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Evaluation of the Enhancing Effect of Industrial Alliance on Independent Innovation Capability of High-Tech Industry

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Abstract: On the basis of the analysis of the role that industrial alliance enhances independent innovation capability of high-tech industry, the paper designs enhancing effect evaluation index around resources integration, achievements output, achievements diffusion, economic benefit, system optimization and environmental improvement of industrial innovation, and constructs index weight determination method and comprehensive evaluation model respectively based on analytic hierarchy process and fuzzy evaluation principle, and conducts empirical study that high-tech industrial alliances in Heilongjiang province are taken as examples, so as to offer decision support to develop industrial alliance and advance independent innovation of the high-tech industry further.

Keywords: high-tech industry, industrial alliance, independent innovation capability, evaluation, effect

1 Introduction

Since the 1980s, aiming at seizing the commanding heights of high-grade and advanced technique, United States, Europe, Japan and other developed countries have guided the formation of a number of industrial alliances, such as U.S. semiconductor alliance, the European biological alliance, etc., which have enhanced the independent innovation capability of high-tech industries in developed countries. To develop industrial alliance is also bound to become focal tool to pull high-tech industry independent innovation strategy [1], thus, a series of high-tech industrial alliances have been established [2], since the Ministry of Science and Technology and other five ministries of P. R. China jointly issued Guidance Regarding Promoting Establishment of Industrial Technology Innovation Strategic Alliance in 2008. Meanwhile, some problems are emerging in endlessly, such as blind establishment, poor contributing to industrial development, etc.. Whether and how the industrial alliance enhances the independent innovation capability of high-tech industry [3], so far, is still a real problem, which puzzles the industrial alliance layout and even important role of industrial innovation radiation. Therefore, it is of great theoretical and practical significance to build evaluation system of the enhancing effect of industrial alliance on independent innovation capability of high-tech industry.

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2 Enhancing effect analysis

Independent innovation capability of high-tech industry is the ability that can support the industry to get core independent intellectual property rights and realize innovation gains [4-6], and is embedded in industrial innovation activity system [7]. Generally, industrial innovation activity system contains innovation resource input, innovation output, innovations diffusion and innovation value realization of four core links, and industrial innovation chain coordination and innovation environment support of two auxiliary links [8, 9], Accordingly, independent innovation capability of high-tech industry should involve innovation resource input capability, innovation output capability, innovation diffusion capability, innovation value realization capability, innovation chain coordination capability and innovation environment creation capability.

Industrial alliance is the concentrated expression of core innovation advantage of the related industrial, and it enhancing independent innovation capability of industry is the process that innovation advantage of industrial alliance is transformed to independent innovation ability of industrial essentially [10][11]. Specifically, industrial alliance is able to enhance the six dimensions of independent innovation capability of high-tech industry.

(1) Industrial alliance can promote integration of industrial innovation resources. As an efficient industrial innovation organization, industrial alliance can gather and share a lot of R & D personnel and funding in the industry [12]. Meanwhile, it can realize complementary

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integration between knowledge, technology and industrialization resources.

(2) Industrial alliance is able to increase industrial innovations output. Industrial alliance concentrates superior innovative resources into complete major industrial innovation tasks to form more symbolic achievements [13], and then enhances the quality and quantity of industrial innovations.

(3) Industrial alliance accelerates industrial innovation infusion. Industrial alliance is powerful to spread innovations throughout the industry, for example, attracts more enterprises join in its technology standard, or authorizes or transfers technology patents to the enterprises outside the union [14].

(4) Industrial alliance helps realize industrial innovation revenue growth. Industrial alliance is able to quickly industrialize innovations within the union, and guides majority of SMEs to innovate supporting high-tech products and services [15]. In addition, industrial alliance has stronger external cooperation ability, and drives the export of high-tech products or services of the whole industry [16].

(5) Industrial alliance optimizes industry innovation chain. Industrial alliance forms a complete and efficient industrial core innovation chain to support advanced independent innovation activities with outstanding performance such as product development cycle shortened [17, 18], R & D cost saved and dependence on foreign technology reduced [19].

(6) Industrial alliance can also improve innovation environment. Industrial alliance sets an example for industrial innovation, orders industry innovation behaviors [20], stimulates industrial innovation consciousness. On the other hand, industrial alliance has become the important carrier for implementation of government policy, and technological and industrial policies including science and technology plan [21], financial, tax policies and etc. oriented industrial alliance objectively stimulate the whole industry innovation.

3 Evaluation system of enhancing effect

3.1 Evaluation index system

According to the effect mechanism that industrial alliance enhances independent innovation capability of high-tech industry, and following the principles of comparability, data availability, scalability and etc., evaluation index system on enhancing effect is designed, as shown in Tab. 1.

Tab. 1 Evaluation index system of the enhancing effect of industrial alliance on independent innovation capability of high-tech industry

Evaluation target	First level indicators	Second level indicators
The effect industrial alliance enhancing independent innovation capability of high-tech industry (V)	Integration effect of industrial innovation resources (V_1)	Proportion industrial alliance R & D personnel accounted for of the whole industry (V_{11})
		Proportion industrial alliance R & D fund accounted for of the whole industry (V_{12})
		Growth rate of university-industry-research institute cooperation projects (V_{13})
	Increase in the output of industrial innovation (V_2)	Growth rate of invention patents (V_{21})
		Growth rate of technical standards (V_{22})
		Growth rate of number of high-tech products (V_{23})
	Diffusion effect of industrial innovation output (V_3)	Ratio of enterprises joined the technical standards of industrial alliance (V_{31})
		Ratio of enterprises using technologies of industrial alliance (V_{32})
	Economic efficiency of industrial innovation (V_4)	Growth rate of sales revenue of high-tech products (V_{41})
		Growth rate of exports of high-tech products (V_{42})
	Optimization effect of industrial innovation system (V_5)	Shortening rate of average R & D cycle of high-tech products (V_{51})
		Saving rate of R & D cost of high-tech products (V_{52})
		Reducing rate of dependence on foreign core technology (V_{53})

	Improvement effect of industrial innovation environment (V_6)	Improvement effect of industrial innovation culture (V_{61})
		Enhancement effect industrial innovation policy support (V_{62})

Secondary indicators are to maximize the quantitative, and focus on the incremental changes of independent innovation capability of high-tech industry caused by the industrial alliance. It should be noted that V61 and V62 are qualitative indicators, and fuzzy evaluation ideology can be used to carry out quantitative treatment in order to facilitate the comprehensive evaluation. In addition, a few quantitative indicators, which are unable to get the values, can also use this method of quantitative treatment.

3.2 Method for index weights determination

Index weights are determined based on analytic hierarchy process, and the main steps are as follows:

(1) Judgment matrix construction. In the judgment matrix A, a_{ij} represents the ratio of the relative importance of the indicator i and j, and provisions with 1,3,5,7,9 denote indicators i and j of the more important, important, very important, extremely important.

(2) Weight calculation. Calculate the product of the each row elements of the matrix A, $M_i=\prod_{j=1}^{n} a_{ij}$ ($\mathrm{i}=1$, 2, ……..n). Calculate n-th root of M_i, $\underline{W_i}=\sqrt[n]{M_i}$. Make normalization processing to $\underline{W_i}$, $W_i=\underline{W_i}/\sum_{i=1}^{n}\underline{W_i}$, and then calculate the weights $W=[W_1,W_2,....W_n]$.

(3) Consistency test.

3.3 Comprehensive evaluation model

Because the vast majority of effect evaluation indicators are quantitative, index membership can be determined by relative membership degree calculation, which the gray fuzzy evaluation principle is used to build a comprehensive evaluation model:

(1) Build index characteristic value matrix. Characteristic value matrix of enhancing effect index is $B=(b_{ij})$, and b_{ij} is the actual observed value for the second level indicators.

(2) Calculate the degree of membership. Membership matrix is $R=\lfloor r_{ij} \rfloor$, and among this matrix,

$$r_{ij}=\begin{cases} 0 & b_{ij}=\wedge b_{ij} \\ \dfrac{b_{ij}-\wedge b_{ij}}{\vee b_{ij}-\wedge b_{ij}} & \vee b_{ij}-\langle b_{ij}\langle \wedge b_{ij} \\ 1 & b_{ij}=\vee b_{ij} \end{cases}$$

(3) Calculate the value of comprehensive evaluation. Fuzzy synthetic value is $V=W\times R$, then comprehensive scores are relatively ranked and evaluation results are analyzed.

4 Empirical research

4.1 Industrial alliances layout

Heilongjiang province is a famous old industrial base in China, and its high-tech industries rapidly develop based on the strong industrial base. Since 2008, a series of industrial alliances are set up high-tech industries in Heilongjiang province. The industrial alliances layout is shown in Tab. 2.

Tab. 2 Industrial alliances layout in high-tech industries in Heilongjiang province

Industrial alliance	Owned industry	Industrial alliance	Owned industry
Industrial alliance of medicine (SA_1)	Pharmaceutical industry	Industrial alliance of semiconductor lighting (SA_6)	Energy efficient industry
Industrial alliance of power equipment (SA_2)	Advanced equipment manufacturing industry	Industrial alliance of Aluminum-magnesium alloy (SA_7)	Metallic materials industry
Industrial alliance of high latitudes electric vehicles (SA_3)	Mechatronics machinery and equipment industry	Industrial alliance of composites (SA_8)	Composites industry
Industrial alliance of	Other optical and electrical	Industrial alliance of graphite	Inorganic non-metallic

agricultural machinery (SA_4)	integration industry	(SA_9)	materials industry
Industrial alliance of wind power (SA_5)	New energy industry	Industrial alliance of environmental protection (SA_{10})	Environmental protection industry

4.2 Index weights determination

Relative importance of first level indicators are scored and averaged by fifteen experts including ten industrial alliance managers, three technology management department officials and two industrial innovation management professors, then a judgment matrix B is formed.

$$B=\begin{bmatrix} 1 & 1.6219 & 1.1860 & 0.9668 & 2.4090 & 2.9860 \\ 0.6167 & 1 & 0.6167 & 0.5962 & 1.4857 & 1.8416 \\ 0.8434 & 1.3675 & 1 & 0.8153 & 2.0317 & 2.5184 \\ 1.0344 & 1.6772 & 1.2265 & 1 & 2.4918 & 3.0887 \\ 0.4151 & 0.6731 & 0.4922 & 0.4013 & 1 & 1.2395 \\ 0.3349 & 0.5430 & 0.3971 & 0.3238 & 0.8067 & 1 \end{bmatrix}$$

By root finding method and normalization processing, first level indicators weights are determined = , and has passed the consistency test.

Similarly, secondary index weights are determined in turn:

$$W_1=(0.2411,0.3264,0.4325),$$

$$W_2=(0.2505,0.4591,0.2904),$$

$$W_3=(0.5873,0.4127),$$

$$W_4=(0.5450,0.4551),$$

$$W_5=(0.2076,0.1350,0.6574),$$

$$W_6=(0.2738,0.7262).$$

4.3 Comprehensive evaluation analysis

By consulting the Statistical Yearbook of the High-tech Industry in Heilongjiang Province and visiting industry alliances, government technology management sectors, the value of 10 indicators fromV11 to V42 in 2010 and 2011 are accessed. No statistical data correspond to the five indicators from V51 to V62; thus, the indicators are scored and averaged by those fifteen experts. The second level index values are shown in Tab. 3.

Tab. 3 Evaluation index values of the enhancing effect of industrial alliances on independent innovation capability of high-tech industries in Heilongjiang province

Second level indicators \ Alliances	SA_1	SA_2	SA_3	SA_4	SA_5	SA_6	SA_7	SA_8	SA_9	SA_{10}
V_{11}	0.4300	0.2903	0.1100	0.0817	0.3415	0.1600	0.3400	0.1302	0.0413	0.3841
V_{12}	0.6200	0.3200	0.1200	0.1333	0.3667	0.1803	0.4904	0.2300	0.0612	0.4200
V_{13}	0.3333	0.2333	0.1800	0.2011	0.4523	0.1211	0.5189	0.1401	0.1874	0.5477
V_{21}	0.1333	0.2316	0.3700	0.2204	0.4318	0.2416	0.1804	0.3689	0.2674	0.1667
V_{22}	0	0.2200	0.3333	0	0	0	0.1667	0.3667	0	0
V_{23}	0.2500	0.1767	0.4367	0.1747	0.1106	0.2800	0.2000	0.2650	0.1544	0.1318
V_{31}	0	0.2100	0.1333	0	0	0	0.0667	0.1500	0	0
V_{32}	0.1222	0.2104	0.3100	0.1200	0.0090	0.1300	0.1456	0.4178	0.1146	0
V_{41}	0.2813	0.2104	0.1405	0.1700	0.0233	0.1456	0.2605	0.7420	0.1000	0.1411
V_{42}	0.2213	0.2304	0.1326	0.2784	0.0623	0.0987	0.2315	0.1321	0.0977	0
V_{51}	0.3500	0.1467	0.0899	0.2467	0.0667	0.1503	0.2144	0.3423	0.1123	0.0867
V_{52}	0.2334	0.1879	0.1377	0.1023	0.0203	0.1134	0.1567	0.1312	0.0545	0.0756
V_{53}	0.1876	0.2156	0.3411	0.0544	0.2278	0.1755	0.2106	0.5667	0	0.1422
V_{61}	0.3333	0.2566	0.2217	0.1567	0.0978	0.2178	0.2334	0.3767	0.1256	0.1329
V_{62}	0.2107	0.2500	0.2500	0.3233	0.1211	0.1456	0.2467	0.4500	0.1667	0.2311

Through the calculation of relative membership degree, membership matrix of fuzzy comprehensive evaluation (R^T) is obtained.

Through layer-by-layer matrix calculation, comprehensive evaluation scores of enhancing effect corresponding to the 10 industry alliances are obtained,

and the relative ranking are given out. Assuming that fuzzy intervals uniformly distributes, the fuzzy intervals of excellent, good, fair and poor are set: [0.75,1], [0.5,0.75), [0.25,0.5) and [0,0.25). Specific results are shown in Tab. 4.

$$R^T = \begin{bmatrix} 1.0000 & 0.6406 & 0.1767 & 0.1039 & 0.7723 & 0.3054 & 0.7685 & 0.2287 & 0.0000 & 0.8819 \\ 1.0000 & 0.4631 & 0.1052 & 0.1290 & 0.5467 & 0.2131 & 0.7681 & 0.3021 & 0.0000 & 0.6421 \\ 0.4974 & 0.2630 & 0.1381 & 0.1875 & 0.7764 & 0.0000 & 0.9325 & 0.0445 & 0.1554 & 1.0000 \\ 0.0000 & 0.3293 & 0.7930 & 0.2918 & 1.0000 & 0.3628 & 0.1578 & 0.7893 & 0.4492 & 0.1119 \\ 0.0000 & 0.5999 & 0.9089 & 0.0000 & 0.0000 & 0.0000 & 0.4546 & 1.00010 & 0.0000 & 0.0000 \\ 0.4275 & 0.2027 & 1.0000 & 0.1966 & 0.0000 & 0.5195 & 0.2741 & 0.4735 & 0.1343 & 0.0650 \\ 0.0000 & 1.0000 & 0.6348 & 0.0000 & 0.0000 & 0.0000 & 0.3176 & 0.7143 & 0.0000 & 0.0000 \\ 0.2925 & 0.5036 & 0.7420 & 0.2872 & 0.0215 & 0.3112 & 0.3485 & 1.0000 & 0.2743 & 0.0000 \\ 0.3590 & 0.2603 & 0.1631 & 0.2041 & 0.0000 & 0.1702 & 0.3300 & 1.0000 & 0.1067 & 0.1639 \\ 0.7949 & 0.8276 & 0.4763 & 1.0000 & 0.2238 & 0.3545 & 0.8315 & 0.4745 & 0.3509 & 0.0000 \\ 1.0000 & 0.2824 & 0.0819 & 0.6354 & 0.0000 & 0.2951 & 0.5214 & 0.9728 & 0.1610 & 0.0706 \\ 1.0000 & 0.7865 & 0.5509 & 0.3848 & 0.0000 & 0.4369 & 0.6401 & 0.5204 & 0.1605 & 0.2595 \\ 0.3310 & 0.3804 & 0.6019 & 0.0960 & 0.4020 & 0.3097 & 0.3716 & 1.0000 & 0.0000 & 0.2509 \\ 0.8444 & 0.5694 & 0.4442 & 0.2112 & 0.0000 & 0.4303 & 0.4862 & 1.0000 & 0.0997 & 0.1259 \\ 0.2724 & 0.3919 & 0.3919 & 0.6148 & 0.0000 & 0.0745 & 0.3819 & 1.0000 & 0.1386 & 0.3344 \end{bmatrix}$$

Tab. 4 Comprehensive evaluation results of the enhancing effect of industrial alliance on independent innovation capability of high-tech industry in Heilongjiang province

Alliances / Evaluation result	SA_1	SA_2	SA_3	SA_4	SA_5	SA_5	SA_7	SA_8	SA_9	SA_{10}
Comprehensive scores	0.4509	0.5233	0.4592	0.2818	0.2540	0.2042	0.5253	0.6852	0.1312	0.2728
Relative ranking	5	3	4	6	8	9	2	1	10	7
Fuzzy result	Fair	Good	Fair	Fair	Fair	Poor	Good	Good	Poor	Fair

5 Conclusion

First of all, industrial alliance can promote industrial advantageous innovative resources integration of, and increase the industrial innovative output, and accelerate industrial innovative diffusion, and achieve industrial innovative revenue growth, and optimize the industrial innovative chain and improve industrial innovative environment; on this basis, the enhancing effect evaluation index system has been constructed. Secondly, evaluation of the effect that industrial alliance enhances independent innovation capability of high-tech industry belongs to the multi-dimensional, multi-level comprehensive evaluation, and to determine the index weight based on the analytic hierarchy process can give full play to the collective wisdom of experts, and gray fuzzy evaluation principle can also effectively avoid the problem that evaluation criteria is difficult to set up, and meanwhile improve objective validity of the evaluation. Finally, application process of the evaluation index and method has been shown and scientific validity of the evaluation system is further proved through empirical analysis on comprehensive evaluation of the effect industrial alliances enhancing high-tech industries in Heilongjiang province.

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