Research on Comprehensive Evaluation Method of Enterprise Technical Innovation Capacity Based on Fuzzy Theory

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Abstract: This paper combines the qualitative analysis with quantitative analysis, starting with ascertaining the comprehensive evaluation index system, and applies fuzzy theory to a comprehensive evaluation of the enterprise technical innovation capacity, thus it provides a scientific, objective and effective method for evaluating the enterprise innovation capacity and is of great significance to a correct understanding to the enterprise technical innovation capacity, grasping and summarizing the enterprise technical innovation law and improving enterprise technical innovation level
Key words: Fuzzy theory; Innovation capacity; Evaluation method; Weight

1 Introduction

The western developed countries started the research on enterprise technical innovation capacity earlier and have scored some achievements both in theory and practice. The earliest concept about the technical innovation capacity in China appeared in the research on microscopic science and technology policy and in 1980s some researchers introduced the concept to the microcosmic companies. With the establishment of modern economic system, technical innovation has been regarded as the basic support and become the core competitive forces of the enterprise. Nowadays, scholars have carried out the research on the multi-indexes evaluation by using analytic hierarchy process, osculating value method, grey system method and so on, however those methods have the following flows as large calculation amount, less accuracy of choosing the evaluation index and hard to perform large scale evaluation. This paper will apply the fuzzy mathematic method to the comprehensive evaluation of the enterprise technical innovation capacity, which provides a scientific, objective and effective method to the evaluation of the enterprise innovation capacity.

Enterprise Technical innovation Capacity means the enterprises carry out research and development or introduce technology towards market, turn the technical achievement into products, furthermore acquire a rapid growth of capacity in economics. The Constitution of enterprise technical innovation capacity includes: (1)Innovative Resources Input Capacity, (2)Innovative Management Capacity, (3)Innovation Trend , (4)R&D capacity, (5)Manufacturing capacity, (6)Marketing capacity.

2 Construction of Enterprise Technical Innovation Capacity Index System

2.1 Principle for constructing enterprise technical innovation capacity index system.

1)Systematic principle, 2) Scientific principle, 3) Comparative principle, 4) Operational principle, 5) Integrated quantitative and qualitative principle, 6)Practicable principle[1].

2.2 Choosing the comprehensive evaluation index system of enterprise technical innovation capacity

Enterprise technical innovation capacity is organically coupled by several factors concerning many links such as enterprise input, output process. Based on the principles for construction enterprise technical innovation capacity index system, this paper carries out a scientific screening among all the indexes of enterprise technical innovation capacity by using Delphi method, thus gets the following evaluation index system:

Table 1 Comprehensive Evaluation Index System of the Enterprise Technical Innovation Capacity

U1 R&D capacity	U11 amount of patents and proprietary knowledge
	U12 independent innovation products rate
	U13 digestive and absorbing capacity of the imported technology
	U14 update period of the main products
U2 Innovation resources input capacity	U21R&D personnel quality
	U22 R&D personnel rate
	U23 input intensity of technology import
	U24 technical innovation input intensity
U3 manufacturing capacity	U31 workers' technical level
	U32 main manufacturing equipment level

	U33 engineering conditions
	U34 products quality standard level
U4 innovation management capacity	U41 decision making capacity of innovative
	U42 innovation incentive mechanism
	U43 cooperative capacity among the inside enterprise sections
	U44 cooperative capacity between the enterprise and other technical forces
U5 innovation trend	U51 innovation frequency
	U52 innovative thinking of leaders
	U53 innovative thinking of the personnel
	U54 innovation planning
U6 marketing capacity	U61marketing research level
	U62 understanding level of the customers and users
	U63 fitness of the marketing system
	U64 marketing network

2.3Ascertaining each index weight of the evaluation system by using the fuzzy Theory

Six first level indexes of the evaluation system are divided into six sets of factor class and each set is divided into 4 factors, thus there are 24 factor items. After experts' review, the importance degree (full sore is 10) of the first level index A is:U1=10,U3=U6=6,U2=U4=U5=2

Hence comes:

Table 2 Paired Comparison Judgment Matrix

	U1	U2	U3	U4	U5	U6
U1	10/10	10/2	10/6	10/2	10/2	10/6
U2	2/10	2/2	2/6	2/2	2/2	2/6
U3	6/10	6/2	6/6	6/2	6/2	6/6
U4	2/10	2/2	2/6	2/2	2/2	2/6
U5	2/10	2/2	2/6	2/2	2/2	2/6
U6	6/10	6/2	6/6	6/2	6/2	6/6

Horizontal summation of table one:

U_i =(U1,U2,U3,U4,U5,U6)=(19.33,3.87,11.6,3.87,3.87,11.6)

Thus: U=U1+U2+U3+U4+U5+U6=54.14

So the weight set of factor class is $W_u=\{u_i\}$ (i=1,2,3,4,5,6 $u_i=\frac{Ui}{U}$)

$W_u=\{u_1,u_2,u_3,u_4,u_5,u_6\}$={0.3570,0.0715,0.2143,0.0715,0.0715,0.2143}

Similarly the weight set of each factor item can be calculated:

$W_{ui}=\{u_{ij}\}$ (i=1,2,3,4,5,6 j=1,2,3,4)

W_{u1}={0.479,0.277,0.112,0.112}, W_{u2}={0.352,0.300,0.174,0.174}

W_{u3}={0.479,0.277,0.112,0.112}, W_{u4}={0.479,0.277,0.112,0.112}

W_{u5}={0.476,0.275,0.158,0.091}, W_{u6}={0.476,0.275,0.158,0.091}

3 Application of the Fuzzy Mathematic Method to the Comprehensive Evaluation of the Enterprise Technical Innovation Capacity

3.1 Summery of the comprehensive evaluation method of enterprise technical innovation capacity

As the index system is layered structure, the fuzzy comprehensive evaluation results can not be directly calculated by the fuzzy evaluation matrix of the factors; it has to be started from the lowest layer and layer by layer calculate the fuzzy evaluation matrix of the relevant upper layer factor sets by using single factor evaluation matrix, at the same time combining the fuzzy weight, thus finally the fuzzy comprehensive evaluation results can be calculated. [4]

For example: the factor item set of "R&D capacity" U1 is: U1 = { U11 , U12, U13 , U14 }, its weight set is: W_{u1}, from U1 the single factor evaluation matrix R_{u1}, calculate the max-min compositional operations by using model M(∧,∨), then the comprehensive evaluation results of R & D

capacity can be calculated as: $B_{u1} = W_{u1} \ O \ R_{u1}$;and similarly $B_{u2}, B_{u3}, B_{u4}, B_{u5}, B_{u6}$ can be calculated too. Target layer U, the single factor evaluation matrix $R_u = (B_{u2}, B_{u3}, B_{u4}, B_{u5}, B_{u6})^T$, its weight set is: W_u, calculate the max-min compositional operations by using model M(∧, ∨), then the comprehensive evaluation results of target layer U can be calculated as: $B_u = W_u \ O \ R_u$, the comprehensive evaluation results are presented by the fuzzy set B_u, according to the principle of maximum degree of membership, the evaluation grades of enterprise innovation capacity can be finally determined.

3.2 Case analysis

After a review by a committee composed of 10 experts towards the comprehensive evaluation of a certain enterprises technical innovation capacity with Delphi method, the evaluation results of each factor item are as follows:

Table 3 Comprehensive Evaluation of an Enterprise's Technical Innovation Capacity

Factor class	Factor class weight	Factor item	Factor item weight	Evaluation result of factor class				
Ai	a_i	Bij	b_{ij}	high	higher	general	lower	low
R&D capacity (A1)	0.313	B11	0.479	0.000	0.833	0.167	0.000	0.000
		B12	0.277	0.677	0.167	0.167	0.000	0.000
		B13	0.112	0.000	0.500	0.500	0.000	0.000
		B14	0.112	0.000	0.833	0.167	0.000	0.000
Resource input capacity (A2)	0.125	B21	0.352	0.000	0.200	0.400	0.400	0.000
		B22	0.300	0.000	0.000	0.500	0.500	0.000
		B23	0.174	0.167	0.167	0.633	0.000	0.000
		B24	0.174	0.000	0.000	0.333	0.667	0.000
Manufacturing capacity (A3)	0.188	B31	0.479	0.000	0.667	0.167	0.167	0.000
		B32	0.277	0.000	0.000	0.500	0.500	0.000
		B33	0.112	0.677	0.333	0.000	0.000	0.000
		B34	0.112	0.000	0.677	0.333	0.000	0.000
Innovation management capacity (A4)	0.062	B41	0.479	0.000	0.833	0.167	0.000	0.000
		B42	0.277	0.000	0.667	0.167	0.167	0.000
		B43	0.112	0.000	0.000	0.833	0.167	0.000
		B44	0.112	0.000	0.667	0.167	0.167	0.000
Innovation trend (A5)	0.125	B51	0.476	0.833	0.167	0.000	0.000	0.000
		B52	0.275	0.000	0.833	0.167	0.000	0.000
		B53	0.158	0.000	0.667	0.167	0.167	0.000
		B54	0.091	0.833	0.167	0.000	0.000	0.000
Marketing capacity (A6)	0.188	B61	0.476	0.000	0.000	0.500	0.500	0.000
		B62	0.275	0.000	0.000	0.833	0.167	0.000
		B63	0.158	0.000	0.667	0.333	0.000	0.000
		B64	0.091	0.000	0.167	0.167	0.667	0.000

Based on the above method, the evaluation set of each factor class can be calculated:

B_{u1}={0.185, 0.608, 0.207, 0.000, 0.000}, B_{u2}={0.032, 0.100, 0.459, 0.409, 0.000}

B_{u3}={0.397, 0.395, 0.418, 0.061, 0.000}, B_{u4}={0.000, 0.685, 0.268, 0.067, 0.000}

B_{u5}={0.472, 0.429, 0.073, 0.026, 0.000}, B_{u6}={0.000, 0.181, 0.535, 0.284, 0.000}

Finally, from $B_u = W_u \ O \ R_u$ the evaluation set of factor class is B_u={0.168, 0.409, 0.315, 0.108, 0.000}. According to the principle of maximum degree of membership, the comprehensive evaluation grade of this enterprise's technical innovation capacity is 'higher'; through analyzing the evaluation set of each factor class, it can be calculated that the innovative recourses input capacity and marketing capacity are low and need a further improvement.

4 Conclusion

Comprehensive evaluation is to make an overall evaluation for an object or phenomenon restricted by several factors. As it is hard to avoid the fuzziness and subjectivity while evaluating an object in many respects, the application of fuzzy mathematic method to the comprehensive evolution of enterprise technical innovation capacity will make the results more scientific, objective, effective and with more practical significance.

Based on the characteristics of general enterprises, this paper establishes a set of comprehensive evaluation index systems and puts forward the comprehensive evaluation method for enterprise technical innovation capacity which can be applied universally. However while putting it into practice, this system should be combined with the enterprise's reality and construct a more scientific evaluation index system and weight. At the same time, with the development of the enterprise's productivity and emergence of new conflicts such as information level, environmental benefits and so on, establishing a set of time-effective, objective and operational evaluation index systems will be the final target for the research on comprehensive evaluation of enterprise technical innovation capacity.

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