Empirical Study on Dynamic Factors of Information Industry
Collaborative Innovation

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Keywords: Information industry, Collaborative innovation, Fuzzy Comprehensive Evaluation, Dynamic factor.

Abstract. Since the reform and opening-up, information industry has achieved rapid growth in China, though there are a lot of problems waiting to be dealt with. For purpose of finding out the key driving factors of the information collaborative innovation, the paper constructs information industry collaborative innovation dynamic factors system on the base of correlative references. After obtaining large quantities of data by questionnaire survey and using Fuzzy Comprehensive Evaluation do empirical research on each factor, we finally found the key driving factors of information collaborative innovation in China. Specifically, the mechanism of innovation motivation, the support of national policy, and the research scale of information industry are the most important factors. In order to enhance China’s information industry collaborative innovation capability and international competitiveness, it must facilitate the key dynamic factors internally and externally.

Introduction

Informatization is the tendency of today's world and is also a significant impetus to the change of social. At present, global information technology as the core of a new technological revolution surge changes of industrial, bringing opportunities and challenges to many countries. Compared with developed countries, China start late on information industry, and has weak basis. Since the reform and opening-up, China’s information industry has seen rapid growth, with its scale continued expansion, its product mix continued optimized, and its international competitive power strengthened gradually. However, there are still lots of problems need to be solved, such as lack of key technology, weak in core competence and market focus centers on middle and low-end field and so on.

Collaborative innovation is an effective organizational pattern in technological innovation, by pushing forward the main body of innovation breaking through the barriers to cooperate deeply, integrating the innovation resources and innovative elements effectively and markedly improving innovation ability and efficiency. Collaborative innovation is increasingly becoming a most distinctive trait in scientific and technological innovation activities, especially after the international financial crisis, developed countries and regions have taken measures to the layout of it. Currently, with the world economy recovering slowly, China's economy on path for ‘new normal’, and the momentum of development transforming from element-driven to innovation-driven gradually, Integration development and collaborative innovation are becoming the theme in Chinese information industry.

Literature Review

Collaborative Innovation

Johan Bruneel(2010) found that cooperation experience and a high level of trust are the key to break through the barriers existed in collaborative innovation[1]. Chesbrough from United States(2011) first presented his theory about open innovation in his book Open Innovation, which systematically studied the value of internal and external innovation elements[2]. Isabel Maria Bodas Freitas(2013)
took Brazil as an example, analyzing the success factors in newly industrialized countries emerging industry and mature industry[3]. Mustafa Bombaywala(2015), whose study shows that some barriers to collaboration can be grouped into two types, technical and perspective, but the more imperative barriers are lack of trust, skepticism about new technologies and conflict of interest. Trust continues to be the major barrier for collaboration[4].

**Dynamic Factors**

Zheng Chou(2013) thought the main external dynamics including the driving force of science and technology, market demand’s pulling power, market competition pressure and the support of government, and the major internal dynamics including interest-driven power, strategic guidance power, internal incentives impetus and innovation support ability[5]. Xue-chao Wu(2014) puts forward that the level government supports, the government and university’s relevant policies as well as the intellectual property, enterprise-scale and government supports on research and development, financial supports, tax privileges are major constraining factors for both enterprise and university[6]. Alexandra Rese(2016) divides the dynamic factors on the success of collaborative energy innovation projects into three categories, namely supply side, demand side and regulatory factors[7].

**Brief Comment**

Gratifying results have been achieved, however, most of them are theoretical analysis, so it’s hard to determine which factor is more important. In order to find out the key factor, we research the dynamic factors of collaborative innovation empirically on the base of international and domestic academic results.

**The Empirical Research**

**The Measuring System of Dynamic Factors**

Dynamic factors can be divided into macroscopic and microscopic ones, according to the sources and nature of them. We construct the measuring index system, and you can see it in table1. Of all the Classified indicators, the first three ones belong to the macro factors, the left belong to the micro-level factors, respectively A_i and B_i, where the i ∈ [1,3].

**Measurement Method and Its Principle**

The fuzzy analytic hierarchy process is a decision method, which combine with qualitative and quantitative method. It is based on the principle that evaluations and measurements of a complex problem are divided into some specific index which mutual relationships will be studied and give reasonable weight, then hierarchical structure will be constructed in sequence. Through comparing important degree of elements, membership degrees of specific index will be tested.

**Data Collection and Process**

In order to get the perceptions and attitudes of different subjects, we have developed a questionnaire and survey corresponding groups. After data have been collected, we calculate the important degree of each index by SPSS software, as is shown in table 1.

**Single Factor Fuzzy Evaluation**

This paper use single factors of fuzzy evaluation to determine the specific importance. Take teams of research and development B_{11} and results of prophase research B_{12} as well as the infrastructure of R&D B_{13} for example, According to data collected by questionnaire survey, those single factor fuzzy matric about three micro-level indicators were established, and a three-factor evaluation matrix R is obtained.
### Table 1. The measuring system of dynamic factors and the important degree of each index.

| Classified indicators | Specific indicators                                                                 | Survey results |
|-----------------------|-------------------------------------------------------------------------------------|----------------|
|                       |                                                                                     | Very important | Important | Gener Important | Not too Important | Unimportant | Scores of Comprehensive assessment |
| National policy A₁    | The support of national policy A₁                                                  | 0.423          | 0.477     | 0.1             | 0               | 0            | 87.17 |
|                       | The protection of national laws and regulations A₁                                  | 0.308          | 0.456     | 0.336           | 0               | 0            | 47.98 |
|                       | The demand for scientific research A₁                                               | 0.323          | 0.211     | 0.232           | 0               | 0            | 26.49 |
| Investment in R&D of the information industry A₂ | The financing capacity of information industry A₂                                    | 0.246          | 0.127     | 0.378           | 0.249           | 0            | 27.51 |
|                       | The research scale of information industry A₂                                      | 0.146          | 0.534     | 0.22            | 0.1             | 0            | 59.37 |
|                       | The basic research capacity of information industry A₃                              | 0.18           | 0.347     | 0.432           | 0.111           | 0            | 35.30 |
|                       | Basic scale of ceeusro cooperation A₃                                               | 0              | 0.111     | 0.674           | 0.101           | 0.14         | 8.01  |
|                       | The number of patents A₃                                                           | 0.044          | 0.268     | 0.478           | 0.201           | 0            | 26.49 |
| The capacity of enterprise R&D B₁ | Teams of research and development B₁                                               | 0.232          | 0.427     | 0.233           | 0.11            | 0            | 53.06 |
|                       | Results of prosephase research B₁                                                 | 0.255          | 0.122     | 0.433           | 0.19            | 0            | 29.24 |
|                       | The infrastructure of R&D B₁                                                       | 0              | 0         | 0.746           | 0.254           | 0            | 16.15 |
|                       | The organizational structure of R&D B₂                                              | 0.232          | 0.427     | 0.233           | 0.11            | 0            | 26.53 |
|                       | The mechanism of innovation motivation B₂                                            | 0.246          | 0.127     | 0.378           | 0.249           | 0            | 95.13 |
|                       | The management system of R&D B₂                                                    | 0.146          | 0.534     | 0.22            | 0.1             | 0            | 40.45 |
|                       | The integration and collaboration of innovation teams B₂                             | 0.18           | 0.347     | 0.432           | 0.111           | 0            | 25.88 |
|                        | The consciousness and atmosphere of innovation B₂                                  | 0              | 0.111     | 0.674           | 0.101           | 0.01         | 52.74 |
|                        | The channel of R&D and consultation B₂                                              | 0.044          | 0.268     | 0.478           | 0.201           | 0            | 25.24 |
|                        | The ability of learning B₂                                                          | 0.218          | 0.427     | 0.223           | 0.11            | 0            | 52.27 |
| Innovation diffusion and marketing capacity of enterprise B₃ | The patent protection of R&D B₃                                                    | 0.255          | 0.122     | 0.433           | 0.19            | 0            | 35.30 |
|                       | The conversion ability of research findings B₃                                      | 0.112          | 0         | 0.746           | 0.254           | 0            | 68.99 |
|                       | The degree of understanding on market B₃                                             | 0.246          | 0.127     | 0.378           | 0.249           | 0            | 24.96 |
|                       | The capability of marketing B₃                                                     | 0.146          | 0.534     | 0.22            | 0.1             | 0            | 49.03 |

### Comprehensive Fuzzy Evaluation

The comprehensive evaluation matrix B is gotten by results of single factor fuzzy evaluation multiply the weights of factors, which based on a single element.

\[ B = A \odot R = (b_1, b_2, b_3, \ldots, b_n) \]

It can be applied to the membership of different evaluation system under the different levels. According to previous analysis, we can determine the specific amount for weight distribution:

\[ A = (0.54, 0.3, 0.16) \]

The comprehensive assessment of those three indicators are as follows:

\[ B = A \odot R = (0.27, 0.16, 0.11, 0.03, 0) \]

Result normalization:

\[ B = \begin{pmatrix} 0.27 & 0.16 & 0.11 & 0.03 & 0 \\ 0.57 & 0.57 & 0.57 & 0.57 & 0.57 \end{pmatrix} = (0.474, 0.281, 0.193, 0.053, 0) \]
The above result reflects that 47.4% respondents consider it is very important, 28.1% think it is important, 19.3% believe it is General important, and 5.3% consider it is not too important. Following the principle of maximum membership, we think the above three indicators are “Very important”.

Construction of Judgement Matrix

According to the comprehensive fuzzy evaluation of the importance of specific factors mentioned before, the judging matrix is as follows:

\[
\begin{array}{c|ccc}
A & A1 & A2 & A3 \\
\hline
A & 1/2 & 1 & \\
B & 1 & 2 & 1/2 \\
\end{array}
\]

\[
\begin{array}{c|ccc}
B & B1 & B2 & B3 \\
\hline
B1 & 1/2 & 1/3 & 1 \\
B2 & 2 & 1 & 3 \\
B3 & 1 & 1/2 & 2 \\
\end{array}
\]

\[
\begin{array}{c|ccc}
C & C1 & C2 & C3 \\
\hline
C1 & 3 & 2 & 1 \\
C2 & 1/2 & 1 & 1/2 \\
C3 & 1 & 2 & 1/3 \\
\end{array}
\]

\[
\begin{array}{c|ccc}
C & C4 & C5 \\
\hline
C4 & 1/2 & 1 \\
C5 & 1 & 2 \\
\end{array}
\]

\[
\begin{array}{c|ccc}
C & C6 & C7 & C8 \\
\hline
C6 & 2 & 3 & 1 \\
C7 & 1/2 & 1 & 1/3 \\
C8 & 1 & 2 & 1/2 \\
\end{array}
\]

Weight Calculation and Consistency of Examination

The following judgment matrix can be established according to those three indicators mentioned above.

Column vector normalization:

\[
A = \begin{bmatrix}
0.501 & 0.571 & 0.545 \\
0.334 & 0.286 & 0.273 \\
0.167 & 0.143 & 0.182 \\
\end{bmatrix}
\]

Row sum: \( A = (1.627, 0.893, 0.492)^T \); Normalization: \( W = (0.539, 0.298, 0.164)^T \); So, \( A_v = (1.617, 0.896, 0.492)^T \), The sorted results for three indicators: \( w = (0.539, 0.298, 0.164)^T \).

So,

\[
\lambda = \frac{1}{3} \left( \frac{1.617}{0.539} + \frac{0.896}{0.298} + \frac{0.492}{0.164} \right), \quad \lambda_{max} = 3
\]

In the judgment matrix(2) mentioned above, “n” equals three. So, “RI” equals 0.58 through the scientific calculator and “CR” equals 0.007 according to the equation that “CI” divided by “RI”. To sum up, the judgment matrix is of consistency because 0.007 is less than 0.1.

Calculations of Combination Weight Vector and the Combination of Consistency Check

Based on the principle of fuzzy analyze hierarchy process method, the result of calculating the weight vector is shown in table 2.

Basic Results of Measurement

In order to better illustrate the influence of the index, we classify its influence according to the weight of the index and ranking in table 2. Specific classification criteria are shown in table 3.
Summary

To sum up, the key dynamic factors of China's information industry collaborative innovation include the system internal and external factors by empirical analyses. Specifically, the mechanism of innovation motivation, the support of national policy, and the research scale of information industry are the most important factors. In order to enhance our information industry collaborative innovation capability and international competitiveness, it must facilitate the key dynamic factors internally and externally.

Table 2. Weight vector values of index combination.

| Specific indicators and codes | Weight | Sorting | Specific indicators and codes | Weight | Sorting |
|-------------------------------|--------|---------|-------------------------------|--------|---------|
| The mechanism of innovation motivation B_{22} | 0.1056 | 1 | The channel of R&D and consultation B_{26} | 0.0308 | 12 |
| The support of national policy A_{11} | 0.0952 | 2 | The financing capacity of information industry A_{21} | 0.0246 | 13 |
| The research scale of information industry A_{22} | 0.0852 | 3 | The degree of understanding on market B_{13} | 0.0245 | 14 |
| The conversion ability of research findings B_{32} | 0.0801 | 4 | The organizational structure of R&D B_{21} | 0.0232 | 15 |
| Teams of research and development B_{11} | 0.0678 | 5 | The ability of learning B_{22} | 0.0218 | 16 |
| The demand for scientific research A_{13} | 0.0623 | 6 | The basic research capacity of information industry A_{31} | 0.018 | 17 |
| Basic scale of ceeusro cooperation A_{32} | 0.0589 | 7 | The integration and collaboration of innovation teams B_{24} | 0.018 | 18 |
| The protection of national laws and regulations A_{12} | 0.0521 | 8 | The infrastructure of R&D B_{13} | 0.0176 | 19 |
| The patent protection of R&D B_{31} | 0.0455 | 9 | The capability of marketing B_{34} | 0.0146 | 20 |
| The consciousness and atmosphere of innovation B_{15} | 0.0451 | 10 | The management system of R&D B_{23} | 0.0146 | 21 |
| The number of patents A_{33} | 0.0403 | 11 | Results of prophase research B_{12} | 0.0085 | 22 |

Table 3. Index impact of standards.

| The degree of impact | Highly impact | Moderate impact | Low impact |
|---------------------|---------------|-----------------|------------|
| Weight sorting      | 0.0521-0.1056 | 0.0218-0.0455   | 0.0085-0.018 |

Acknowledgement

This study was supported by National Natural Science Foundation of China. China (Grant No.71373113) and Hunan Province Social Science Foundation of China (Grant No.14JD52).

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