Evaluation of Hebei province's science and technology innovation capability from the perspective of innovation ecosystem

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Abstract. Based on the perspective of the innovation ecosystem, a scientific and technological innovation capability evaluation index system can be built from three aspects: the technological innovation community, the technological innovation environment, and the technological innovation potential. The factor analysis method is used to dynamically evaluate the scientific and technological innovation capacity of Hebei Province, and it is found that the environment of Hebei Province for scientific and technological innovation is not ideal, weakness of individual strength, and imperfection of the industrial structure. However, its technological innovation as a whole is on the rise in 2011-2018. Based on the shortcomings of Hebei Province's scientific and technological innovation, the countermeasures and suggestions are put forward from a systematic perspective to improve Hebei's scientific and technological innovation capabilities.

1. Introduction
China has entered a critical period of transformation and development. Sustainable and balanced development is our ultimate goal. As the driving force of social development, technological innovation can promote the country and region to move towards an intelligent and intensive society, and sustain and coordinate the development of the region. More important. The situation of scientific and technological innovation in Hebei Province has been poor for many years. The innovation ecosystem is the latest stage of innovation research. From the perspective of the innovation ecosystem, how to better realize the coordinated development of innovative individuals and boost the improvement of scientific and technological innovation capabilities is worthy of further exploration. Based on the existing research results, this article puts the elements of scientific and technological innovation under the perspective of the innovation ecosystem, and uses factor analysis to conduct an empirical analysis of the scientific and technological innovation capabilities of Hebei Province to explore the development trend of scientific and technological innovation capabilities in Hebei Province.

2. Related concepts and influencing factors analysis
2.1. The concept of innovation ecosystem and technological innovation
The innovation ecosystem is a complex network system with enterprises, universities, and scientific research institutions as the main body, and the government and other institutions as its element carriers. Through the exchange and cooperation between organizations, it gathers innovation factors, integrates innovation elements, and serves the innovation activities of each subject and value creation to realize the sustainable development of each subject [1].

Technological innovation is a process of gaining competitive advantage by continuously reforming production methods and introducing new management concepts. Main elements and resource elements are an important part of the scientific and technological innovation system. Main elements include multiple types of organizations, mainly referring to the implementers of innovation activities. Resource elements mainly refer to knowledge, talents, information, funds, etc. related to innovation activities [2].

2.2. Influencing factors on technological innovation
Both the collaborative innovation theory and the innovation system theory regard enterprises, universities, and scientific research institutions as the main bodies of technological innovation in the innovation ecosystem. The government macro-controls the innovation activities in the system through financial support, policy guidance, etc. Therefore, the government is regarded as a scientific and technological innovation coordination community in the innovation ecosystem. Financial and intermediary institutions provide support for the development of innovative individual scientific and technological innovation activities in the system through financial and information services. The two major groups of financial institutions and intermediary institutions are called the expansion community of scientific and technological innovation [3].

The technological innovation community and the regional market environment, information environment, talent environment and other technological innovation environments together constitute an innovation ecosystem. The environmental conditions of the innovation ecosystem, the interaction and cooperation between innovation individuals, and the specific activities of each individual in the innovation ecosystem all have an impact on the regional technological innovation capabilities [4].

3. Evaluation index system of scientific and technological innovation capability from the perspective of innovation ecosystem

3.1. Evaluation index selection
Table 1 shows the specific evaluation index system of Hebei's scientific and technological innovation capability from the perspective of innovation ecosystem.

| First level indicator | Secondary indicators | Level three indicators                                                                 |
|----------------------|----------------------|-----------------------------------------------------------------------------------------|
| Technological        | Drive community       | Sales revenue of new products in high-tech industry                                      |
| Innovation Community |                      | Number of regulated industrial companies with R&D activities                           |
|                      | Coordinated community | Number of R&D projects in research and development institutions                         |
|                      | Expanded community    | Internal expenditure of R&D funds of ordinary colleges and universities                  |
|                      | Talent environment    | Research and experimental development (R&D) internal expenditure comes from government funds |
| Technological        |                      | Number of national technology business incubators                                       |
| Innovation environment|                      | Number of legal entities in the financial industry                                      |
|                      |                      | Full-time equivalent of research and experimental development (R&D) personnel per 10,000 people |
|                      |                      | Average number of students in higher education schools per 100,000 population           |
3.2. Evaluation method and process

The specific steps to use factor analysis to explore the development trend of Hebei's scientific and technological innovation capabilities are as follows.

3.2.1. Data standardization the collected data is standardized by zscore. The standardized data is

\[ x_i^* = \frac{x_i - x_j}{\delta}, \]

where \( x_i \) is the original data of the indicator, \( x_j \) is the average of the original data, and \( \delta \) is the standard deviation.

3.2.2. Test whether it is suitable for factor analysis. Use SPSS22.0 to perform KMO and Bartlett test on the standardized values of each three-level indicator under the technological innovation community, technological innovation environment and technological innovation potential, KMO>0.5, Bartlett test probability P<0.001, and factor analysis can be performed.

3.2.3. Determine the number of factors. Use the principal component method to extract, set the characteristic value \( \lambda > 1 \), if the number of common factors extracted is \( m \), and the cumulative variance contribution rate of the first \( m \) factors is not less than 70%, the first \( m \) factors are used to reflect the original index.

3.2.4. Factor rotation. Rotate the factors so that the load coefficients of each variable on the \( m \) factors after the rotation are more prominent than before, and it is easier to obtain the obvious practical significance of extracting the \( m \) factors.

3.2.5. Calculate factor score. Use regression method to calculate the extraction factor A score,

\[ F_{hi} = \sum_{j=1}^{n} f_{ij} x_i^* \]

where \( F_{hi} \) is the \( h \)-th main factor score extracted from the \( i \)-th sample \( (h \leq i, \text{ where } i=1, 2, \ldots, 8, \text{ i from 1 to 8 represents } 2018, 2017, \ldots, 2011), n \) is the total number of variables number, \( f_{ij} \) is the component score coefficient of the extracted \( h \)-th principal factor relative to the \( j \)-th variable. Formula

\[ \omega_h = \frac{W_h}{\sum_{g=1}^{m} W_g} \]

is used to calculate the weight of the extracted factors for quantitative analysis, \( \omega_h \) is the weight of the \( h \)-th factor score, \( W_h \) is the variance contribution rate of the \( h \)-th main factor after
rotation, and \( \sum_{g=1}^{m} w_g \) is the cumulative variance contribution rate of the extracted \( m \) main factors. Calculate the comprehensive score for each year and perform ranking analysis. The comprehensive score for year \( i \) is

\[
E_i = \sum_{h=1}^{m} F_{ih} \omega_h.
\]

4. Analysis of evaluation results of Hebei province's scientific and technological innovation ability

4.1. Data sources

The specific data of each three-level indicator in Table 1 are taken from the 2012-2019 China Statistical Yearbook, China Science and Technology Yearbook and China Torch Statistical Yearbook.

4.2. Evaluation results and analysis

Using the factor analysis method, through SPSS22.0 analysis, it is obtained that the KMO values of the three subsystems: the technological innovation community, the technological innovation environment, and the technological innovation potential are all greater than 0.6, and their P is less than 0.001, so factor analysis can be performed. After the analysis, the explanation of the total variance of the extracted principal components is shown in Table 2.

Table 2. A slightly more complex table with a narrow caption.

| Subsystem | ingredient | Before rotating | After rotating |
|-----------|------------|----------------|---------------|
|           | total      | % of variance  | % of Cumulative| total         | % of variance  | % of Cumulative|
| Technological Innovation Community | 1 | 6.655 | 95.075 | 95.075 | 6.655 | 95.075 | 95.075 |
| Technological Innovation Environment | 2 | 5.469 | 78.131 | 78.131 | 4.774 | 68.196 | 68.196 |
| Technological Innovation Potential | 3 | 1.315 | 18.785 | 96.917 | 2.010 | 28.721 | 96.917 |
| Technological Innovation Potential | 4 | 3.401 | 68.013 | 68.013 | 3.401 | 68.012 | 68.012 |
| Technological Innovation Potential | 5 | 1.026 | 20.521 | 88.534 | 1.026 | 20.521 | 88.534 |

Further factor analysis of the scores of the three subsystems obtained the comprehensive scores of scientific and technological innovation capabilities of Hebei Province from 2011 to 2018. Table 3 shows the ranking of the scores of various subsystems and comprehensive capabilities of scientific and technological innovation in Hebei Province from 2011 to 2018.

Table 3. Score and ranking of Hebei Province's scientific and technological innovation capability from 2011 to 2018 under the innovation ecosystem.

| years | Technological Innovation Community Subsystem | Science and Technology Innovation Environment Subsystem | Scientific and technological innovation potential subsystem | Technological innovation ability |
|-------|--------------------------------------------|------------------------------------------------------|-----------------------------------------------------------|---------------------------------|
| Score | Rank | Score | Rank | Score | Rank | Score | Rank |
| 2018  | 1.42476 | 109399 | 1 | 1.57289 | 1 | 1.64756 | 1 |
| 2017  | 1.16275 | 87178 | 2 | 0.39194 | 3 | 0.96534 | 2 |
| 2016  | 0.46151 | 44436 | 3 | 0.48948 | 2 | 0.5665 | 3 |
| 2015  | 0.13536 | 1056 | 4 | -0.57325 | 7 | -0.14228 | 4 |
| 2014  | -0.23545 | -3136 | 5 | -0.18409 | 4 | -0.3015 | 5 |
| 2013  | -0.51921 | -44479 | 6 | -0.31596 | 5 | -0.51484 | 6 |
| 2012  | -0.98039 | -68511 | 7 | -0.35592 | 6 | -0.80167 | 7 |
| 2011  | -1.44933 | -107222 | 8 | -1.02511 | 8 | -1.4191 | 8 |
In order to more intuitively present the development trend of scientific and technological innovation capabilities in Hebei Province from 2011 to 2018, based on the factor analysis results in Table 3, a line chart as shown in Figure 1 is drawn.

Figure 1. 2011-2018 Hebei province science and technology innovation capability score line chart.

It can be seen from Figure 1 that the comprehensive capacity of scientific and technological innovation in Hebei Province has improved year by year from 2011 to 2018, showing a good development trend. The score of comprehensive ability of scientific and technological innovation in 2011-2015 was negative; the comprehensive score of scientific and technological innovation ability in 2016-2018 was upright. During this period, the scientific and technological innovation level of Hebei Province has improved significantly. From 2011 to 2018, the scores of the technological innovation community and technological innovation environment subsystem of Hebei Province increased year by year; in terms of technological innovation potential, 2018 scored the highest, followed by 2016 and 2017. The score in 2015 was only higher than that in 2011, but the overall score it is an upward trend.

5. Conclusions
By using factor analysis to explore the development of scientific and technological innovation in Hebei Province in recent years, it is found that the scientific and technological innovation in Hebei Province is getting better and better. It is mainly due to two aspects. One is the increasing emphasis on technological innovation and the strengthening of investment in technological innovation; The 2014 Beijing-Tianjin-Hebei integrated development strategy and the 2017 Xiongan New Area development strategy have played a leading role in the development of Hebei Province. The technological innovation environment has been improved to some extent, but the technological innovation capacity of Hebei Province is still not ideal. Status are there is still much room for improvement. For the rapid improvement of Hebei’s scientific and technological innovation capabilities, the following countermeasures are proposed.

5.1. Smooth the innovation chain and scientifically optimize the layout of the industrial structure
Building an integrated innovation chain requires collaboration and cooperation of individuals in the system. The Hebei Provincial Government should organize all parties to jointly build a cooperation platform and explore effective models for planning an integrated chain of scientific and technological innovation. The three major innovation entities of enterprises, universities, and scientific research institutions must strengthen their sense of cooperation. Financial, intermediary and other scientific and technological innovation service institutions shall actively carry out foreign cooperation to ensure funds and information for the development of innovative activities. Reshape the industrial structure,
promote the construction of high-tech industrial parks and high-level industrial clusters, change the development thinking speed, economy, technology, and environment, and deepen the reform of the industrial structure. Reduce the proportion of traditional manufacturing and heavy industries, shift the development focus to cutting-edge industries with international competitiveness, and gradually realize the scientific layout of the industrial structure and sustainable development.

5.2. Enrich the talent pool and improve the ecological environment of technological innovation

Improve the legal system, cultivate a humanistic atmosphere that respects talents and emphasizes innovation, and pays attention to balance scientific and technological workers' contributions with returns. Create a good living environment, continuously improve the quality of the ecological environment, improve infrastructure construction, highlight the advantages of Hebei Province as the "back garden" of Beijing and Tianjin, and attract high-level talents to develop in Hebei. Improve information network construction to ensure the timeliness and accuracy of information. Formulate a medium- and long-term plan for the investment of scientific and technological innovation funds, gather social funds to enter the field of scientific and technological innovation, increase investment in basic research, and stimulate original scientific and technological innovation capabilities. We will focus on the construction of online and offline platforms for the transformation of scientific and technological innovation achievements, and use the open technology market and "Internet + big data" as the link to seize the opportunity of the integrated development of Xiongan New Area and Beijing-Tianjin-Hebei, and strengthen the collaborative cooperation between innovative internal and external individuals to improve the environment for technological innovation.

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