Evaluation on the Effect of High-Level Scientific and Technological Talents Team Building in Local Industry Based on DEA

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Abstract. In recent years, the attraction and investment of high-level scientific and technological talent team in local industries have been increasing. But how to evaluate the effect of team building is a challenging problem in the development of local industries. This paper establishes a DEA model in which human and financial resources are input, knowledge output, economic benefit and social benefit are output, based on DEA method, combining the characteristics of local industry development and the current situation of high-level scientific and technological talent team. And then, this paper evaluates the construction effect in the past five years and clarifies the shortage of professional and technological talents in W City, clarifies the problems of insufficient professional and technical personnel, insufficient professional team strength and low concentration of regional innovation and entrepreneurship in this city, and puts forward corresponding countermeasures. The purpose of this paper is to provide theoretical ideas for the evaluation of the effect of high-level scientific and technological talents team building in local industries.

Keywords. Local industry; talent team; effect evaluation; DEA.

1. Introduction

In to implement the ideas of the order innovation-driven strategy put forward by the country, the evaluation of the construction effect of the scientific and technological talent team has become the core issue of regional development. The evaluation process of the science and technology innovation team is complex and has many uncertain factors. It is difficult to accurately measure the performance of science and technology innovation from the perspective of quantitative evaluation. Therefore, it is necessary to adopt a combination of qualitative and quantitative methods to evaluate it [1]. At present, scholars at home and abroad have conducted a large number of empirical studies on performance management, and developed a series of methods and tools for the performance evaluation of scientific and technological innovation teams, such as fuzzy comprehensive evaluation (FCA), balanced scorecard (BSC), regression analysis, Analytic hierarchy process (AHP), ratio analysis, data envelopment analysis, etc. There are some deficiencies in traditional evaluation methods. For example, although BSC has established a detailed performance evaluation system, it is highly subjective and cannot explain the importance of the evaluation indicators and the internal connection [2]. The regression analysis method uses statistical analysis methods and uses functional relationships to evaluate performance. The results are relatively scientific and reasonable, but it is impossible to distinguish the efficiency of each evaluation object. The ratio analysis method is simple and easy to understand, and the meaning of the financial ratio is clear, but it is impossible to evaluate the whole based on a single indicator. Fuzzy comprehensive analysis (FCA)
utilizes the simple principle of fuzzy mathematics and uses fuzzy relation synthesis operations to quantify some indicators with ambiguous extensions and difficult to quantify. At the same time, it comprehensively considers the influence of multiple factors and affects the evaluation. The index’s membership level is judged, but the evaluation score depends on the subjective judgment of the person, and the weight is often difficult to reasonably allocate when there are many factors [3]. Data Envelopment Analysis (DEA) can largely avoid subjective factors and achieve multiple inputs and multiple outputs. This method treats the input and output weights of the decision unit (DMU) as unknown variables, which are determined by the function operation of the DMU raw data, eliminating subjective judgments [4]. Fare [5] proposed that efficiency is the ratio between input and output, and characterizes the utilization of resources, which will affect the reduction of organizational costs or increase of output. Chen et al. [6] used the DEA tool to make a comprehensive evaluation of the company’s operating performance, and believed that the performance evaluation of the company should be a combination of qualitative and quantitative evaluation. Xu et al. [7] used the DEA method to evaluate the performance of listed building materials companies by taking main business costs, total capital, and the number of employees as inputs and using main business income and net profit as output variables. Based on the super-efficiency DEA model, Zhang [8] performed a performance evaluation of the Chinese provincial factor input structure, and clarified the input structure problem. Zhou [9] used a dynamic dual frontier network DEA model to evaluate the effectiveness of sustainable supply chains. Chen [10] used the RAM-DEA model to establish expected energy crowding and undesired energy crowding models, and conducted empirical research on 28 sub-industries of Chinese manufacturing.

Previous studies have demonstrated the applicability of the DEA method in effect evaluation methods. The project intends to use the data envelopment analysis method to evaluate the input and output effects of high-level talent teams in local industries and find out the existing problems.

2. Introduction to Data Envelope Analysis

Well-known operations researcher Charnes and other scholars based on relative efficiency and proposed the data envelopment analysis (DEA) theory to evaluate the efficiency or effectiveness of the decision unit (DMU) based on multiple input and multiple output indicators. Decision making units (DMU) refer to the same type of department, enterprise, or the same unit at different times in the daily management of an organization that require relative efficiency evaluations [11-13]. The DEA is evaluated based on the input and output indicators of the DMU. Among them, the C2R model is a model with good evaluation effect and widely used.

The basic idea of the model:

Identify the organization that measures performance as a decision unit.

Let $n$ decision units ($j = 1,2,...,n$).

Each decision unit has the same $m$ inputs (inputs) ($i = 1,2,...,m$).

Each decision unit has the same $s$ term output (outputs) ($r = 1,2,...,s$).

$x_{ij}$ —— the $i$-th input of the $j$-th decision unit.

$y_{rj}$ —— the $r$-th output of the $j$-th decision unit.

Assuming that the decision objective is the efficiency value of the $j_0$-th decision unit and the constraint is the efficiency value of all decision units, the C2R model is listed as:

$$\max h_{j_0} = \frac{\sum_{r=1}^{s} u_r y_{rj_0}}{\sum_{i=1}^{m} v_i x_{ij_0}}$$
3. Selection and Setting of Evaluation Indicators

3.1. Selection Basis of Evaluation Indicators

(1) The basis for determining input indicators is that technological innovation is an extremely complex activity, and the measurement of its effectiveness requires the simultaneous selection of multiple indicators. The international competitiveness indicator system mainly includes elements such as human resources and financial resources. Therefore, this article determines the input indicators of the scientific and technological talent team as two aspects of scientific and technological financial resources and scientific and technological human investment [16-18].

(2) The basis for determining output indicators is: a full analysis of the entire innovation process from input and output of science and technology, and reference to the “Outline of the National Medium and Long-term Science and Technology Development Plan” formulated by the State Council [18]. With reference to the input-output theory, following the law of science and technology input and output and the principle of performance evaluation, in line with the characteristics of local talent team input and output, select key indicators that can reflect local reality [19]. This article considers that the output indicators of scientific and technological talent teams mainly include knowledge output, economic benefit output and social benefit output [20-22].

3.2. Evaluation Index Setting

Input indicators:

(1) Scientific and technological manpower input
   (a) High-level talent teams in the city (number)
   (b) Number of high-level talent teams in the city (person)

(2) Technology investment
   (a) Investment for high-level talent team construction in the city (10,000 yuan)
   (b) Proportion to regional GDP (%)  
   (c) Local financial science and technology funding for high-level talent teams in the city (10,000 yuan)
   (d) Proportion of local fiscal expenditure (%)

The input indicators are shown in table 1.

Output indicators:

(1) Knowledge output
   (a) The number of academic papers or works published by the talent team in the city (number);  
   (b) The number of patent applications for the city's talent team throughout the year (number);
(c) The total number of scientific and technological achievements awarded by the talent team in the city (number);

(2) Economic benefits output
(a) Annual output of the talent team in the city (10,000 yuan);
(b) Annual turnover of technology market contracts for talent teams in the city (10,000 yuan);
(c) The talent team in the city absorbed other main investment quotas (10,000 yuan).

(3) Social benefit output
The number of brand recognition teams in the city (number);
The output indicators are shown in table 2.

### Table 1. Table of investment indicator system.

| First-level indicators | Secondary indicators | Tertiary indicators |
|------------------------|----------------------|---------------------|
| Input indicator        |                      |                     |
| Manpower input (A1)    |                      |                     |
| Financial investment (A2) |                    |                     |
| High-level talent teams in the city (number) |                     |
| Number of high-level talent teams in the city (person) |                     |
| Investment for high-level talent team construction in the city (10,000 yuan) |                     |
| Proportion to regional GDP (%) |                     |
| Local financial science and technology funding for high-level talent teams in the city (10,000 yuan) |                     |
| Proportion of local fiscal expenditure (%) |                     |

### Table 2. Table of output indicators for talent team building.

| The output indicators are shown in table first-level indicators | Secondary indicators | Tertiary indicators |
|---------------------------------------------------------------|----------------------|---------------------|
| Output indicator                                              |                      |                     |
| Knowledge output (B1)                                         |                      | Academic papers or works(number) |
| Patent applications (number)                                  |                      | Achievement rewards (number) |
| Annual GDP (10,000 yuan)                                      |                      | Annual technology market contract turnover (10,000 yuan) |
| Economic benefits (B3)                                        |                      | Absorb investment (10,000 yuan) |
| Social benefit (B3)                                           |                      | Brand recognition (number) |

### 4. Evaluation of the Construction Effect of High-Level Scientific and Technological Talent Team in W City

#### 4.1. Investment Situation
The investment of high-level scientific and technological talent team construction in W City from 2013 to 2017 is shown in table 3.

### Table 3. Investment in talent team building.

| Indicator name (year)                 | 2013 | 2014 | 2015 | 2016 | 2017 |
|--------------------------------------|------|------|------|------|------|
| Number of talent teams in the city   | 110  | 171  | 186  | 268  | 299  |
| Number of talents in the city        | 599919, 654402, 772849, 888776, 995432 |
| Investment funding for talent team construction in the city | 586000, 687900, 740000, 881300, 956400 |
| Local financial science and technology funding for talent team | 13440, 16075, 25610, 2676, 46361 |
4.2. Output Situation
The output of high-level scientific and technological talent team construction in W City from 2013 to 2017 is shown in Table 4.

Table 4. Output of talent team building.

| Indicator name/year                  | 2014   | 2015   | 2016   | 2017   | 2018   |
|--------------------------------------|--------|--------|--------|--------|--------|
| Academic thesis or scholarly work    | 1500   | 1500   | 1500   | 1500   | 1500   |
| patent application                   | 17066  | 20086  | 26680  | 28911  | 27524  |
| Achievement reward                   | 3      | 10     | 7      | 10     | 10     |
| Annual GDP                           | 23095539 | 24573234 | 26954385 | 29632563 | 32459664 |
| Year-round technology market contract turnover | 369734 | 410288 | 455789 | 482981 | 644000 |
| Attract investment                   | 23926406 | 27091936 | 30068978 | 33422401 | 37683457 |
| Brand recognition                    | 40     | 51     | 62     | 74     | 85     |

4.3. Construction Effect Evaluation
After preliminary analysis of the obtained data excavations, and the application of DEA method to fully screen each index, the index system of the following Table 5 was selected [19]:

Table 5. Evaluation results of talent team building.

| Year Invest | Manpower Input: Sum of manpower indicators | Financial investment: Sum of financial indicators | Knowledge output: Sum of knowledge output | Economic benefits: Sum of economic benefits add up | Social benefit: Sum of Social benefits add up |
|-------------|-------------------------------------------|-------------------------------------------------|------------------------------------------|---------------------------------------------------|-----------------------------------------------|
| 2014 600029 | 588000                                    | 18634                                           | 49237320                                 | 781140                                            |
| 2015 654573 | 703975                                    | 21675                                           | 54158262                                 | 816251                                            |
| 2016 773035 | 765610                                    | 28260                                           | 59060666                                 | 806362                                            |
| 2017 889044 | 883976                                    | 30517                                           | 65677756                                 | 838174                                            |
| 2018 995731 | 1002761                                   | 29163                                           | 73102890                                 | 842185                                            |

Because there is a time lag between the input and output of the construction of a scientific and technological talent team, when analyzing the input and output indicators, the article follows the usual assumption of a lag period of one year. This article selects 2013-2017 data as input and 2014-2018 data as output. Then use DEA2.1 software to operate the selected data to generate the efficiency analysis shown in Table 6.

Table 6. Analysis of construction efficiency.

| Firm | crste | vrste | Scale | 
|------|-------|-------|-------|
| 2014 | 1.000 | 1.000 | 1.000 | - |
| 2015 | 0.989 | 0.989 | 1.000 | - |
| 2016 | 1.000 | 1.000 | 1.000 | - |
| 2017 | 0.986 | 1.000 | 0.986 | drs |
| 2018 | 0.857 | 0.862 | 0.994 | drs |
| mean | 0.966 | 0.970 | 0.996 | |
If the technical efficiency of the sample data analyzed is 1, and the pure technical efficiency and scale efficiency are also 1, it means that the input and output of talent team construction is better during this sample period, that is, the construction effect is good. Otherwise, it indicates that the sample size does not match the input and output, and the talent team building plan needs to be improved.

According to the DEA model analysis results, we can see:

(1) During the period of 2014-2018, the efficiency change between the input and output of the talent team construction in W City. Through policy analysis, the introduction, training, support, and incentive of talents are all directions policies that the W city government pays special attention to. A series of policies hope that this can achieve the situation of efficient introduction of talents while improving the output of talents efficiency, forming a good situation of "excellent value for money, the best use of people." In order to meet the background of rapid economic and social development, the input-output efficiency of talents has been significantly improved under the encouragement of a series of talent policies adopted by the W city Municipal Government.

(2) Since 2014, the input-output efficiency of talents in W City has been relatively good, especially in 2014-2016, indicating that there is no excess input and deficit output, and the 2017-2018 two-year period Input-output mismatch, over-input. To this end, we should make improvements based on existing talent policies.

(3) The technical efficiency input did not reach the optimal value in 2018. Compared with 2017, the technical efficiency value input declined. According to the DEA effectiveness analysis, the 2018 input-output efficiency did not achieve DEA effectiveness. According to the analysis of returns to scale, it is concluded that the input-output in 2018 is in a period of decreasing returns to scale, indicating that the inputs are redundant at this time and the benefits of scale have not been reached.

5. Construction of High-Level Talent Team in W City

Based on the evaluation of the team building effect of high-level talents in W City, we can see that the following problems exist in team building [22]:

(1) Lack of professional and technical personnel and insufficient total

From the DEA model, we can see that 2017 and 2018 are particularly obvious. There is a large degree of decline in the trend of human and financial input, and there is a large room for increase in output, which indicates that the human input in W City in recent years The efficiency of investment in financial resources is not high, and it cannot be quickly and accurately converted into actual results, which does not play a good role in promoting the economic and social development of W City.

(2) Inadequate support from professional team forces for performance improvement

From the analysis results of the DEA model, the human and financial input of W City has increased year by year, but the speed and ratio of the output of knowledge output, economic benefit and social benefit have not kept up with the input speed. The strength of the team is not enough to support the performance improvement effect of W City, and it is not able to convert large inputs into actual outputs. To some extent, this reflects the lack of government service resources and limited cultivation quality. In terms of serving professional teams, the government has insufficient application of new technologies such as cloud computing, big data, artificial intelligence, etc. The talent evaluation mechanism and talent finance need to be further strengthened [23].

(3) The concentration of regional innovation and entrepreneurship needs to be improved

The performance of local high-level talent teams benefits from the regional innovation and innovation environment. However, compared with Silicon Valley, Shanghai, Zhongguancun and other regions, it can be seen that the concentration of innovation and entrepreneurship in W City needs to be increased. At present, the innovation and entrepreneurship of local high-level talent teams mostly rely on policy guidance rather than market areas and spontaneously form. An atmosphere of innovation and entrepreneurship that encourages innovation and accepts failures has not yet been created. The culture of innovation and courage to innovate and dare to challenge still needs to be
improved [23]. Moreover, the number of local venture capital institutions, incubators, and crowd-creation spaces, such as innovative entrepreneurship training and support institutions, is not large.

(4) Incomplete talent market system and inadequate social security

The People’s Government of W City and other cities in the Yangtze River Delta jointly formed a talent market in the Yangtze River Delta, and gradually formed a multi-level talent market system. However, the development of the talent market system in W City was slow. The social security system is also imperfect, and the employee participation rate has not increased significantly. Further investment is needed to promote reform.

6. Suggestions on Improving the Effectiveness of Talent Team Construction in W City

In a highly competitive market environment, if you want to gain a foothold in the economic environment, you must attach great importance to the building of talent teams. Based on the above empirical conclusions, this article gives the following suggestions and countermeasures:

(1) Strengthening mechanism construction

Strengthen communication between enterprises, universities, governments, and other entities, build an effective mechanism for industry-university-research cooperation, promote the effective integration of public resources, and form a unique entity in W City that focuses on enterprises, governments, and universities, and market demand Orientation and the establishment of W City's own innovative cooperation system. In addition, the government should increase investment in universities and other technologies, so that scientific and technological achievements can be transformed in a more timely and effective manner.

(2) Improve the construction of social security system

Local governments should further increase financial investment and establish a sound social security system. The government should increase the breadth and depth of social security at the social level, and at the same time strengthen the supervision and management of social security to ensure the transparency and openness of the various uses of social security. Finally, we must strengthen the legal system of the social security system and formulate and improve relevant laws and regulations.

(3) Increased professional services for performance improvement

The strength of the professional service team plays an important role in W City’s self-construction and development. In order to make W City’s future talent team construction effect more reasonable and effective, the role of the government will be crucial. Therefore, the W city Municipal Government should increase the supply of socialized service resources, strengthen government training, increase the attractiveness of policies, and rationally transform talent input into key points to promote urban development in W City.

(4) Increase the concentration of regional innovation and entrepreneurship

The improvement of the performance of high-level talent teams in W City depends on the ecological atmosphere of regional innovation and entrepreneurship. The local innovation and entrepreneurship concentration in W City needs to be greatly improved [23]. The specific countermeasures are as follows:

(a) Form W City’s unique innovation and entrepreneurship culture. Compared with foreign innovation and entrepreneurship teams, China’s innovation and entrepreneurship is still far away. Compared with the first-tier cities such as Beijing and Shanghai, W City’s innovation and entrepreneurship culture is still lacking. But W City’s own characteristics of vitality and vitality “Happy City” culture of innovation and entrepreneurship is gradually taking shape, the good social atmosphere of hard work, continuous progress, hard work, and big waves of sand is gradually improving.

(b) Correct the drive guidance. At present, the innovation and entrepreneurship of the high-level talent team in W City relies on policy guidance and lacks initiative. The talent team in W city should gradually adjust from being totally dependent on government policy guidance to market-driven, spontaneous, voluntary, and initiative innovation.
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