Investigation on Evaluation of Core Competitiveness of Airlines Based on Gray Theory

Ma Liuyan, Wang Xiaoyi, Zhao Xing, Chao Hui
School of Computer and Information Engineering, Beijing Technology and Business University, Beijing, P.R.China, 100048
(E-mail: sdwangxy@163.com, zhaoxing98@gmail.com)

Abstract On the basis of deeply investigating the core competitiveness of enterprise, the evaluation indicators system for core competitiveness of airlines determined by combination Delphi method in System Engineer and Principal Components Analysis while the weight to each evaluation indicator determined by means of Analytic Hierarchy Process to, the model of evaluation of core competitiveness of airlines based on Gray Theory is established and, through empirical research on the instance of China Eastern Airlines, the effectiveness of the above model is testified.
Key words Airlines; Core competitiveness; Analytic Hierarchy Process; Gray theory

1 Introduction

With globalization of world economy and the acceleration of Traffic Rights' openness process, the China's airlines are facing enormous challenges. Therefore, how to obtain the long-term stable strength in competition has become the problem which requires to be urgently investigated and solved for all airlines. And it's believed that the solution lies in the enhancement the core competitiveness of enterprises. C.K. Prahalad and Garry Hamel point out that core competitiveness is the cumulated knowledge in organization, especially the knowledge about how to coordinate different production skills and integrate the knowledge of all schools organically. It is impossible to direct enterprises to nourish and improve core competitiveness unless enterprises are provided objective and thorough evaluations[1]. Due to the significance of evaluation on enterprises' core competitiveness, investigations conducted by scholars home and abroad are gradually becoming empirical orientation rather than theoretical.

Currently, Evaluation methods of core competitiveness can be divided into four categories: non-quantitative analysis, semi-quantitative analysis, quantitative analysis and combination of semi-quantitative and quantitative analysis[2]. Qualitative analysis of the evaluation of ethnic culture tourism resources in Wuling mountain area of China was conducted by Ouyang Danni[3]. Semi-quantitative analysis of side slope stability was introduced by Peng Guangyao who utilized the instance of a side slope in Nanjing[4]. Calculation of patents was used by Patel to measure core competitiveness of enterprises[5]. the component-structure method of combination of semi-quantitative analysis and quantitative analysis was exploited by Henderson to accomplish the evaluation of indicators after component ability and structure ability indicators are constructed respectively[6]. As for this article, on account of the most factors which influences core competitiveness being ambiguous and gray, the method first adopted is combination of Delphi method and Principal Components Analysis to determine the evaluation indicators system for core competitiveness of airlines while the one second adopted is Analytic Hierarchy Process which is utilized to determine the weight to each evaluation indicator, so that, based on Gray Theory, the model of evaluation for core competitiveness of enterprises can be established, which, furthermore, uses airlines industry as research target to evaluate and testify the model, aiming to offer an effective approach to evaluate the core competitiveness of enterprises.

2 Evaluation Indicators System for Core Competitiveness of Airlines

Indicators system is the benchmark of core competitiveness. Thus, only by scientific and complete indicators system can evaluations for core competitiveness be obtained objectively and correctly; only adopting feasible and exercisable indicators can quantitative results be possessed; moreover, only after the comparably quantitative results are owned can it be possible to effectively support the correct decisions of enterprises[7]. Therefore, scientificity, systematicness, comparableness and practicability should be complied when the indicators system is established. Besides, the principle of integration of dynamic and static methods should be followed simultaneously.

According to the above principles while on the basis of a plenty of references, airlines' core competitiveness indicators system is ascertained as follows:

(1) Human Resource, including the following four indicators: employee education level, average

employee training expenses per year, employee profession composition and employee loyalty.

(2) Technology level, including the following six indicators: technology innovation ability, information technology utilization ratio, information technology investment growth rate, safe operation technique, aircraft repair technique and transport technique support.

(3) Marketing ability, including the following seven indicators: market share, navigable cities and airports, brand value, market response ability, market expansion ability, enterprise social image and consumer loyalty.

(4) Management ability, including the following four indicators: strategic planning and decision ability, strategy implement and control ability, organization structure reasonableness and management ability of core qualified personnel.

(5) Operation performance, including the following fourteen indicators: daily aircrafts utilization ratio, human-computer ratio, load factor, transport total turnover, occupation rate, prime operating revenue, net profit, average growth rate of prime operating revenue in latest three years, average growth rate of net profit in latest three years, assets and liabilities ratio, net asset, net asset profit ratio, total asset profit ratio and allover labor productivity.

(6) Enterprise culture, including the following ten indicators: members identity, team significance, concern for human, unit identity and control, risk tolerance degree, remuneration standard, conflict tolerance degree, approach-result tendency and system openness.

(7) Service level, including the following four indicators: airlines' on-time arrival rate, passenger cabin service level, aircraft hardware facilities and land services level.

On the basis of initial indicators system, Principal Components Analysis is adopted to analyze indicators in each hierarchy in order to extract primary indicators, which eventually determines the evaluation indicators system for the core competitiveness of airlines. Display as table 1.

Table 1 Evaluation Indicators System for the Core Competitiveness of Airlines

First level Indicators	Second level Indicators	First level Indicators	Second level Indicators
Human Resource U_1	employee education level V_{11}	Operation performance U_5	daily aircrafts utilization ratio V_{51}
	Employee profession composition V_{12}		human-computer ratio V_{52}
	employee loyalty V_{13}		load factor V_{53}
Technology level U_2	Technology innovation ability V_{21}		transport total turnover V_{54}
	information technology investment growth rate V_{22}		occupation rate V_{55}
	aircraft repair technique V_{23}		average growth rate of prime operating revenue in latest in latest three years V_{56}
	transport technique support V_{24}	Enterprise culture U_6	members identity V_{61}
Marketing ability U_3	market share V_{31}		team significance V_{62}
	navigable cities and airports V_{32}		concern for human V_{63}
	market response ability V_{33}		unit identity V_{64}
	consumer loyalty V_{34}		control V_{65}
Management ability U_4	strategic planning and decision ability V_{41}	Service level U_7	passenger cabin service level V_{71}
	organization structure reasonableness V_{42}		aircraft hardware facilities V_{72}
	management ability of core qualified personnel V_{43}		land services level V_{73}

3 Evaluations for Core Competitiveness of Enterprises Based on Gray Theory

3.1 Gray evaluation

Gray Evaluation approach evolved from Grey Theory, which was proposed by the China's notable scholar Deng Julong in 1982 and used as a kind of fresh method to investigate small amount of data and poor information uncertain problems.

According to the evaluation indicators system in Table 1, U is assumed to represent first level indicators set of U_i, noting as $U=\{U_1,U_2,\cdots,U_m\}$; $V_i=(i=1,2,\cdots m)$; represents second level indicators set, noting as $V_i=\{V_{i1},V_{i2},\cdots,V_{in_i}\}(j=1,2,\cdots,n_i)$. Therefore, the concrete steps of Gray Evaluation are as follows:

(1) Design grade standards for evaluation indicators

(2) Determine the weight of indicators U_i and V_{ij}: first level indicators' weight vector $A=(a_1,a_2,\cdots,a_i)$, where $a_i\geq 0,\sum_{i=1}a_i=1$; And second level indicators' weight vector $w_i=(w_{i1},w_{i2},\cdots,w_{ij})$ where $w_{ij}\geq 0,\sum_{j-1}w_{ij}=1$.

(3) Calculate evaluation sample matrix. Assume there are q valuators, thus

$$D=\begin{bmatrix} d_{111} & d_{112} & \cdots & d_{11q} \\ \cdots & \cdots & \cdots & \cdots \\ d_{1n_11} & d_{2n_12} & \cdots & d_{2n_1q} \\ d_{211} & d_{212} & \cdots & d_{21q} \\ \cdots & \cdots & \cdots & \cdots \\ d_{2n_21} & d_{2n_22} & & d_{2n_2q} \\ \cdots & \cdots & \cdots & \cdots \\ d_{m11} & d_{m12} & \cdots & d_{m1q} \\ \cdots & \cdots & \cdots & \cdots \\ d_{mn_m1} & d_{mn_m2} & \cdots & d_{mn_mq} \end{bmatrix}$$

(4) Determine evaluation Gray Scale and calculate coefficients of Gray Evaluation

Assume sequence number of evaluation Gray Scale is e $(e=1,2,\cdots g)$; define weighted functions as f_e; Gray Evaluation coefficient of evaluation indicator V_{ij} which is belong to the position of e in the evaluation Gray Scale, noting as X_{ije};

$$X_{ije}=\sum f_e(d_{ijq}),\quad q\in[1,p] \tag{1}$$

The total Gray Evaluation numbers belonging to each evaluation Gray Scale are noted as X_{ij}, Therefore

$$X_{ij}=\sum X_{ije},\quad e\in[1,g] \tag{2}$$

(5) Calculate Gray Evaluation weight vectors

Gray Evaluation weight of the e th Gray Scale which is claimed by evaluation indicators V_{ij}, noting as r_{jie}

$$r_{ij}=(r_{ij1},r_{ij2},\wedge,r_{ijg}),\quad r_{ije}=\frac{X_{ije}}{x_{ij}} \tag{3}$$

Each Gray Scale evaluation weight vector of evaluation indicators V_{ij} are noted as r_{ij}; After integrating every Gray Scale evaluation weight vector of evaluation indicators V_{ij} which is belonged to the second evaluation indicator V_i, we get its Gray Scale evaluation weight R_i

$$R_i=\begin{bmatrix} r_{i1} \\ r_{i2} \\ M \\ r_{in} \end{bmatrix}=\begin{bmatrix} r_{i11} & r_{i12} & \wedge & r_{i1g} \\ r_{i21} & r_{i22} & \wedge & r_{i2g} \\ & & M & \\ r_{in1} & r_{in2} & \wedge & r_{ing} \end{bmatrix}$$

(6) Conduct an integrated evaluation for V_i. The result is B_i

$$B_i=A_i\times R_i=(b_{i1},b_{i2},\wedge,b_{ig})$$

(7) After the integrated evaluation for U, calculate the Gray Evaluation weight matrix B of each evaluation Gray Scale corresponding to indicators U_i which belongs to U .

$$B = \begin{bmatrix} B_1 \\ B_2 \\ M \\ B_m \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & b_{1g} \\ b_{21} & b_{22} & b_{2g} \\ & M & \\ b_{m1} & b_{m2} & b_{mg} \end{bmatrix}$$

Evaluate U integrally and note the results as F, thus

$$F = A \times B_i = A \times \begin{bmatrix} A_1 \times R_1 \\ A_2 \times R_2 \\ M \\ A_m \times R_m \end{bmatrix} = (f_1, f_2, \wedge, f_g)$$

(8) Provide the integrated evaluation of evaluated object as well as conclusion.

$$Z = F \times C^T$$

The integrated evaluation of evaluated object is Z , Gray Scale equivalent vector is C.

3.2 Re-obtain weights based on AHP

Analytic Hierarchy Process ("AHP" for short) was first proposed by the notable operational researcher T.L.Satty in 1970s which was a multi-targets and multi-norms decision analysis method. [8] The basic idea of AHP is that through dividing an intricate engineer problem into its constituted factors and grouping these factors by dominance relationship, the Order Increased Hierarchy Structure can be built so that the relative significance of each factor in each hierarchy can be determined by comparison between any two of them. And then it generates judgment matrix through Nine Scales Method to calculate the weight of each factor while testifies the reasonableness of the consistence of judgment matrix so that the entire sequencing of relative significance of decision factors is determined.

The basic steps to obtain weights of attributes by AHP are as follows:

Construct the judgment matrix of indicators' weights.

Calculate coefficients of indicators' weights.

Calculate the maximum eigenvalue of judgment matrix and testify its consistence.

4 The Application of Gray Theory on Evaluation of Core Competitiveness of Airlines

4.1 Acquisition of evaluation data

According to evaluation indicators system of core competitiveness of airlines, questionnaires that investigate the core competitiveness were designed for China Eastern Airlines (CEA) and evaluators were invited to score the above 28 indicators by (5,4,3,2,1) which means (great, good, average, poor, bad) respectively. As a result, 76 valid questionnaires were obtained and one third of them came from the employees of CEA while the rest from forum of civil aviation community. Finally, 70 questionnaires are used as evaluation data through selections.

4.2 Acquisition of each indicator's weight through AHP

Here, judgment matrix is acquired again according to experts' re-score for the indicators in Table 1. Results are as follows:

A = [1,4,0.5,0 .3333,0.2, 1,0.5;0.25 ,1,0.2,0.3 333,0.125, 0.3333,1;2 ,5,1,0.333 3,0.2,3,1;
3,3,3,1,0. 3333,5,5;5 ,8,5,3,1,5 ,5;1,3,0.3 333,0.2,0. 2,1,1;2,1, 1,0.2,0.2, 1,1]

B_1 = [1,3,1;0.3 333,1,0.5; 1,2,1]

B_2 = [1,5,3,1;0 .2,1,0.333 3,0.2;0.33 33,3,1,0.5 ;1,5,2,1]

B_3 = [1,3,4,5;0 .3333,1,3, 3;0.25,0.3 333,1,3;0. 2,0.3333,0 .3333,1]

B_4 = [1,6,4;0.1 429,1,0.2; 0.25,5,1]

B_5 = [1,3,0.2,1 ,1,0.1429; 0.3333,1,0 .3333,1,1, 0.2;5,3,1, 3,3,0.2;1, 1,0.3333,1 ,1,0.2;
1,1,0.3333 ,1,1,0.2;7 ,5,5,5,5,1]

B_6 = [1,2,0.5,0 .2,0.3333; 0.5,1,0.33 33,0.2,1;2 ,3,1,0.333 3,4;5,5,3, 1,6;3,1,0. 25,0.1667, 1]

B_7 = [1,3,5;0.3 333,1,2;0. 2,0.5,1]

Calculate the weights by Analytic Hierarchy Process and results are displayed in Table 2:

Table 2 Indicators' Weight of Core Competitiveness of China Eastern Airlines

First Level Indicators	Weight	Second Level Indicators	Weight	First Level Indicators	Weight	First Level Indicators	Weight
U_1	0.0723	V_{11}	0.4434	U_5	0.4013	V_{51}	0.0832
		V_{12}	0.1692			V_{52}	0.0635
		V_{13}	0.3874			V_{53}	0.2115
U_2	0.0400	V_{21}	0.4011			V_{54}	0.0722
		V_{22}	0.0689			V_{55}	0.0722
		V_{23}	0.1713			V_{56}	0.4974
		V_{24}	0.3587	U_6	0.0653	V_{61}	0.0908
U_3	0.1167	V_{31}	0.5312			V_{62}	0.0751
		V_{32}	0.2559			V_{63}	0.2296
		V_{33}	0.1385			V_{64}	0.4942
		V_{34}	0.0745			V_{65}	0.1104
U_4	0.2299	V_{41}	0.6799	U_7	0.0745	V_{71}	0.6483
		V_{42}	0.0704			V_{72}	0.2296
		V_{43}	0.2497			V_{73}	0.1220

4.3 Evaluation results analysis

As the concrete steps of Gray Evaluation are followed, the integrated scores of core competitiveness of CEA is calculated according to sample matrix and after disposal of normalization, the integrated score of CEA is 0.6737. Therefore, the core competitiveness of CEA is "good".

To testify the effectiveness of Gray Evaluation, Analytic Hierarchy Process is simultaneously used to evaluate the core competitiveness of CEA and the eventual result is 0.5912, which also belongs to "good". As a result, the evaluation method based on Gray Theory is feasible.

5 Conclusions

Due to the factors that influence the core competitiveness of enterprises are gray, ambiguous and hard-to-quantification in most cases, the model based on Gray Theory which is used to evaluate the core competitiveness of airlines industry is established on the basis of indicators evaluation system of core competitiveness for airlines industry, and through testification of AHP, the method is proved to be effective and feasible, demonstrated by the evaluation results.

References

[1] Prahalad C.K., Hamel G. The Core Competence of the Corporation[J]. Harvard Business Review, 1990, (5/6): 79-92

[2] Chen Jin, Wang Yi, Xu Qingrui. Core Competence of Corporation: A Literature Review[J]. Science Research Management, 1999, 9(5): 13-20 (In Chinese)

[3] Ouyang Danni. Evaluation of Ethnic Culture Tourism Resource for Wuling Mountain Area[J]. Journal of Hubei Institute for Nationalities (Philosophy and Social Sciences), 1996, 14(3) (In Chinese)

[4] Peng Guangyao, Li Xiaozhao, Zhao Xiaobao. A Semi-quantitative Method of Evaluation of Slope Stability[J]. Journal of Disaster Prevention and Mitigation Engineering, 2007, 27(4) (In Chinese)

[5] Patel P., Keith P. The Technological Competencies of the World's Largest Firms: Complex and Path-dependent[J]. ResPol, 1997, (26): 141-156

[6] Henderson R., Cockburn. Measuring Competence Exploring Firm Effects in Pharmaceutical[J]. Strategic Management Journal, 1994, 15(8): 63-84

[7] Qiao Yunxia. Evaluation and Analysis on Core Competitiveness of China Commercial Share Banks[J]. Modern Economic Science, 2006, (5): 60-64 (In Chinese)

[8] Zhao Wei, Yue Dequan. Algorithm of AHP and Its Comparison Analysis[J]. Mathematics in Practice and Theory, 1995, 25(1): 25-47 (In Chinese)