Research on Evaluation System Construction and Empirical Analysis of Self-dependent Innovation Demonstration Areas Competitiveness: The Case of Three Demonstration Areas in Beijing, Shanghai, Wuhan

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Abstract. Self-dependent innovation demonstration area is the demonstrating and leading zone in the development of the self-dependent innovation and high-tech industry promotion in China, whose competitiveness performance will determine the developing direction of our country's innovation level. This paper constructs a self-dependent innovation demonstration area competitiveness evaluation model with the evaluation index system called "four-dimensional CIAE" reflecting the core functions of self-dependent innovation demonstration including carrier support, Independent innovation, agglomeration-radiation and external expansion, utilizes the composite relation entropy matter-element model and conducts a comparative analysis of the performances and the characteristics of three large demonstration areas' comprehensive competitiveness, which provides a scientific and effective evaluation tool for the national self-dependent innovation demonstration area construction.

1. Introduction

The self-dependent innovation demonstration area, approved by the State Council in China acting as a role of exploring experience, making demonstration in promoting self-dependent innovation and high technology industry development pilot area, imposes significant effect on driving the innovation engine development and speeding up the shift of the mode of our country's economic development.

Foreign theoretical and industrial circles design the high-tech zone competitiveness evaluation system from different angles. On behalf of the main achievement are as follows: Bruno and Tyebjee designed the corresponding evaluation index system according to venture capital, policy tilt, entrepreneur ability, convenient traffic and other 12 factors [1]. Makecki evaluated the circumstance of high-tech zone according to the fluidity of research personnel, the fluidity of venture capital, government support and the like 8 factors. Silicon Valley Network published annually index since 1995 to the present, which was according to 5 aspects of human resources, innovation economy, the living place and regional management with a total of 82 measures[2-3]. The domestic scholar Shouqing Fu elaborated 5 stages and corresponding features of the demonstration area with the example of Zhongguancun demonstration area, and summarized regional innovation networks and industrial ecological environment were two key factors [4].Shuhua Hu analyzed the internal relationships and operational mechanism of 12 innovative elements of demonstration area in system dynamics [5].Jialong Xie discussed unbalance degree and change trend of high-tech zone in our country on the basis of international foreign exchange earnings, innovation, social contribution, support with a total of 21 indicators evaluation system[6].

2. Comprehensive Competitiveness Evaluation System Building of Three Demonstration Areas

2.1 Construction of "The Four-three Structure" Mode and Index Selection

This paper takes the theoretical achievements of Jialong Xie for reference. The index system framework is designed from four dimensions (hereinafter referred to as the "The Four-dimensions CIAE"), such as Carrier Support, Independent Innovation, Accumulation-Radiation and External Expansion[6].

Table 1 "The Four-dimensional CIAE" Competitiveness Evaluation Index

first level index	Second level index	third level index
Carrier Support B1	Hard carrier C1	D1:enterprise average
		D2:employee scale
		D3:number of universities and research institutions
		D4:asset-liability ratio
		D5:geographical position
		D6 :number of Productivity promotion center
		D7:the total of Science and technology incubator
		D8 :Science and technology incubation space
	Soft carrier C2	D9 policy support dynamics
		D10:campus culture of innovation
		D11: local laws completeness
		D12 :professional quality of service
		D13 :venture capital support
		D14: basis supporting environment
independent innovation B2	Innovation input C3	D15:average stock of R&D funds
		D16 :the intensity of R&D spending
		D17 :activities of science and technology personnel
		D18 :talent input structure
		D19:employees' level of education
		D20 :the activities of science and technology personnel per capita R&D funds
	Innovation output C4	D21 :technology income scale
		D22 :income outcome structure
		D23 :income R&D funding to create technology
		D24 :new product sales ratio
		D25 :patent weighted quantity
		D26 :the relative amount of enterprise incubator graduation
		D27 :profitability
		D28 :the number of independent well-known brands
Agglomeration & Radiation B3	Accumulate strength C5	D29 :human concentration of high-technology
		D30 :capital element concentration
		D31 :space gathered density
		D32 :science and technology incubation density
	Radiation driven C6	D33 :economic driving degree
		D34 :export pulling force
		D35 :employment absorption force
		D36 :tax contribution
		D37 :environment improving degree
External Expansion B4	Foreign exchange earning level C7	D38 export scale
		D39 per capita export
		D40 export growth
		D41 degree of dependence on export
	Strength of investment and capital attracting C8	D42:the degree of park openness
		D43 :the actual use of foreign capital scale
		D44:per capita use of pinch
		D45 degree of utilization of foreign capital

Through theory selection and empirical selection, evaluation criterions of the competitiveness form index system including four dimensions and three layers. This index system covers 4 first level indexes, 8 second level indexes and 45 third level indexes, and combines quantitative indexes and qualitative indexes, absolute indexes and relative indexes. The design is an active extension and bold attempt based on the existing research results, and that also ensures the objectivity and feasibility of the index system.

2.2 Evaluation Model Building of the Competitive Comprehensive

Due to the statistical caliber normalization of demonstration areas is relatively poor, and evaluation indexes contain a lot of qualitative indexes, leading to not explicitly give weight information of evaluation indexes. In order to improve the objectivity of evaluation process, the paper adopts relative entropy to determine the weight coefficient of each index.

First, calculate the grey correlation coefficient of $\underset{\sim mn}{R}$. The reference sequence $Y_0 = \{y_1, y_2, \cdots, y_n\}^T$ $(y_j = \max\limits_{1 \le i \le m} \mu_{ij}, j = 1, 2, \cdots, n)$ is established. Compare sequences and reference sequences together make up the grey correlation $@GRF = \left[Y_0 \ \underset{\sim mn}{R} \right]$, thus to get diversity sequence $\Delta_i = \left| Y_0 - Y_i \right|$. Then grey relational coefficient of C_j is expressed as

$$\zeta_{ij} = \frac{\min\limits_i \min\limits_j \Delta_i + \rho \max\limits_i \max\limits_j \Delta_i}{\left| \mu_{ij} - y_j \right| + \rho \max\limits_i \max\limits_j \Delta_i} \quad (1)$$

The ρ in the formula is distinguish coefficient, normally $\rho = 0.5$, in order to weaken distortion of correlation coefficient of evaluation indexes, because the biggest absolute difference is too large.

Then, calculate the entropy of evaluation index. Because entropy is a function of measurement uncertainty in information theory, entropy value is bigger, the greater the corresponding information. So the entropy of C_j is

$$F_j = -(\ln m)^{-1} \sum_{i=1}^{m} \frac{\zeta_{ij}}{\sum_{i=1}^{m} \zeta_{ij}} \ln \frac{\zeta_{ij}}{\sum_{i=1}^{m} \zeta_{ij}}, (i = 1, 2, \cdots, m; j = 1, 2, \cdots, n) \quad (2)$$

Finally, determine the weight coefficient of evaluation index. According to the deviation degree $k_j = 1 - F_j$, get the weight coefficient of C_j is $\omega_j = k_j \Big/ \sum_{j=1}^{n} k_j$. And build a composite matter-element of indexes' weight of the competitiveness evaluation of demonstration zones:

$$R_{\omega j} = \begin{bmatrix} & C_1 & C_2 & \cdots & C_n \\ \omega_j & \omega_1 & \omega_2 & \cdots & \omega_n \end{bmatrix} (3)$$

(4) Calculate the evaluation results of comprehensive competitiveness

Composite relation entropy matter-element $\underset{\sim mH}{R}$ of the competitiveness evaluation is made by $\underset{\sim mn}{R}$ and $R_{\omega j}$.

$$\begin{aligned} \underset{\sim mH}{R} &= \begin{bmatrix} & M_1 & M_2 & \cdots & M_m \\ H_i & H_1 & H_2 & \cdots & H_m \end{bmatrix} \\ &= \begin{bmatrix} & M_1 & \cdots & M_i & \cdots & M_m \\ H_i & -\sum\limits_{j=1}^{n} P(\omega_j \mu_{1j}) \ln P(\omega_j \mu_{1j}) & \cdots & -\sum\limits_{j=1}^{n} P(\omega_j \mu_{ij}) \ln P(\omega_j \mu_{ij}) & \cdots & -\sum\limits_{j=1}^{n} P(\omega_j \mu_{mj}) \ln P(\omega_j \mu_{mj}) \end{bmatrix} \end{aligned} \quad (4)$$

In this formula, $P(\omega_j \mu_{ij}) = \omega_j \mu_{ij} \Big/ \sum_{j=1}^{n} \omega_j \mu_{ij}$, $i = 1, 2, \cdots, m; j = 1, 2, \cdots, n$, measure value of the competitiveness evaluation of i is H_i. And more value of the H_i, comprehensive competitiveness the better. Thereby comprehensive competitiveness of three demonstration zones is

ranked by the value of H_i.

3. Comparative analysis of comprehensive competitiveness of Demonstration Area

Combining with demonstration area's competitiveness evaluation structure of "four dimensional CIAE", comparative analysis of performance and characteristics of three demonstration areas' competitiveness is conducted from the "4 + 1" dimensions of carrier support, self-dependent innovation, the development of accumulated-radiation, external expansion and comprehensive competitiveness.

Table2 comprehensive competitiveness evaluation measure value about "The Four-dimensional CIAE" of Three Demonstration Areas

Demonstration Area	Zhongguancun	sort	Zhangjiang	sort	East Lake	Sort
Carrier Support B1	0.7390	1	0.6207	2	0.4127	3
Hard carrierC1	0.8275	1	0.5134	2	0.4672	3
Soft carrierC2	0.6485	2	0.7304	1	0.3570	3
Independent Innovation B2	0.8375	1	0.4460	3	0.4820	2
Innovation input C3	0.7200	1	0.4888	3	0.5938	2
Innovation output C4	0.9157	1	0.4176	2	0.4076	3
Agglomeration Radiation B3	0.9463	1	0.3854	3	0.4508	2
Accumulate strength C5	0.9030	1	0.3547	3	0.4650	2
Radiation driven C6	0.9857	1	0.4133	3	0.4379	2
External Expansion B4	0.4383	3	0.9182	1	0.4670	2
Foreign exchange earning level C7	0.4392	3	0.8412	1	0.5230	2
Strength of investment attractinC8	0.4373	2	1.0000	1	0.4076	3
Comprehensive Competitiveness	0.7643	1	0.5637	2	0.4528	3

3.1 Comparative analysis of Carrier Support

According to the calculated result which can be found in table 2, the carrier support of Beijing Zhongguancun (0.7390) and Shanghai Zhangjiang (0.6270) have similar performance, more outstanding than the others. The hard carrier of Zhongguancun (0.8275) and the soft carrier of Zhangjiang (0.7304) are in the first place of the three demonstration areas. By comparison, the construction level of hard carrier and soft carrier of Wuhan East Lake are the lowest. In the field of hard carrier, Wuhan East Lake not only has significant congenital disadvantage in the location (central inland), but also shows weakness in many indexes (enterprise average D_1 and employee scale D_2). Similarly, it is also weak in the area of soft carrier support formed by government departments, agencies, and venture capital firms.

3.2 Comparative analysis of Self-dependent Innovation Ability

According to the calculated result which can be found in table 2, the innovation input (0.7200) and the output (0.9157) of Beijing Zhongguancun have obvious leading advantage, much higher than the other two demonstration areas and the score of the whole competition condition of the self-dependent innovation B2 is almost twice as that of Wuhan East Lake. The calculated structure of Wuhan East Lake is close to Shanghai Zhangjiang, which is 0.4460 and 0.4820 respectively. In innovation output C4 area and the scores of most indexes of Wuhan East Lake are slightly higher than the Shanghai Zhangjiang, showing that Wuhan East Lake obtains higher innovation output in the condition of lower scale of innovation investment and has stronger transfermation ability of science and technology.

3.3 Comparative analysis of Accumulating-radiation Force

According to the calculated result which can be found in table 2, Beijing Zhongguancun area has the best accumulating-radiation effect (B3 = 0.9463), even higher than the total score of Shanghai Zhangjiang and Wuhan East Lake. As a central leader in science and technology innovation and industry upgrading, Wuhan shows better radiation intensity (C5 = 0.4650) and the radiation drive (C6 = 0.4379). In addition, its score of accumulation of radiation B3 is slightly higher than the

Shanghai Zhangjiang, ranking the second. At the same time, it contributes 45.43% for export-led region relying on advantages of technology and products in the field of optoelectronic information industry.

3.4 Comparative analysis of of External Expansion Force

According to the calculated result which can be found in table 2, the various indexes of the external expansion force of Shanghai Zhangjiang B_4 ranks the first, much higher than the others. By contrast, the external expansion trends of Beijing Zhongguancun and Wuhan East Lake are weak, but Wuhan East Lake stands firm in the international market by virtue of optoelectronic information technology (Changfei, Fenghuo, etc.), and has higher foreign exchange earning level than that of Beijing Zhongguancun. Through strengthening export orientation of science and technology products and supporting the area in aspects such as taxation, financing and technology, many indexes (export earnings growth D40, average use of resource D44, and degree of utilization of foreign capital D45) of Wuhan East Lake shows a rising trend. Although there is still a gap compared with mature coastal high-tech zone at present, the external expansion of East Lake will be expanded with the rise of the Yangtze River economic belt.

4. Conclusion

Results show that the Beijing Zhongguancun demonstration zone has stronger competitive advantages than Zhangjiangin in all aspects except the external expansion, especially self-dependent innovation B2 and accumulation-radiation B3, which has the strongest comprehensive competitiveness. The comprehensive competitiveness of Shanghai Zhangjiang demonstration zone ranks the second, but still much weaker than the Zhongguancun demonstration zone. Having the unique geographical advantage, Zhangjiang demonstration area’s external expansion B4 is outstanding, but self-dependent innovation B2 and accumulation-radiation B3 are poor. Comprehensive competitiveness of Wuhan East Lake demonstration area ranks the last and the carrier support B1 level is low, especially soft carrier support. However, in recent years, its input intensity of various innovative elements has increased, external expansion has been increasing apparently, and export earning has been growing by years. Additionally, Wuhan East Lake is advantageous in areas of the self-dependent innovation B2 and accumulation-radiation B3, compared with Zhangjiang demonstration area.

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