An Evaluation of the Science and Technology Innovation Ability on National High-tech Zones

—Factor Analysis Based on Multi-inndex Panel Data

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***Abstract*—This article adopts the method of panel data index factor analysis, to evaluate and analyze the input and output capacity of science and technology among88 national high-tech zones in China in the past six years. First of all, the author designs eight evaluation indexes on science and technology innovation ability, then, carries on six factor analysis to 88 state-level high-tech zones between 2008 to 2013 with SPSS18.0 software, and extracts the two common factors: Input factor and output factor. Then, the author calculates their factor scores and integrated total scores with Microsoft Excel. Finally, the author calculates the integrated total score of panel data, finds out the factors which affect the development of science and technology innovation ability on high-tech zones according to the score, and provides a reference to the scientific and technological development of high-tech zones.**

Keywords—national high-tech zone; multi-index; panel data; factor analysis

I. INTRODUCTION

Nowadays, with the rapid developing of science and technology, scientific and technological innovation is very crucial factor for an enterprise, regional or national of making science and technology progress, promote the economic development. Presently, the development of science and technology innovation has become the driving one of the important factors of the development of new and high technology industries in the zone.

Given the important role of science and technology innovation high-tech zones in the park of economic development, the current research on high-tech zone is gradually increasing scientific and technological innovation, research method involves hierarchical analysis, principal component analysis, cluster analysis, data envelopment analysis, etc. these analysis methods in a certain sense, to improve the technological innovation capability of high-tech zones have given some help. Guo Yanjun combines the method of fuzzy mathematics and AHP, comprehensive evaluation of 7 representative national level high-tech zones in the west, central and eastern of china, but because too few selected high-tech zones, for the evaluation of the results of a certain one-sidedness[1]. Fan bonai is the use of expert method and identification method theoretical indicators were screened using principal component analysis of the technological innovation capability of 52 high-tech zones of comprehensive evaluation, but this study is to select a time data on the section, which is obviously the new high-tech zones set up is unfair[2]. To solve the above problem, this paper attempts to use multiple indicators panel data and factor analysis method of combining the technological innovation capability of high-tech zones studied.

II. BASIC FEATURE OF MULTI INDEX PANEL DATA

A. Evaluation method

Since the 1980's, scholars at home and abroad have achieved preliminary results on the panel data studies. Michel Mouchart and Jeroen V.K Romouts carried out clustering analysis of the single index panel data through the stepwise regression[3]; Zhang Mingxi analyzed the economic contribution of 53 high-tech zones' R & D investment only by the method of multi-index panel data. The results have certain persuasive, but failed to reflect the level of every high-tech zones[4]; Xiao Zelei, Li Bangyi etc. carried out clustering analysis of the multidimensional panel data through the similarity index of the sequence matrix after the data dimension reduction process[5]; Zheng Bingyun built the Sum of Squares of Deviations function and the Distance function of multidimensional panel data through the principle of clustering analysis and then carried out the multi - index panel data clustering analysis on the production efficiency of the enterprises in our country[6]. These studies are mostly analyzing sample index by constructing econometric model. Studies using the method of combining statistical analysis and panel data are rare. This paper will build several scientific and technological innovation capability indicators, across different years, take the existing state-level high-tech zones in our country as the sample and then conduct factor analysis of multi-index panel data combining the panel data and multivariate statistical analysis.

B. Basic steps of multi index panel data factor analysis

1) Firstly, to standardized the original data. Using the method of Z-score to carry out standardization, assume that we have N samples, p index, X_{ij} means the value of the index j of the sample i, among them, $i=1,2,\ldots,N, j=1,2,\ldots,p$. After standardization, indicated by Z_{ij}, then,

$$Z_{ij} = \frac{(X_{ij} - \overline{X}_j)}{S_j}$$

2) Establish the correlation coefficient matrix R=r_{jk} of index data, r_{jk} indicates the correlation coefficient between index j and k [7].

$$r_{jk} = \frac{1}{N-1}\sum_{i=1}^{N} Z_{ij} Z_{jk}$$

Among them, j=1,2,...,p, k=1,2,…,p.

3) According to the correlation coefficient matrix, find out their eigenvalue and eigenvector, and then calculate the variance contribution rate, next, extraction on the number of factors according to the cumulative variance contribution rate. Generally, the number of factors in the extraction is the number of eigenvalues when the cumulative variance contribution rate is more than 85%.

4) To evaluate the extraction factors, and then calculate the factor score and comprehensive score. The score of factor k in the sample i can be expressed by the factor score function,

$$F_{\mathrm{ki}} = \omega_{k1} X_{1i} + \omega_{k2} X_{2i} + \ldots + \omega_{kp} X_{pi} \qquad (1)$$

Among them, ω_{kp} is the factor load of index j, is the value of variable j at the sample i, j= 1,2,…,p, i=1,2,…,N.

According to the factor score and the variance contribution rate of the extraction factor, the comprehensive score function of the sample i was obtained,

$$F_i' = \frac{\theta_1 F_{1i} + \theta_2 F_{2i} + \ldots + \theta_{k1} F_{ki}}{\theta_1 + \theta_2 + \ldots + \theta_k} \qquad (2)$$

Among them, θ_k means the variance contribution rate of the factor K.

5) Finally, find out the total score and total score of common factors of panel data. According to the factor score function infer to the total score function of panel data,

$$S_{\mathrm{ki}} = \frac{\theta_k(t_0)\cdot F_{ki}(t_0) + \theta_k(t_1)\cdot F_{ki}(t_1) + \ldots + \theta_k(t_T)\cdot F_{ki}(t_T)}{\theta_k(t_0) + \theta_k(t_1) + \ldots + \theta_k(t_T)} \qquad (3)$$

Among them, $t_0 \le t \le T$, t_0 is the first sample i began to enter the statistical year.

Further, get the total score of the panel data of the sample i ,

$$S_i' = \frac{\varphi'(t_0)\cdot F_i'(t_0) + \varphi'(t_1)\cdot F_i'(t_1) + \ldots + \varphi'(t_T)\cdot F_i'(t_T)}{\varphi'(t_0) + \varphi'(t_1) + \ldots + \varphi'(t_T)} \qquad (4)$$

Among them, φ’(t) represents the cumulative variance contribution rate of samples i.

III. EMPIRICAL RESEARCHES

A. Index system establishment and data source

1) Index system

To evaluate the innovation of technology, first, one of the key to be solved is the selection of evaluation index system, which should not only consider the scientific, systematic, comprehensive of indicators, but also take into account the index data availability. when discussing on the evaluation method of ability of technological innovation, Li Zongzhang put forward that in the selection of evaluation indexes, should follow four principles of selecting index in the statistics , feasibility, comparability, system and scientific, although for those indexes which are good to evaluate structure, it is difficult or can not to extract data statistics, can give up completely[8]; Wei Yanli was put forward that evaluate the innovation ability for a sample, the evaluation should include evaluating the development research capacity for the sample, the capacity of regional innovation and input and output capacity of technology[9]. Combined with the experience of scholars both at home and abroad, this article selects eight indexes which can reflect the high-tech zone of capability of technology innovation, covers the funding of activities of technology, personnel input, output of technology, the detail shows in table 1.

TABLE I. EVALUATION INDEX OF SCIENTIFIC AND TECHNOLOGICAL INNOVATION ABILITY

	Original index
X1	Capital investment intensity of scientific and technological activities
X2	Input intensity of scientific and technical personnel
X3	Overall quality of staff
X4	Core personnel of scientific and technological innovation
X5	Technical income
X6	R&D expenditure
X7	Industrial output value
X8	Net profit

2) Data source

The data source of this paper is based on the scientific nature and availability of the evaluation index, selection the data from 2008 to 2013, by the end of 2013, the number of high-tech zones is 105, but, make up the author’s mind, the number of this article analysis is 88, because the evaluation of the high-tech zones is only analyzed in 2013, for the newly established 17 National high-tech zones in 2013, it was only for one year to participation analysis, obviously, this is contrary to the original intention of this article, because the purpose of this paper is the multi index panel data, at the same time, it will bring some one-sided analysis of the results. These data are from the *China torch plan statistical yearbook 2008 to 2013.*

B. Positive analysis

This paper using SPSS software to make six times factor analysis of 88 high-tech zones, among them, 2008 to 2009 there are 54 National high-tech zones, 2010 to 2011 have 56 National high-tech zones, and 2011 to 2013 have 88 National high-tech zones. After factor analysis, using Excel software to calculate the score of each factor, and calculate the total score

and the total score of the factors. Due to limited space, author only lists the results of the analysis in 2010.

1) Factor extraction and solution of factor load matrix

The situation of the total variance of the original variable is explained by the gravel plot and the factor, the cumulative variance contribution rate of the 2 factors was 85.672%, in addition to 2010, the other years was more than 85%. Overall, the original variable information is relatively complete, and the effect of factor analysis is relatively satisfactory. So, the two factors are relatively reasonable. After the rotation of the factor load matrix see Table Ⅰ.

TABLE II. FACTOR LOAD MATRIX AFTER ROTATION

	Component	
	1	*2*
X1	0.960	0.219
X2	0.919	0.197
X3	0.909	0.355
X4	0.862	0.378
X5	0.279	0.918
X6	0.737	0.305
X7	0.220	0.902
X8	0.397	0.749

As see in Table 2, there are five indicators in the public factor F1 has a high load, X1, X2, X3, X4, and X6. These five indicators could explain the input capacity of the high-tech zone, so we named the scientific and technological activities input capacity factor as F1.

The remaining three indicators, X5, X7, and X8. These three indicators have a high load at the public factor F2, it could explain the output capacity of the high-tech zone, and so we named the scientific and technological activities output capacity factor as F2.

(2) Calculate the factor score

Firstly, calculate the factor scores of the two common factors, according to the factor score coefficient matrix and the standardization of the original variable. The expression of factor score is,

F1=−0.062 ·X1−0.165 ·X2−0.170 ·X3+0.214 ·X4+
0.285 ·X5+0.238 ·X6+0.200 ·X7+0.295 ·X8

F2=0.330 ·X1+0.465 ·X2+0.469 ·X3−0.019 ·X4−0.141 ·X5
−0.045 ·X6−0.031 ·X7−0.140 ·X8

The functional expression of the total score of the sample i at the time t is,

$$F_i'(t)=\frac{0.52545\cdot F_{1i}+0.33127\cdot F_{2i}}{0.85672}$$

Take Nanjing as an example, the number is 15, using $F_{15}'(3)$ means Nanjing (number 15) comprehensive score in third year (2010).

$$F_{15}'(3)=\frac{0.52545\times 0.12545+0.33127\times 0.62875}{0.85672}=0.32006$$

Similarly, make six times factor analysis of 88 high-tech zone, obtain the variance contribution rate and the accumulated variance contribution rate of the common factors extracted from each year. As shown in Table Ⅱ.

TABLE III. VARIANCE CONTRIBUTION RATE AND ACCUMULATED VARIANCE CONTRIBUTION RATE

component		F1 (%)	F2 (%)	Cumulative (%)
time	***2008***	54.625	32.790	87.415
	2009	53.287	33.815	87.102
	2010	52.545	33.127	85.672
	2011	52.868	30.65	83.526
	2012	56.169	26.595	82.764
	2013	54.858	32.100	86.958

3) Calculate the panel data integrated total score

Take Nanjing as an example, using $S_{1\cdot 15}$ as the total score of the first factor, by formula (3),

$$S_{1\cdot 15}=\frac{0.54625\times 0.29258+\ldots+0.54858\times 0.33188}{0.54625+\ldots+0.54858}=0.14971$$

Similarly, $S_{2\cdot 15}$ =0.53434

Calculate the panel data integrated total score S_{15}',by formula (4),

$$S_{15}'=\frac{0.87415\times 0.29258+\ldots+0.86958\times 0.33188}{0.87415+\ldots+0.86958}=0.29177$$

In the same way, calculate the others integrated total score, the factor total score and the integrated total score are shown in Fig. 1.

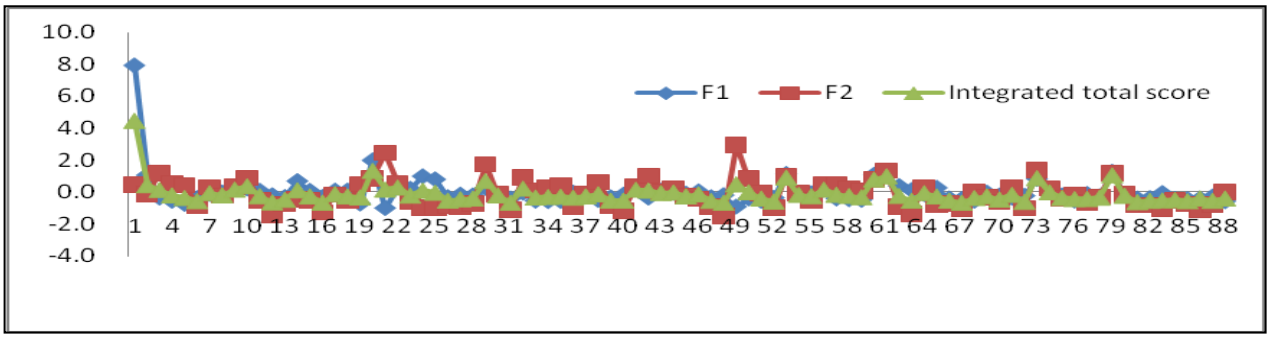

Fig. 1. Score distribution

In this paper, we extracted 2 common factors from the original 8 index variables; F1 is scientific and technological activities input capacity factor, F2 is scientific and technological activities output capacity factor. We can see from Fig. 1, the comprehensive score is influenced by these two factors, it shows that the high-tech zone should focus on the input and output of scientific and technological activities in order to improve its technological innovation capability. Among them, the variance contribution rate of factor F1 is relatively large, it means that while increasing the construction of two factors, the high-tech zone should focus on the investment in scientific and technological activities, but also cannot ignore the output of scientific and technological activities. Because of space limitations, this paper involves a large number of samples; the score and rank of 88 high-tech zones are not list. Here is still taking Nanjing as an example, the first factor score in this high-tech zone is 0.33, rank 13th, the second factor score is 0.53, rank 17th, combined total score is 0.29, rank 12th. Relatively speaking, this high-tech zone is not a big drop in the rankings; the scientific and technological input and output of this high-tech zones are in a relatively stable state, in the future, this suggests that at the same time of increase the investment, it is necessary to appropriately increase the output of this high-tech zones, this will be more advisable, and the effect will be better.

On the whole, 22 high-tech zones scored better than the average scored, most of these are in the coastal area or the Middle East developed region, it means that regional construction and government intervention in the development of science and technology innovation in the high-tech zone has a certain role in promoting. This also give a revelation to other high-tech zones, while the high-tech zones increases devotion and enhances the capability of technological innovation, it should be combined with the local government's preferential policies to improve the financing of enterprises in the high-tech zone and other measures to improve the overall scientific and technological innovation capacity of high-tech zones.

IV. CONCLUSION AND SUGGESTIONS

Through these studies, what we can see is that the current level of technological innovation capability of our national high-tech zones greatly influenced by science and technology activities inputs and outputs, high-tech zones at strengthening scientific and technological innovation capacity building itself, should focus on strengthening science and technology funding, building efforts put into the quality of scientific and technical personnel as well as scientific and technical personnel, which is the development of high-tech zones have a certain role. Eastern developed areas and high-tech zones in the eastern coastal areas of science and technology investment has certain advantages, but should pay attention to quality and efficiency of the use of science and technology investment and scientific and technological output, and strengthen the management of staff, to attract high-quality personnel, and promote science and technology the rapid development of innovative bidirectional inputs and outputs. For the Midwest or high-tech zones in underdeveloped areas, and actively absorb the development experience in high-tech zones technology innovation developed regions, while more should be combined with their own circumstances to take reasonable and effective measures to promote the development of science and technology innovation.

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