0.3\times 100=30$ respectively. On the basis of the above, we combine every expert's advice to determine the proportion attributed to appraisal "strong, semi-strong, average, weak" in each identification and comprehensive appraisal, which is shown by Table 6.

Thus, we can identify the competitiveness of the logistics enterprise concretely through the identification of competitiveness. If an expert's appraisal of advance, malleability, historical dependence and value are 20, 12, 18 and 24 respectively, the total score is 64, which is included in "semi-strong" range. So the competitiveness of the enterprise is appraised as "semi-strong". If 100 experts are invited, 12 of whom appraise the competitiveness index as "strong", 60 "semi-strong", 20 "average" and 8 "weak", the membership of the appraisal set of the enterprise market competitiveness is R＝{0.12，0.60，0.20，0.08}.

Table 6. Table of Index Appraisal Based on Identification

identification	appraisal			
	strong	semi-strong	average	weak
advance	Obvious leadership in industry 25-30	Inferior to leadership 18-24	Middle level in industry 12-17	Obvious behind others 0-11
malleability	Great influence in many fields 13-15	Influence in some fields 9-12	Middle level in industry 6-8	No influence 0-5
historical dependence	Most difficult to imitate 21-25	More difficult to imitate 16-20	Imitate at great cost 11-15	Imitate easily 0-10
value	Obvious profit advantage 24-30	Fairly good profit 18-23	Middle level in industry 12-17	Profit disadvantage 0-11
Comprehensive appraisal	81-100	61-80	41-60	0-40

4 Example for Calculating and Analysis

On the basis of the above analysis of the investigation, we appraise the competitiveness of the enterprise through appraisal model we have set up. The concrete procedure is as follows.

We get the weight number vector of X to U

$N_1=[N_{11} \quad N_{12}]=[0.5 \quad 0.5]$

$N_2=[N_{21} \quad N_{22} \quad N_{23} \quad N_{24}]=[0.3 \quad 0.2 \quad 0.2 \quad 0.3]$

$N_3=[N_{31} \quad N_{32} \quad N_{33}]=[0.4 \quad 0.3 \quad 0.3]$

and the weight number vector of U to A

$C=[C_1 \quad C_2 \quad C_3]=[0.3 \quad 0.3 \quad 0.4]$ from Figure 1.

We get the appraisal membership matrix of the index factor X_{ij} to the appraisal set V

$$R_1=\begin{bmatrix}0.200 & 0.100 & 0.450 & 0.250\\ 0.175 & 0 & 0.275 & 0.500\end{bmatrix}$$

$$R_2=\begin{bmatrix}0.125 & 0.200 & 0.175 & 0.500\\ 0.200 & 0.200 & 0.400 & 0.200\\ 0.325 & 0.025 & 0.575 & 0.075\\ 0.375 & 0.050 & 0.500 & 0.075\end{bmatrix}$$

$$R_3=\begin{bmatrix}0.025 & 0.175 & 0.050 & 0.750\\ 0 & 0.425 & 0 & 0.575\\ 0 & 0.250 & 0.050 & 0.700\end{bmatrix}$$

Then

$$B_1=N_1\bullet R_1=[0.5 \quad 0.5]\begin{bmatrix}0.200 & 0.100 & 0.450 & 0.250\\ 0.175 & 0 & 0.275 & 0.550\end{bmatrix}$$

$$B_2=N_2\bullet R_2=[0.3 \quad 0.2 \quad 0.2 \quad 0.3]\begin{bmatrix}0.125 & 0.200 & 0.175 & 0.500\\ 0.200 & 0.200 & 0.400 & 0.200\\ 0.325 & 0.025 & 0.575 & 0.075\\ 0.375 & 0.050 & 0.500 & 0.075\end{bmatrix}$$

$$=[0.113 \quad 0.060 \quad 0.150 \quad 0.150]$$

$$B_3=N_3\bullet R_3=[0.4 \quad 0.3 \quad 0.3]\begin{bmatrix}0.025 & 0.175 & 0.050 & 0.750\\ 0 & 0.425 & 0 & 0.575\\ 0 & 0.250 & 0.050 & 0.700\end{bmatrix}$$

$$=[0.010 \quad 0.128 \quad 0.020 \quad 0.300]$$

Then the single-factor appraisal matrix of U is

$$R=N_3\bullet R_3=[0.4 \quad 0.3 \quad 0.3]\begin{bmatrix}0.025 & 0.175 & 0.050 & 0.750\\ 0 & 0.425 & 0 & 0.575\\ 0 & 0.250 & 0.050 & 0.700\end{bmatrix}$$

$$=[0.010 \quad 0.128 \quad 0.020 \quad 0.300]$$

The multi-factor appraisal matrix of U is

$$R=\begin{bmatrix}B_1\\ B_2\\ B_3\end{bmatrix}=\begin{bmatrix}0.100 & 0.050 & 0.225 & 0.275\\ 0.113 & 0.060 & 0.150 & 0.150\\ 0.010 & 0.128 & 0.020 & 0.300\end{bmatrix}$$

$$B=[b_1 \quad b_2 \quad b_3 \quad b_4] = C \bullet R = [0.3 \quad 0.3 \quad 0.4] \begin{bmatrix} 0.100 & 0.050 & 0.225 & 0.275 \\ 0.113 & 0.060 & 0.150 & 0.150 \\ 0.010 & 0.128 & 0.020 & 0.300 \end{bmatrix}$$

$$=[0.034 \quad 0.051 \quad 0.068 \quad 0.120]$$

Through reduction to unity and assuming $b_t = \frac{b_t}{\sum_{t=1}^{4} b_t}$, we get

$$B' = [b_1' \quad b_2' \quad b_3' \quad b_4'] = [0.124 \quad 0.187 \quad 0.248 \quad 0.441]$$

We can draw the conclusion according to B.

The membership numbers of the competitiveness of the enterprise to Y_1（strong）, Y_2, Y_3 and Y_4 are 12.4%, 18.7％, 24.8％ and 44.1％ respectively. According to the principle of maximum membership, we appraise the competitiveness of the enterprise as “weak”.

5 Conclusion

Finally we can work out the competitiveness of an enterprise by appraising through the comprehensive fuzzy appraisal method, which proves to be a reasonable one. The method takes various kinds of factors into consideration and reflects the reality objectively. The appraisal outcome is accurate and easy to work out. So it has realistically instructive significance.

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References

[1] Wu Wangming. Method of Applied Fuzzy Set Beijing: Beijing Normal University Press 1985:114—132.
[2] Wang Zhitai. Modern Logistics Management. Beijing: Press China Laborer Press. 2001.
[3] Wang Cheng. Practice and Cases of Modern Logistics Management. Beijing: Enterprise Management Publishing House. 2001.
[4] Song Weigang. Logistics Engineering and Application. Beijing: China Machine Press. 2003:20-23.
[5] Wang Zhitai. Modern Logistics. Beijing: China Logistics Publishing House. 1995:363-367.