

AHP Based Study to Improving the Innovation Ability of Enterprise R&D Center

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Abstract

This paper is based on the scholars' study of the enterprise R&D center, getting its evaluation index with systematic research. And then determining the weight of every factor with AHP, providing some reference of improving the innovation ability of enterprise R&D center.

Keywords: AHP, Enterprise R&D Center, Innovation, Reference

Introduction

The 21st century, economic competition is becoming increasingly prominent in science and technology, global industrial adjustment is further accelerating, companies which can survive need to seize the opportunity and make the appropriate innovation to meet the market' demand. We can see that enterprises are particularly fond of building their own R&D centers and they have played a positive role in the development of enterprises. With the advancement of science and technology and increasing fierce competition, companies must put the building of its R&D center's innovation capability in an important position, if they want to be in an invincible position in the competition, they must put it in an important way. From this, they can adapt to the increasingly fast changing marketing.

1. Review

In recent years, there are many scholars studying on the innovation capacity of enterprise R&D center, mainly making the study of the innovation capabilities of enterprise R&D center from the six factors :

1.1 Studying on the relationship between innovation ability of enterprise R&D center and the scale of enterprise.

Cheng Zhengzhong, Wu Yonglin, Xie Chaoyang^[1](2008)research that the technological innovation capability of large electronic and communications equipment manufacturing enterprises is stronger than that of SMEs in china. Cohen^[2](1995)believes that the innovative activity in large-scale enterprises show more productivity. Yu Junbo, Shu Zhibiao^[3](2007) reveal a positive relationship between the scale of enterprise and the total output of innovation, and confirming that SMEs have an advantage in innovation efficiency and innovation output in some industries.

1.2 Studying on the relationship between innovation ability of enterprise R&D center and human input.

Wang Guijun^[4](2009)analyzes the current situation of R&D center staff' innovation capability in chinese high-tech enterprise, and creating and describing its development model. Cao Qinyun^[5](2009)believes the R&D personnel play a key role in the success of R&D project. Zhong Heping, Zhang Xumei, Fang Runsheng^[6](2009)think that it has a great relationship between enterprise technological innovation and human resources. Luo Zhengying, Tang Lingling, Chang Chang^[7](2013)find that the average reign of the executive team is significantly negatively correlated with enterprise R&D investment, and the personnel proportion with technical background in team members is positively correlated with enterprise R&D investment. Chen Dezhi^[8](2007)thinks R&D personnel are short of high-quality talent in Shanghai, the knowledge and age of R&D staff are at a low structural state of creativity.

1.3 Studying on the relationship between innovation ability of enterprise R&D center and R&D financial investment

Zhao Jianbing, Yuan Wei, Zhong Wei^[9](2009) believe that R&D capital investment model is concerned with the economic development stage and technological innovation capacity. Liu Hedong, Liang Dongli^[10](2006) find that it has long-term stable equilibrium relationship between R&D investment and innovation capability. Liu Liping, Wang Yalin^[11] (2011) prove that R&D investment significantly impact on independent innovation. Liu Li^[12] (2003) believes that less enterprise R&D investment constraint enterprise' innovation capacity in China.

1.4 Studying on the relationship between innovation ability of enterprise R&D center and research infrastructure

Zhao Wei, Peng Jie^[13](2007) propose the index system' principles of technology infrastructure operation performance, and specific analysis the evaluation factors of every index. Wang Juanle, Peng Jie^[14](2007) explore the external and internal relationship between technological innovation capability and technological infrastructure. Lai Yongjian^[15] (2013) shows that infrastructure is significantly positively correlated with innovative possibilities and the number of innovation in domestic enterprises, while the role of infrastructure is difference in foreign-funded enterprises.

1.5 Studying on the relationship between innovation ability of enterprise R&D center and R&D management capacity

Li Dan^[6](2011) believes research and development activities need to establish an efficient management system and develop long-term plan which improves R&D management level. Chen Wei, Liu Jingjian^[17](2007) are proposed the reference measures to improve R&D management level of chinese enterprises.

1.6 Studying on the relationship between innovation ability of enterprise R&D center and enterprise environment

Chen Liping, Zhang Xinxin^[18](2012) think that the intensity and the total amount of R&D fund, the distribution and the source of R&D fund have obvious geographical features, which is closely related to the level of economic development in the region and the stage of technological development. Chen Zhongchang, Yu Xiang^[19](2007) show that the market demand for new products has a positive impact on enterprise research and development activities. Xu Kai, Gao Shanxing^[20](2009) test and verify the contact between enterprises and universities can promote enterprise product innovation through the data research.

2. Evaluation index

In this paper, building the evaluation index of enterprise R&D center through AHP, and its index system involves almost all departments of enterprise. Combining with the scholars' research at present, this article is building the index of the criterion layer B from the scale of enterprise, human input, financial investment, research infrastructure, R&D management capacity and enterprise environment, and then giving the index of solution layer C. The scale of enterprise includes total assets, turnover, brand advertising investment and the number of employees; Human input includes the number of R&D center employees, the number of experts and the number of technicians; Financial investment includes the growth of research funds, the proportion of the research funds and average annual research funds; Research infrastructure includes the level of technical equipment, communication infrastructure, transport infrastructure and energy infrastructure; R&D management capacity includes the capacity of planning, the capacity of organization, the capacity of control and the capacity of coordination; Enterprise environment includes the condition of local economy, the condition of industry and the condition of collaboration with research institutions. As it shows in Table 1:

Table 1 the evaluation index of enterprise R&D center'innovation ability

B1: The scale of enterprise	B2: Human input
C1:total assets	C5:the number of R&D center employees
C2:turnover	C6:the number of experts
C3:brand advertising investment	C7:the number of technicians
C4:the number of employees	
	B4: Research infrastructure
B3: Financial investment	C11:the level of technical equipment
C8:the growth of research funds	C12:communication infrastructure
C9:the proportion of the research funds	C13: transport infrastructure
C10:average annual research funds	C14: energy infrastructure
B5: R&D management capacity	B6: Enterprise environment
C15: the capacity of planning	C19:the condition of local economy
C16: the capacity of organization	C20:the condition of industry
C17: the capacity of control	C21: the condition of collaboration with research institutions
C18: the capacity of coordination	

3. AHP^[21]

AHP (The Analytic Hierarchy Process) is made by an american operational research expert T.L.Saaty in 1970s.It makes the factors related to the decisions into the goal, guidelines,programs and other levels,and then making qualitative and quantitative analysis. The steps are as follows.

3.1 Establish hierarchy

When establishing hierarchy by AHP,it usually is divided into three levels, containing the target layer A, the criterion layer B and the solution layer C. It builds the relationship of all factors from the target layer A to the solution layer C.In this paper, the evaluation index of enterprise R&D center'innovation ability is shown in Table 1.

3.2 Construction of judgment matrix

Using the numbers 1-9 and their reciprocal as scale to define judgment matrix,details are as follows in Table 2.

Table 2 The fundamental AHP judgement scale		
Intensity of weight	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favour one over another
5	Strong importance	Experience and judgment strongly favour one over another
7	Very strong importance	An activity is strongly favoured and its dominance is demonstrated in practice
9	Absolute importance	The importance of one over another affirmed on the highest possible order
2,4,6,8	Intermediate values	Used to represent compromise between the priorities listed above
Reciprocals		If activity i has one of the above non-zero numbers assigned to it when compared to activity j, then j has the reciprocal value when compared with i

Getting the judgment matrix A 、 B_1 、 B_2 、 B_3 、 B_4 、 B_5 、 B_6 according to the experts scoring, results are as follows:

$$A = \begin{bmatrix} 1 & 1/5 & 1/4 & 1/3 & 1/2 & 1 \\ 5 & 1 & 2 & 3 & 4 & 5 \\ 4 & 1/2 & 1 & 2 & 3 & 4 \\ 3 & 1/3 & 1/2 & 1 & 2 & 3 \\ 2 & 1/4 & 1/3 & 1/2 & 1 & 2 \\ 1 & 1/5 & 1/4 & 1/3 & 1/2 & 1 \end{bmatrix} \quad B1 = \begin{bmatrix} 1 & 2 & 4 & 3 \\ 1/2 & 1 & 3 & 2 \\ 1/4 & 1/3 & 1 & 1/2 \\ 1/3 & 1/2 & 2 & 1 \end{bmatrix}$$

$$B2 = \begin{bmatrix} 1 & 1/3 & 1/2 \\ 3 & 1 & 2 \\ 2 & 1/2 & 1 \end{bmatrix} \quad B3 = \begin{bmatrix} 1 & 1/3 & 1/5 \\ 3 & 1 & 1/2 \\ 5 & 2 & 1 \end{bmatrix} \quad B6 = \begin{bmatrix} 1 & 1/4 & 1/5 \\ 4 & 1 & 1/2 \\ 5 & 2 & 1 \end{bmatrix}$$

$$B5 = \begin{bmatrix} 1 & 2 & 5 & 3 \\ 1/2 & 1 & 3 & 2 \\ 1/5 & 1/3 & 1 & 1/2 \\ 1/3 & 1/2 & 2 & 1 \end{bmatrix} \quad B4 = \begin{bmatrix} 1 & 3 & 2 & 4 \\ 1/3 & 1 & 1/2 & 2 \\ 1/2 & 2 & 1 & 3 \\ 1/4 & 1/2 & 1/3 & 1 \end{bmatrix}$$

3.3 Consistency test

First, calculating the consistency index *CI* (consistency index)

$$CI = \frac{\lambda_{max} - n}{n - 1}$$

λ_{max} represents the maximum eigenvalue of the judgment matrix. *n* represents how many index the judgment matrix has.

Second, finding the consistency index *RI* (Table 3).

Table 3: Average Random Consistency Index

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14
<i>RI</i>	0	0	0.5	0.8	1.1	1.2	1.3	1.4	1.4	1.4	1.5	1.5	1.5	1.5
			2	9	2	4	6	1	6	9	2	4	6	8

Third, calculating the ratio of consistency *CR* (consistency ratio)

$$CR = \frac{CI}{RI}$$

At the time that $CR < 0.10$, the consistency of judgment matrix is considered acceptable. Otherwise, adjusting the judgment matrix appropriately. In this paper, the maximum eigenvalues of *A*, *B1*, *B2*, *B3*, *B4*, *B5*, *B6* are 6.0808, 4.0310, 3.0092, 3.0037, 4.0310, 4.0145 and 3.0246. Consistency ratio are 0.0128, 0.0116, 0.0088, 0.0036, 0.0116, 0.0054 and 0.0236, so all of their consistency ratio are acceptable.

3.4 Weight calculation

Getting the weights of factors in *A*, *B1*, *B2*, *B3*, *B4*, *B5*, *B6* by AHP software. They are shown in Table 4.

Table 4 AHP judgment matrix

AHP judgment matrix for level A

LevelA	B1	B2	B3	B4	B5	B6	proportion (p_i)
B1	1	1/5	1/4	1/3	1/2	1	0.0588
B2	5	1	2	3	4	5	0.3794
B3	4	1/2	1	2	3	4	0.2491
B4	3	1/3	1/2	1	2	3	0.1569
B5	2	1/4	1/3	1/2	1	2	0.0969
B6	1	1/5	1/4	1/3	1/2	1	0.0588

AHP judgment matrix for level B1

LevelB1	C1	C2	C3	C4	p_i
C1	1	2	4	3	0.4668
C2	1/2	1	3	2	0.2776
C3	1/4	1/3	1	1/2	0.0953
C4	1/3	1/2	2	1	0.1603

AHP judgment matrix for level B2

LevelB2	C5	C6	C7	p_i
C5	1	1/3	1/2	0.1634
C6	3	1	2	0.5396
C7	2	1/2	1	0.2970

AHP judgment matrix for level B3

LevelB3	C8	C9	C10	p_i
C8	1	1/3	1/5	0.1095
C9	3	1	1/2	0.3093
C10	5	2	1	0.5816

AHP judgment matrix for level B4

LevelB4	C11	C12	C13	C14	p_i
C11	1	3	2	4	0.4668
C12	1/3	1	1/2	2	0.1603
C13	1/2	2	1	3	0.2776
C14	1/4	1/2	1/3	1	0.0953

AHP judgment matrix for level B5

LevelB5	C15	C16	C17	C18	p_i
C15	1	2	5	3	0.4832
C16	1/2	1	3	2	0.2717
C17	1/5	1/3	1	1/2	0.0882
C18	1/3	1/2	2	1	0.1569

AHP judgment matrix for level B6

LevelB6	C19	C20	C21	p_i
C19	1	1/4	1/5	0.0974
C20	4	1	1/2	0.3331
C21	5	2	1	0.5695

The weights that the factors in the solution layer C are accounting for the target layer A are shown in Table 5:

Table 5: The weight that factors in the solution layer C account for the target layer A

the target layer A	the criterion layer B	the solution layer C	
Innovation Ability of Enterprise R&D Center	B1: The scale of enterprise (0.0588)	C1:total assets	0.0275
		C2:turnover	0.0163
		C3:brand advertising investment	0.0056
		C4:the number of employees	0.0094
		C5:the number of R&D center employees	0.0620
		C6:the number of experts	0.2048
	B2: Human input (0.3794)	C7:the number of technicians	0.1127
		C8:the growth of research funds	0.0273
		C9:the proportion of the research funds	0.0770
	B3: Financial investment (0.2491)	C10:average annual research funds	0.1448
		C11:the level of technical equipment	0.0733
	B4: Research infrastructure (0.1569)	C12:communication infrastructure	0.0251
		C13: transport infrastructure	0.0436
		C14: energy infrastructure	0.0150
	B5: R&D management capacity (0.0969)	C15: the capacity of planning	0.0468
		C16: the capacity of organization	0.0263
		C17: the capacity of control	0.0086
		C18: the capacity of coordination	0.0152
	B6: Enterprise environment (0.0588)	C19:the condition of local economy	0.0057
		C20:the condition of industry	0.0196
		C21: the condition of collaboration with research institutions	0.0335

4. Conclusion

We can see,through this research,evaluating the innovation ability of enterprise R&D center by AHP is in line with the actual situation.Therefore, the method is feasible.By the end of this article,we find that there are three key factors in the criterion layer B,their are human input,financial investment and research infrastructure.When it is specific to the solution layer C,we can get it that the number of experts,the number of technicians and average annual research funds are very important to the innovation ability of enterprise R&D center. First, companies should be more cooperation with universities and experts, and improving the level of knowledge; Second, companies should try to recruit technicians who have a certain degree of knowledge, and improving the general level of knowledge; Finally, companies need to increase capital investment in the enterprise R&D center.Those suggestions may provide some reference to improve the innovation ability of enterprise R&D center.

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