

Study on Channels for Improving Innovation Capacity of Emerging Technology Enterprises ——Based on Data of Software and Information Service Companies in the Growth Enterprise Market in China

Yuping Chu^a, Xiaona Xu^b

School of Business Administration University of Science and Technology Liaoning, Anshan 114051, China

^achuyuping@163.com, ^b1205351153@qq.com

Abstract

with progress of globalization and knowledge-based economy, the emerging technology enterprises have developed rapidly. Greater innovation capacity is increasingly crucial to improving their core competitiveness in an ever fiercer international competition market. This article established an index system to evaluate the innovation capacity of emerging technology enterprises by using an analytic hierarchy process and fuzzy comprehensive evaluation method based on the data of listed companies in the Growth Enterprise Market in China, and put forward channels for improving their innovation capacity.

Keywords

Emerging technology enterprise, innovation capacity, fuzzy comprehensive evaluation method, channels.

1. Introduction

With development of a knowledge-based economy, emerging technology enterprises have become an important and active driving force in modern economic system due to innovativeness and high-growth. Important parts of the national economy in China, emerging technology enterprises are an important engine for continuous economic growth and technical innovation in China based on their technical advantages, flexible operation mechanism and quick response to emerging markets.

However, emerging technology enterprises depending on high-techs are facing with many challenges with increasing globalization and updating knowledge. These enterprises shall improve their core competitiveness by enhancing their innovation capacities so as to continue to compete in an ever fiercer international market. At the same time, it is pointed out in the Report to the 18th National Congress of the Communist Party of China that efforts shall be made to promote a health development of strategic emerging enterprises and advanced manufacturing industries. This policy is practically significant to speeding up economic growth pattern and promoting strategic economic structure adjustment. Therefore, we shall correctly judge the changes in technical demand and tendency of technical development and improve the innovation capacity of emerging technology enterprises. Only through this way can we promote a rapid development for these enterprises, accelerate the economic growth pattern transformation and promote strategic economic adjustment.

Currently, domestic and foreign scholars have made relevant studies on emerging technology enterprises and their innovation capacity.

Chen Yue (2012) proved that the emerging technologies emerged and developed based on a dynamic evolution of the enterprises based on the Schumpeter's innovation theory, discovered how evolution of emerging technologies influenced the evolution of enterprise capacities, and made an empirical test on the evolution of enterprise capacities influenced by evolution of emerging technologies. He Yinglong and Zhou Zongfang (2010) analyzed the industrial, technical and market characteristics of emerging technology enterprises, summarized and built a relevant characteristic function, and created

a growth model for these enterprises. Hu Zhongwen and Xia Hongsheng (2010) built a performance assessment model for knowledge employee in emerging technology enterprises, performed performance assessment for research and development personnel in Shenzhen ZTE using a multilevel fuzzy comprehensive evaluation method, and put forward several suggestions based on the results. Gu Jing and Zhou Zongfang (2010) put forward a method for identify the credit risks of emerging technology enterprises based on VPRS model, and made an empirical test on the method based on some listed emerging technology enterprises, and the test results showed that this method could well indentify the credit risks.

Though relevant studies on emerging technology enterprises and their innovation capacity have been done by domestic and foreign scholars, study on innovation capacity evaluation and improvement channels is rare. This article put forward how to create innovation capacity evaluation index and improvement channels.

2. Concept Definitions

2.1 Emeging Technology Enterprise

Emerging technologies refer to high-tech technologies which recently emerge or are under development. They are based on other technologies including information technology, biotechnology and energy technology, and are featured by high uncertainty in terms of technology, market and management and can result in creative destruction. They have important influence on industrial development and economic structure. Emerging technology enterprises refer to enterprises which conduct commodity production and provide relevant services based on emerging technologies and finally commercialize the emerging technologies.

2.2 Innovation Capacity of Emerging Technology Enterprises

Innovation capacity of an enterprise refer to the capacity of the enterprise to create new technologies, products and processes by integrating the enterprise' resources based on new ideas and knowledge and realize the enterprise' values and a continuous growth.

The uniqueness of products or services of emerging technology enterprises lies in that these products or services are offered based on at least one high tech among information technology, nano technology or bioengineering technology. Thus, the innovation capacity of emerging technology enterprises refers to the enterprises' innovation in high-techs including information technology, nano technology and bioengineering technology and capacity to commercial these technologies and realize enterprise values.

3. Factors Influencing Innovation Capacity

Innovation Input

Continuous technical innovation is required for the development of emerging technology enterprises whose growth is based on high-techs. Prerequisites for technical innovation include fund, talent, equipment, technology and information. Fund is needed in every step of the whole innovation process. The fund needed for technical innovation includes expenditures during internal development and research, charges of external research and development services, costs for purchasing patents, licenses, know-how, designs and technology-based services, fees for buying relevant equipment and manufacturing process, and expenses for selling the innovative products. The higher the R&D input is, the more excellent talents can be attracted. These talents will bring new vitality and ideas for the enterprises. Besides, the enterprises can have more sufficient funds to buy advanced production technologies and equipment to promote development and commercialization of new products.

Talents are major participants of technical innovation activities and play a key role in successful technical innovation of emerging technology enterprises. The technical innovation process is a process in which innovative knowledge is commercialized. Thus, the talents shall have professional technical knowledge, acute market sense, correct judgment and continuous learning ability. Only by attracting professional R&D personnel and excellent talents majored in other sciences can the

enterprises' R&D team create more innovative ideas and develop more innovative products based on market demands.

The development of enterprises is supported by national laws and policies. The government shall create a favorable environment for their innovation efforts, provide relevant infrastructures and funds and provide legal protection for the financing platforms. In China, most of emerging technology enterprises are middle- and small sized high-tech enterprises which are independent legal entities facing with financing difficulties and high financing risks. The fund support from the government can solve their problem of insufficient R&D input and improve their R&D success rate.

Factors during Innovation Process

As a continuous process, the innovation process is full of uncertainties. The new technologies and products under R&D are potential resources of the enterprises, and may create huge values for the enterprises in the future. Influencing factors during innovation process shall not be ignored since potential products emerged during R&D may change the competition pattern in an industry or in a market segment in a certain field and help the enterprises to obtain the power of unfair advantage.

Factors Related to Study and Growth

Successful technical innovation is not only based on existing knowledge and ability of employees of emerging technology enterprises, but also supported by the continuous growth of the employees' knowledge and ability. Besides, to retain the competitive advantages, the enterprises shall have their own technical characteristics, which requires a relevantly stable technical accumulation and certain ability to fill the gap caused by outflow of key technical talents. The enterprises thus shall continue to provide education and trainings for their employees, encourage them to continue to study and create a continuous learning atmosphere. Only by continuing to learn new knowledge can the enterprise employees retain their creativity and provide technical support for new products in a rapidly changing modern society. The knowledge and cultural level of enterprise employees influences their ability and speed to learn and grasp new knowledge. The more the employees with a bachelor degree or above are, the stronger the employees' ability to grasp new knowledge is, which is favorable for their continuous innovation.

Strong innovation capacity will promote a rapid growth of the enterprise, while the growth of the enterprise is favorable for the improvement of the innovation capacity. The growth of the enterprise will provide more resources, for example, more fund input, upgraded equipment and more R&D personnel. The growth rate of net assets is an important indicator showing the development capacity of an enterprise; the higher it is, the stronger the enterprise's growth in future is. High profitability is the most fundamental base for the survival and development of the enterprise. Considering the short development time, high risks, and great financing difficulties, the emerging technology enterprises shall provide resources for their innovation efforts based on their own development.

4. Evaluation Index systems for Innovation Capacity of Emerging Technology Enterprises

Based on analysis on influencing factors of innovation capacity, this paper selected four dimensions for evaluation, namely, innovation input, innovation process, innovation performance, and learning and growth.

(1) Innovation Input

Innovation input indicator, a foundation for an enterprise's innovation effort, is used to evaluate the enterprise's innovation capacity based on its resource input. The indicators selected include: R&D input intensity = R&D input /main business revenue, R&D personnel input intensity = ratio of R&D personnel in total employees and national subsidies. The R&D input intensity indicates fund and equipment resource input of an enterprise in innovation activities; the R&D personnel input intensity indicates the enterprise's input in R&D technical talents; and national subsidies indicates the state's subsidies and awards for the innovation effort of the enterprise.

(2) Innovation Process

Innovation process indicator is used for evaluating the innovation potential of an enterprise. The indicators selected include the number of patents and trademarks under application and the number of new products and technical projects under R&D. Although these indicators are under R&D, they can bring economic benefits to the enterprise and may create imponderable values in the future.

(3) Learning and Growth

This indicator is used for evaluating the enterprise’s innovation knowledge level and development potential. The indicators selected include personnel education fund, employee’s knowledge and cultural level = the ratio of employees with a bachelor degree or over in total employees, and the growth rate of net assets. The personnel education fund refers to the fund provided by the enterprise for the education of employees at a certain proportion to their total wages, fund paid by the enterprises for employees to study advanced technologies and improve their cultural level. The ratio of employees with a bachelor degree or above in total employees indicates the knowledge and cultural level of the employees. The innovation of an enterprise is indispensable from efforts of each employee. Only by improving each employee’s innovation awareness and knowledge and cultural level can the enterprise create a favorable innovation atmosphere, encourage the employees to put forward new ideas, and create new technologies, processes and products. The growth rate of net assets indicates the enterprise’s growth and development potential. Innovation shall be supported by the enterprise’s growth and development. When the enterprise has no development potential, it cannot provide continuous resources for innovation efforts, and thus the innovation will not succeed.

(4) Innovation Performance

The innovation performance indicator uses the innovation achievements to indicate an enterprise’s innovation capacity. Indicators selected include: the new product sales revenue/ total revenue, the total number of patents and software copyrights, the number of registered trademarks, the non-patent technologies and core technologies. The innovation performance indicator is a key to evaluate an enterprise’s innovation capacity. Higher innovation capacity can better promote the enterprise’s development, and the enterprise’s development will benefit to further innovation and provides a good economic support for innovation. In general, the innovation effort and the enterprise’s development are mutual influencing.

Table 1 Indicator System for Innovation Capacity of Emerging Technology Enterprises

Objective Layer	Criterion Layer	Indicator Layer
Evaluation System of Innovation Capacity of Emerging Technology Enterprises	Innovation Input	R&D input intensity = R&D input / main business revenue
		R&D personnel input intensity = ratio of R&D personnel in total employees
		National subsidies: the state’s subsidies and awards for the innovation effort of the enterprise
	Innovation Process	The number of patents and trademarks under application
		The number of new products and technical projects under R&D
	Learning and Growth	Personnel education fund
		Employee’s knowledge and cultural level = the ratio of employees with a bachelor degree or over in total employees
		The growth rate of net assets
	Innovation Performance	The new product sales revenue/ total revenue
		The total number of patents and software copyrights
		The number of registered trademarks
		The non-patent technologies and core technologies

5. Empirical Analysis on Innovation Capacity of Emerging Technology Enterprises

5.1 Sample Selection

Most enterprises in Shenzhen GEM are rapidly growing high-tech enterprises. This paper is based on the data of listed companies in Shenzhen GEM; since emerging technology enterprises are usually enterprises based on information technology, biotechnology and energy technology, data from software information and technology service companies are selected to make the data comparable. Since great gaps will exist in companies listed at different time, data of companies listed in a period from 2011 to 2015 are selected; considering data availability, data of 20 companies among 48 software information and technology companies in Shenzhen GEM listed in a period from 2011 to 2015 are selected.

5.2 Model Building

(1) Building an indicator system for innovation capacity of emerging technology enterprises, as shown in Table 1.

(2) Building a judgment matrix for pair wise comparison

Judgment matrixes for A, A-A1, A-A2, A-A3, A-A4 are built respectively using an AHP method

$$A = \begin{bmatrix} 1 & 5 & 3 & 1/2 \\ 1/5 & 1 & 1/2 & 1/7 \\ 1/3 & 2 & 1 & 1/5 \\ 2 & 7 & 5 & 1 \end{bmatrix} \quad A_1 = \begin{bmatrix} 1 & 2 & 5 \\ 1/2 & 1 & 3 \\ 1/5 & 1/3 & 1 \end{bmatrix}$$

$$A_2 = \begin{bmatrix} 1 & 1/3 \\ 3 & 1 \end{bmatrix}$$

$$A_3 = \begin{bmatrix} 1 & 2 & 5 \\ 1/2 & 1 & 3 \\ 1/5 & 1/3 & 1 \end{bmatrix}$$

$$A_4 = \begin{bmatrix} 1 & 5 & 3 & 1/2 \\ 1/5 & 1 & 1/2 & 1/7 \\ 1/3 & 2 & 1 & 1/5 \\ 2 & 7 & 5 & 1 \end{bmatrix}$$

(1) Calculating index weight

(2) Based on the algorithm of the maximum matrix eigenvalues λ_{\max} and Table 2, the consistency test results are as follows: in matrix A, $\lambda_{\max} = 4.020$ and $CR = 0.008 < 0.1$; in matrix A1, $\lambda_{\max} = 3.004$ and $CR = 0.004 < 0.1$; in matrix A2, $\lambda_{\max} = 2$ and $CR = 0 < 0.1$; in matrix A3, $\lambda_{\max} = 3.004$ and $CR = 0.004 < 0.1$; and in matrix A4, $\lambda_{\max} = 4.020$ and $CR = 0.008 < 0.1$. It thus can be known that all A, A1, A2, A3 and A4 passed the consistency test.

(3) Fuzzy comprehensive evaluation.

(4) First, data are made dimensionless using an average method.

$$y_{ij} = \frac{x_{ij}}{x_j} \quad \bar{x}_j = \frac{\sum_{i=1}^n x_{ij}}{n} \quad (i = 1, 2, 3 \dots n; j = 1, 2, 3 \dots n)$$

(5) Then the influencing indicators are synthesized into a fuzzy matrix $R = \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1n} \\ r_{21} & r_{22} & \dots & r_{2n} \\ \dots & \dots & \dots & \dots \\ r_{m1} & r_{m2} & \dots & r_{mn} \end{bmatrix}$

Table 2 Synthetic Weight of Layer Factors for System Objectives

A	A1	A2	A3	A4	Synthetic Weight
	0.301	0.063	0.110	0.525	
A11	0.581				0.175
A12	0.309				0.093
A13	0.110				0.033
A21		0.250			0.016
A22		0.750			0.048
A31			0.230		0.025
A32			0.122		0.013
A33			0.648		0.072
A41				0.555	0.291
A42				0.218	0.115
A43				0.078	0.041
A44				0.149	0.078

Secondly, a fuzzy synthesis is performed,

$$B = A * R = (a_1 \ a_2 \ \dots \ a_m) * \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1n} \\ r_{21} & r_{22} & \dots & r_{2n} \\ \dots & \dots & \dots & \dots \\ r_{m1} & r_{m2} & \dots & r_{mn} \end{bmatrix} = (b_1 \ b_2 \ \dots \ b_n),$$

wherein A is the synthetic weight of each indicator, “*” is the fuzzy composition operator. In this paper, the fuzzy composition operator is $M(\bullet, \vee)$ (\bullet indicates multiply, \vee indicates larger value is selected).

The result is:

$$B = (0.058 \ 0.053 \ 0.046 \ 0.049 \ 0.051 \ 0.052 \ 0.04 \ 0.048 \ 0.069 \ 0.041 \ 0.041 \ 0.043 \ 0.066 \ 0.067 \ 0.041 \ 0.038 \ 0.056 \ 0.047 \ 0.042 \ 0.053)$$

Since $\sum b_j \neq 1$, it shall be made dimensionless, and the result is

$$B = (0.058 \ 0.053 \ 0.046 \ 0.049 \ 0.052 \ 0.052 \ 0.04 \ 0.048 \ 0.069 \ 0.041 \ 0.041 \ 0.043 \ 0.066 \ 0.067 \ 0.041 \ 0.038 \ 0.056 \ 0.047 \ 0.042 \ 0.053)$$

According to the fuzzy comprehensive evaluation results, listed companies with poor innovation capacity are featured by following points: low R&D input intensity, low R&D personnel input intensity, few investment in employee education, incompetent employees, few R&D achievements and low revenue from core innovation products.

The dimensionless data obtained are listed below:

	A11	A12	A13	A21	A22	A31	A32	A33	A41	A42	A43	A44
1	0.084	0.083	0.010	0.000	0.050	0.004	0.055	0.066	0.048	0.110	0.000	0.013
2	0.033	0.075	0.033	0.000	0.086	0.036	0.053	0.107	0.055	0.059	0.008	0.034
3	0.035	0.066	0.063	0.000	0.000	0.069	0.056	0.057	0.050	0.070	0.003	0.033
4	0.058	0.052	0.093	0.115	0.000	0.030	0.051	0.068	0.055	0.029	0.003	0.038
5	0.027	0.031	0.071	0.037	0.079	0.155	0.049	0.058	0.052	0.022	0.041	0.117
6	0.030	0.057	0.036	0.088	0.072	0.040	0.048	0.048	0.053	0.125	0.003	0.000
7	0.051	0.057	0.080	0.000	0.050	0.023	0.041	0.032	0.043	0.033	0.008	0.006
8	0.052	0.044	0.058	0.023	0.043	0.027	0.048	0.059	0.058	0.037	0.008	0.049

9	0.065	0.074	0.082	0.005	0.108	0.282	0.065	0.000	0.058	0.066	0.038	0.110
10	0.043	0.034	0.074	0.028	0.000	0.008	0.027	0.059	0.053	0.029	0.003	0.044
11	0.029	0.053	0.029	0.000	0.000	0.065	0.040	0.090	0.038	0.063	0.030	0.028
12	0.031	0.031	0.013	0.332	0.043	0.000	0.029	0.022	0.051	0.018	0.125	0.039
13	0.125	0.049	0.013	0.000	0.050	0.000	0.069	0.021	0.058	0.059	0.142	0.059
14	0.048	0.018	0.144	0.000	0.072	0.060	0.057	0.012	0.045	0.088	0.406	0.071
15	0.050	0.048	0.057	0.000	0.043	0.000	0.040	0.060	0.026	0.033	0.011	0.089
16	0.022	0.009	0.009	0.060	0.029	0.000	0.028	0.072	0.059	0.048	0.008	0.023
17	0.048	0.050	0.013	0.194	0.050	0.137	0.058	0.060	0.059	0.022	0.057	0.079
18	0.041	0.038	0.058	0.060	0.086	0.011	0.071	0.062	0.047	0.018	0.038	0.079
19	0.054	0.074	0.010	0.000	0.029	0.000	0.067	0.035	0.044	0.037	0.022	0.031
20	0.073	0.056	0.053	0.060	0.108	0.052	0.048	0.011	0.049	0.033	0.046	0.059

6. Channels for Improving Innovation Capacity of Emerging Technology Enterprises

The following channels for improving innovation capacity of emerging technology enterprises are put forward based on empirical study results.

(1) The enterprises shall optimize the allocation of internal resources in terms of R&D fund and personnel, pay more attention to the R&D efforts, increase the ratio of R&D fund in sales revenue, provide dedicated fund for R&D efforts, recruit full-time R&D personnel and provide a favorable R&D platform and space within the enterprise.

(2) The government shall establish and improve a technology research and development investment system, promote cooperation between technology-oriented enterprises and financing institutions, make full use of the fund advantages of financing institutions, increase investment in R&D activities and improve the R&D fund utilization efficiency. Besides, the government shall provide more support for emerging technology enterprises and provide favorable policies and laws for them.

(3) The enterprise shall improve the independent research and development capacity, and improve the employees' innovation awareness and cultural quality.

While introducing advanced foreign technologies, the enterprises shall make efforts to improve their independent research and development capacity which is the core competitiveness of the enterprises. To improve their independent research and development capacity, the enterprises shall firstly increase R&D investment to ensure the smooth progress of R&D projects, and then build a strong R&D team and attract high-tech talents and innovative management talents with different education background and technologies into the team. Besides, the enterprises shall improve the R&D inventive mechanism, link up the R&D personnel's revenue with their R&D achievements, so as to motivate their creativity. In addition, the enterprises shall provide a favorable environment for innovation, enhance the innovation awareness of all staff, provide innovation-related trainings regularly and encourage employees to put forward new ideas and concepts, and formulate relevant incentive methods to increase their enthusiasm.

References

- [1] Chen Yue. Study on Capability Evolution Path of Emerging Technology Enterprises [J]. Science and Technology Management Research, 2012(22):12-13
- [2] He Yinglong, Zhou Zongfang. Study on Characteristic Function and Growth Model of Emerging Technology Enterprises in China [J]. Technology and Innovation Management, 2010, (10) :92-93
- [3] Hu Zhongwen, Xia Hongsheng. Study on Knowledge Employees Performance Evaluation Model in Emerging Technology Enterprises –Taking Shenzhen ZTE as an Example [J]. Science and Technology Management Research, 2010(13):181-183
- [4]Gu Jing, Zhou Zongfang. Credit Risk Identification for Emerging Technology Enterprises Based on Variable Precision Rough Set [J]. Journal of Industrial Engineering and Engineering Management, 2010,(1):70-71

- [5] Zheng Xia. Study on Factors Influencing Innovation Capacity of Emerging Technology Enterprises in China [J].Research on Financial and Economic Issues, 2014(11):128-129
- [6] Zhao Zhigeng, Yang Chaofeng. Empirical Study on Innovation Capacity of High-tech Enterprises under Transformation in China [J].China Soft Science, 2013(1) :32-33
- [7] Li Longyun, Xie Yi. Evaluation on Innovation Capacity of Listed Companies in China GEM [J]. The Economist, 2011(2):93-95
- [8]He Yinglong. Study on Product Prediction, Market Value and Characteristics of Emerging Technology Enterprises [D]. Chengdu: University of Electronic Science and Technology of China, 2009.