

Evaluation of Industry Innovation Potential Based on DEMATEL Model

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Abstract

Innovation ability is a concentrated expression of a country's comprehensive strength, and industry innovation ability is an important component of innovation ability, and an important embodiment of inter-industry creativity and core competitiveness. This paper takes the industry as the main body, firstly analyzes the current research status of the industry's innovation potential evaluation at home and abroad, constructs an evaluation index system for innovation potential; then assigns index weights through DEMATEL evaluation model and comprehensively obtains the level of industry innovation potential; finally, objective data from multiple industries is used to verify the evaluation model. It is concluded that the investment of R&D personnel and funds occupies an important position in innovation and the pharmaceutical industry has the most innovative potential. Based on the results of this analysis, suggestions are made for the future development and innovation of the industry.

Keywords

Industry innovation potential; DEMATEL; Evaluation system.

1. Introduction

With the development and progress of economy and society, the uncertainty and complexity of the internal and external environments have gradually increased. As the mainstay of economic growth in all walks of life, continuous change and innovation have become hot topics in social development [1]. Innovative strategy is a key element of my country's innovation-driven development strategy. With the in-depth advancement of "mass innovation and entrepreneurship", my country's large, medium and small enterprises have integrated innovative ideas into the economic operation system, which not only provides employment but also promotes economic growth. However, there are often differences in the innovation capabilities of different industries. It is particularly important to start from the reality, scientifically judge the innovation level of the industry, analyze its own strengths and weaknesses, find the crux, and continuously explore and enhance its core competitiveness. Therefore, from a meso level, scientific evaluation and analysis of the innovation potential of the industry can make the industry better achieve sustainable development.

2. Literature Review

In recent years, there have been many research results in this area at home and abroad. Innovation has always been regarded as a driving force for the growth and development of the industry. The so-called innovation essentially refers to the collection of a series of capabilities used to implement, promote and support its innovation strategy [2]. Research on innovation is based on a static perspective. For example, Guan et al (2003) proposed that innovation ability is closely related to resource endowment based on resource-based theory [3]. Hansen et al (2014) believe that innovation is closely related to organizational learning [4]. There are also studies based on a dynamic perspective, which believe that innovation is a complex dynamic

process. Xu (2011) believes that when the external environment changes, companies need to expand research on innovation capabilities, and emphasizes that innovation capabilities have the attributes of process and uncertainty [5].

In addition, there are many studies on innovation evaluation. Zhu et al (2009) conducted a more in-depth study on the technological innovation environment of high-tech industries, and analyzed the constituent elements of the industrial innovation environment [6]. The significant indicators that have been verified to affect industrial innovation activities mainly include: policy environment, market environment, financial environment, innovation basic environment. Liu et al. (2020) used DEA model and Malmquist index to construct high-tech enterprise technological innovation efficiency evaluation model and influencing factor model from the perspective of input and output, and analyzed the efficiency of enterprise technology travel in various provinces in my country [7]. The seven indicators selected by Zhao et al. (2010) in the research are based on the innovation input and output level and then establish an innovation performance evaluation index system [8]. Tang et al. (2018) built an evaluation index system for innovation capability from three aspects: innovation resource input, innovation support, and innovation output capability [9].

To sum up, most of the existing researches are aimed at constructing a theoretical framework for innovation, and tend to evaluate and analyze innovation capabilities at the macro level. However, no meso-micro evaluation research on innovation potential has been produced. Therefore, in order to make up for this shortcoming, this article summarizes the research on the innovation potential of related industries and establishes an evaluation index system for the innovation potential of the industry. And through the evaluation and comparative analysis of the innovation potential of 8 industries, on this basis, corresponding suggestions are put forward for improving the innovation potential of the industry.

3. The Establishment of Indicator System

The innovation ability possessed by the industry itself is a dynamic ability, which includes the generation of innovative thinking, new product development, promotion and sales and management, etc., running through the entire process of innovation [10]. By evaluating the innovation potential of the industry, it can effectively enhance the innovation capability of the industry, improve the status quo of the industry, and promote good development. Especially in the context of the current turbulent environment, in order to respond to changes, it is more necessary to evaluate your own innovation potential. Moreover, as an important force to promote the transformation of the modern economic development mode, as a market entity, it plays an important role in resource allocation and other aspects. It also plays an important role in the development of the national economy and regional economy. Therefore, the meso-level industry is selected as the evaluation object.

At present, there are many domestic researches on the evaluation of industry innovation capabilities, and corresponding indicator systems have been established from different angles. For example, the evaluation indicators included in the perspective of information disclosure mainly include R&D personnel, R&D investment, talent training, partners, marketing innovation, patent technology, tax incentives, etc.; the evaluation indicators included in the perspective of the innovation process mainly include financial investment, human input, and technological achievements. Innovation input and innovation output, etc. The indicators included in the innovation system perspective mainly include scientific research and innovation capabilities, research and development capabilities, innovation output capabilities, marketing capabilities, and innovation support capabilities. It can be seen that most domestic scholars try to study innovation capability from the industrial chain of innovation input-innovation process-innovation output. Therefore, this article will adopt the industrial chain

development model, combined with the growth characteristics of innovation and development, based on the comprehensive, scientific, true and objective basic principles established by the indicator system, taking into account the specific characteristics of the industry, and constructing an evaluation index system for the industry's innovation potential. The indicator system includes three primary indicators and 12 secondary indicators, as shown in the table.

Table 1. Evaluation Index Table of Innovation Potential of Various Industries

First-level index	Second-level index	Indicator attributes
Innovation drivers	Increase of R&D personnel full-time equivalent	+
	Increase of R&D expenditure	+
	Increase of expenditures for new product development	+
	Increase in the number of R&D projects	+
	Increase of the number of companies with organized (management) or marketing innovation activities	+
Elements of the Innovation Environment	Increase of the proportion of enterprises with organized (management) or marketing innovation activities in the proportion of industrial enterprises above designated size	+
	Increase of the proportion of companies that have achieved organizational (management) innovation	+
	Increase of the proportion of companies that have achieved marketing innovation	+
	Increase of the number of patent applications	+
Elements of Innovation Results	Increase of the number of valid invention patents	+
	Increase of the number of new product development projects	+
	Increase of new product sales revenue	+

4. Research Methods and Data Sources

4.1. Data Sources

For an objective evaluation, this article focuses on 8 industries including special equipment manufacturing, pharmaceutical manufacturing, tobacco products, general equipment manufacturing, food manufacturing, coal mining and washing, metal products, and furniture manufacturing as the research objects. Combined with the indicator data information of the eight major industries from 2018 to 2019 provided by the Statistical Yearbook to verify the model.

4.2. Research Methods

4.2.1 Definition of DEMATEL method

The DEMATEL method is a systematic factor analysis method proposed by Battelle laboratory. The main idea is to use graph theory and matrix theory principles to construct a comprehensive relationship matrix between various factors in the system, to obtain a comprehensive influence relationship matrix between various factors in the system, and to obtain the degree of influence and influence of each factor in the system on other factors. Calculate the centrality and cause degree of each factor. The internal management of complex systems can be made more intuitive [11]. The main steps of the method are as follows:

Step 1: Determine the influencing factors included in the system as $r_i, i=1, \dots, n$.

Step 2: Establish a direct relationship matrix. Let the evaluation experts judge the degree of influence of each factor. The expert k believes that the degree of influence of the factor i on the factor j is expressed as x_{ij}^k . Through the arithmetic average of the evaluation results of each

expert to obtain the degree of influence of the final factor i on the factor j , and construct a direct relationship matrix $G = [g_{ij}]_{n \times n}$, $i = 1, \dots, n$, $j = 1, \dots, n$.

Step 3: Calculate the standardized direct relationship matrix X .

$$\alpha = \frac{1}{\max \sum_{j=1}^n g_{ij}}, 1 \leq i \leq n \quad (1)$$

$$X = \alpha \times G \quad (2)$$

Step 4: Calculate the comprehensive influence matrix T .

$$T = X(1 - X)^{-1} \quad (3)$$

Step 5: Calculate the degree of influence and the degree of influence of each factor. Add the elements in the matrix by row to get the influence degree of the corresponding factor q_i , and add the matrix elements by column to get the influence degree of the corresponding factor p_i . The formula is as follows:

$$q_i = \sum_{j=1}^n t_{ij}, i = 1, \dots, n \quad (4)$$

$$p_i = \sum_{i=1}^n t_{ij}, j = 1, \dots, n \quad (5)$$

Step 6: Calculate the cause degree a_i and centrality of each factor b_i . The centrality can be obtained by adding the influence degree of each factor and the affected degree. A high centrality means that it is at the center of the system and is an important factor in the system. The degree of influence of each factor is subtracted from the degree of influence to obtain the degree of cause. A positive value of the cause degree means that the factor has an impact on other factors, and a negative value means that it is more affected by other factors. Calculated as follows:

$$a_i = q_i - p_i, i = 1, \dots, n \quad (6)$$

$$b_i = q_i + p_i, i = 1, \dots, n \quad (7)$$

4.2.2 The modeling process of the DEMATEL method

Combining the influence degree and the influence degree of each factor obtained by the DEMATEL method above, the product of the influence degree and the influence degree is used to represent the weight of the index [11].

$$w_i = \frac{|a_i \times b_i|}{\sum_{i=1}^n |a_i \times b_i|}, i = 1, \dots, n \quad (8)$$

Combined with objective indicator data, comprehensively calculate the value of innovation potential I_t of each industry t , and then sort them accordingly.

$$I_t = \sum_{i=1}^n w_i c_i, i = 1, B \quad n; t = 1, B \quad l \quad (9)$$

5. Empirical Analysis

Based on the industry innovation potential evaluation index system determined above, this section will use the actual data on the innovation potential indicators of various industries provided by the statistical yearbook to verify the model.

First, obtain the direct relationship matrix between each index factor according to expert evaluation, process the data in the matrix and use MATLAB to obtain the comprehensive influence matrix T, as shown in the following table:

Table 2. The matrix of comprehensive influence among various factors

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
1	0.0294	0.0098	0.0147	0.0074	0.0098	0.0098	0.0098	0.0098	0.0147	0.0098	0.0098	0.0074
2	0.0882	0.0294	0.0588	0.0588	0.1176	0.0147	0.0147	0.0294	0.0147	0.0147	0.1176	0.0098
3	0.0588	0.0147	0.0294	0.0098	0.0147	0.0147	0.0098	0.0147	0.0098	0.0098	0.0147	0.0074
4	0.1176	0.0147	0.0882	0.0294	0.0147	0.0147	0.0147	0.0147	0.0147	0.0098	0.0588	0.0147
5	0.0882	0.0074	0.0588	0.0588	0.0294	0.0098	0.0147	0.0074	0.0147	0.0147	0.1176	0.0147
6	0.0882	0.0588	0.0588	0.0588	0.0882	0.0294	0.0147	0.0882	0.0147	0.0147	0.1176	0.0098
7	0.0882	0.0588	0.0882	0.0588	0.0588	0.0588	0.0294	0.0588	0.0147	0.0098	0.0588	0.0098
8	0.0882	0.0294	0.0588	0.0588	0.1176	0.0098	0.0147	0.0294	0.0147	0.0147	0.0588	0.0147
9	0.0588	0.0588	0.0882	0.0588	0.0588	0.0588	0.0588	0.0588	0.0294	0.0147	0.0588	0.0098
10	0.0882	0.0588	0.0882	0.0882	0.0588	0.0588	0.0882	0.0588	0.0588	0.0294	0.0588	0.0098
11	0.0882	0.0074	0.0588	0.0147	0.0074	0.0074	0.0147	0.0147	0.0147	0.0147	0.0294	0.0074
12	0.1176	0.0882	0.1176	0.0588	0.0588	0.0882	0.0882	0.0588	0.0882	0.0882	0.1176	0.0294

Furthermore, the causality and centrality of each factor are calculated according to the comprehensive matrix, and the causal relationship between the factors is drawn, as shown in Figure 1. Use formula (8) to calculate the weight of each indicator, and further combine formula (9) to evaluate the innovation potential value of each industry, and get the following ranking table:

Table 3. Actual data values of various industry indicators

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
I1	0.0140	-0.2541	0.0490	-0.3573	0.2193	0.2284	0.1946	0.1348	-0.0589	0.3259	-0.0910	-0.4643
I2	0.0196	-0.0295	0.1725	0.1119	0.0771	0.1538	0.1150	0.1738	0.0826	0.1281	0.1575	0.0914
I3	-0.1187	0.1420	0.1579	0.0154	0.0392	0.0487	0.1136	-0.0942	0.0372	0.0615	0.1848	-0.0655
I4	0.1786	0.0822	0.5010	0.2077	0.2781	0.2595	0.2167	0.2862	0.0781	0.0965	0.4056	0.1402
I5	-0.0254	0.0494	0.1466	0.1234	0.0664	0.0707	0.0522	0.0587	0.0784	0.0468	0.1395	0.0481
I6	0.1389	0.1978	0.3765	0.2376	0.1880	0.1382	0.1259	0.1373	0.1881	0.1080	0.2983	0.2183
I7	0.1042	0.1186	0.2614	0.1664	0.1371	0.1207	0.0964	0.1268	0.2036	0.1635	0.2131	0.1684
I8	0.0945	0.0702	0.2963	0.1514	0.1611	0.1229	0.1066	0.1297	0.1572	0.0988	0.2392	0.0657

Evaluate the innovation potential of 8 industries by constructing a reasonable indicator system and scientific evaluation model. According to the relevant data of each industry in 2018-2019, the analysis has verified the rationality of the model and some reference conclusions have been obtained.

(1) For the evaluation indicators of the innovation potential of the industry, the proportion of innovation driving factors in the first-level indicators is the highest; the increase in the input of R&D personnel and the increase in the investment of R&D funds in the second-level indicators

are quite important in all indicator systems. The weight of the increase in R&D personnel's investment is 0.1875, and the highest cause is 0.0967, and the weight of the increase in R&D capital investment is 0.1480. This shows that innovation investment plays a key role in the formation of the industry's innovation potential. As a result, the proportion of factors is slightly lower.

Table 4. Weight ranking table and ranking table of innovation potential of each industry

Industry	Innovation potential value	ranking	criteria	weight	ranking	Cause degree	Centrality
			C1	0.1875	1	0.0967	-0.0766
			C2	0.1480	2	-0.0584	0.0785
			C3	0.0257	9	0.0219	-0.0018
			C4	0.1167	4	-0.0439	0.0640
I1	0.0216	8	C5	0.0854	6	0.0495	-0.0294
I2	0.0864	5	C6	0.0162	11	0.0026	0.0175
I3	0.0220	7	C7	0.0797	7	-0.0268	0.0469
I4	0.0544	6	C8	0.0781	8	0.0461	-0.0261
I5	0.1889	1	C9	0.1247	3	0.0677	-0.0476
I6	0.1704	2	C10	0.1043	5	-0.0382	0.0583
I7	0.1419	3	C11	0.0184	10	0.0015	0.0186
I8	0.1256	4	C12	0.0154	12	0.0029	0.0171

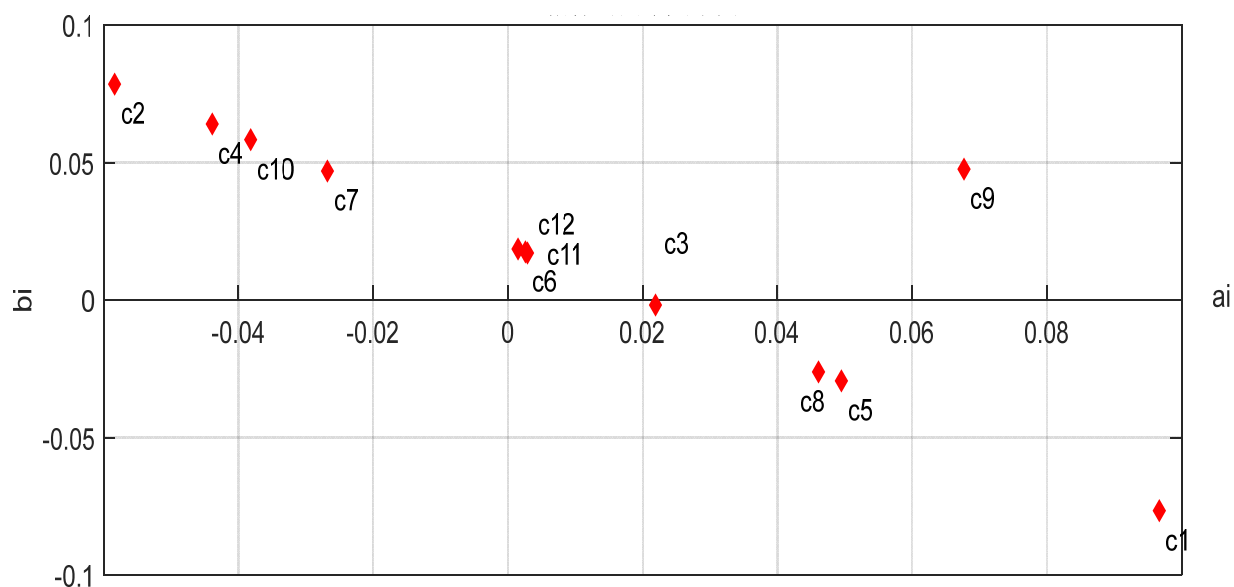


Figure 1. Causality diagram between indicators

(2) Based on actual data, a comprehensive evaluation of the innovation potential of 8 industries is carried out, and the innovation potential value of the pharmaceutical industry is 0.1889, occupying the first place, and the innovation potential value of the coal mining and washing industry is 0.0216 in the last place. From a practical point of view, my country currently attaches great importance to the development of the pharmaceutical industry. The self-innovation awareness of the pharmaceutical industry continues to increase. The number of drug research and development companies, the number of drug research and development, the number of patents, etc. have been significantly improved in terms of quantity and quality, so its innovation potential is higher. In recent years, the coal industry has been presenting an oversupply situation. Coal prices have continued to fall, innovation is lacking, and the problems of backward production capacity and excess production capacity have hindered the innovation and development of the coal industry.

Further analyze the above conclusions and put forward relevant development suggestions:

- (1) Among the indicator factors of innovation potential, the weight of innovation driving factors is slightly higher than that of result factors. It shows that all walks of life should pay attention to strengthening the investment of people, finances, and resources in the process of innovation to provide support and guarantee for innovation and development. At the same time, the result element is a key indicator used to test innovation results and measure the effectiveness of innovation. It should also be emphasized and strive to build a more complete innovation system.
- (2) Different industries should adopt different development ideas for innovation. For industries with high technology content and high potential, we should build on the accumulation of scientific and technological strength, optimize and strengthen related industries, and cultivate various innovation environments; for companies with high technology content, they should learn to build a knowledge network platform and be guided by the value-added knowledge. Promote high-end through the collaborative innovation of industry, university and research; for industries with high technology and low content, we should learn to transform the development mode, promote the advanced industrial structure, change the low-end situation of related industries, and accelerate the optimization and upgrading of products.

6. Conclusion

By selecting a representative sample, this paper verifies the practicability and rationality of the evaluation model, which has a certain reference value and reference value for the innovation and development of other enterprises. At the same time, the exploration of the evaluation model also has shortcomings, such as the selection of indicators is not comprehensive; the evaluation data only selects the changes during the two years of 2018-2019, which can only illustrate the current development potential of various industries, and future development may face many Change scenarios. It is hoped that future research can make up for the shortcomings and further verify.

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