Таблица 3. Полные затраты ВЭД 17 базового и планово-прогнозного вариантов, тыс. руб

	Полные затраты ВЭД 17		Изменение
	базовый вариант	новый вариант	
Всего	5 622 186	6 746 623	1 124 437
На налоги	631 502	757 803	126 301

При этом 54 % от этой суммы государство получает от ВЭД 17, а 46 % государству поступит от других ВЭД.

Таким образом, рассмотренная модель налоговых потоков и отчислений делает возможным определить прямые и полные затраты и их структуру на налоговые платежи и отчисления любого ВЭД, вычислить изменение полных и прямых затрат на налоги, которые можно отнести к переменным затратам, при изменении объемов производства конечного продукта и определить полную сумму и структуру увеличения выплат налогов и отчислений государству, позволяет выполнить анализ изменения полных и прямых затрат на уплату налогов и отчислений при различных налоговых ставках для выбранного ВЭД, а также решать другие задачи в рамках налоговой политики государства, возникающие при прогнозировании и планировании на уровне взаимодействия ВЭД, т.е. на уровне, связывающем макроэкономическое и отраслевое планирование.

RESEARCH ON THE EVALUATION OF INNOVATION CAPABILITY OF INDUSTRIAL ENTERPRISES IN CHINA'S PROVINCES BASED ON FACTOR ANALYSIS AND CLUSTER ANALYSIS

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Abstract: Through the creation of 4 primary indicators “contribution of innovation”, “result of innovation” and “innovation of the internal and external environment” and 11 secondary indicators, a system of assessment indices was created for the potential of industrial innovation in China. The method of factor analysis and the method of cluster analysis are combined to assess the innovative ability of industrial enterprises in 30 provinces and cities in 2016. The study shows that the innovative capacity of industrial enterprises in the southeast has a strong advantage over other regions, which is mainly reflected in high investment and production of industrial enterprises. The low industrial innovation potential of the central region is mainly due to insufficient investment and unfavorable innovation environment, and the domestic innovation environment in the western region needs to be improved. Based on this, this article makes proposals for promoting innovation and the development of industrial enterprises in China.

Keywords: industrial enterprise innovation ability; evaluation; factor analysis; cluster analysis

1. Introduction

Innovation is the fundamental driving force for national and regional development and the core of economic competitiveness, while industrial enterprises are the best carrier for developing regional independent innovation. In recent years, many experts and scholars have analyzed the factors influencing the innovation ability of enterprises. Ji Xiaoding[1] et al. use AHP (Analytic Hierarchy Process) method and fuzzy comprehensive evaluation method to evaluate the technological innovation ability of enterprises. Liu Chao[2] et al. used rough set method to analyze the key factors affecting the development of innovation ability in Zhengzhou City. Zhu Shanli[3] et al. used data envelopment analysis to study the influencing factors of technological innovation in China's high-tech industry. Based on the literature review, this paper selects appropriate financial and non-financial indicators, and uses factor analysis to comprehensively compare the innovation capabilities of industrial enterprises in China's provinces, and studies the level of innovation development in China based on cluster analysis results. Provide guidance for enterprises to “improve industrial innovation capability” and provide reference for the government to “develop incentive and innovation policies”.

The data used in the experimental analysis of this paper comes from the 2016 Statistical Yearbook of Scientific and Technological Activities of Industrial Enterprises issued by the National Bureau of Statistics of China in 2017. Due to the lack of data in the Tibet Autonomous Region, this paper only statistically analyzes the situation of other 30 provinces (cities) in mainland China.

2. Indicator System

This paper first studies the “National Innovation Capability Evaluation Index System” published by the National Bureau of Statistics of China, then refers to the “Global Innovation Index” issued by WIPO, and comprehensively draws the following 11 evaluation indicators to construct an evaluation index for industrial enterprises. The system, as shown in Table 1:

Table 1. Evaluation Index System of Industrial Enterprises' Innovation Ability in China's Provinces

Primary indicator		Secondary indicator
Innovation investment	x_1	R&D personnel equivalent to full-time equivalent
	x_2	R&D expenditure
	x_3	Technical renovation expenditure
	x_4	Number of companies with R&D activities
	x_5	Number of new product development projects
Innovative output	x_6	Number of patent applications
	x_7	New product sales revenue
Innovative external environment	x_8	R&D funding from government departments
	x_9	Government funds
Innovative internal environment	x_{10}	Expenditure on domestic research institutions / R&D expenditure
	x_{11}	Number of researcher / R&D personnel full time equivalent

3. Evaluation Model

3.1 Factor analysis

Factor analysis is a multivariate statistical analysis method designed to simplify the original model and decompose the original observed variables into linear combinations of factors by constructing a factor model. Using factor analysis, multiple variables can be grouped according to the calculated correlation. Each group represents a basic element, which we call a common factor. The implicit information of the original variable is expressed by fewer common factors, it is conducive to scientific research and analysis, and can be widely used in evaluation research in various industries.

3.2 Mathematical model

$$\begin{cases} x_1 = a_{11}f_1 + a_{12}f_2 + \cdots + a_{1m}f_m + e_1 \\ x_2 = a_{21}f_1 + a_{22}f_2 + \cdots + a_{2m}f_m + e_2 \\ \quad \cdots\cdots\cdots\cdots\cdots \\ x_n = a_{n1}f_1 + a_{n2}f_2 + \cdots + a_{nm}f_m + e_n \end{cases}, m < n \qquad (1)$$

Equation (1) can be simplified as:

$$X = AF + e \qquad (2)$$

Where x_n represents the original variable, which is the evaluation index. a_{ij} represents the weight of the variable x_i on the common factor f_j, which is the standard regression coefficient. f_j represents the common factor.

In the process of using factor analysis, researchers generally choose the maximum variance method, which can make the standard regression coefficient matrix more reasonable, explain common factors more easily, and the actual meaning is more distinct.

4. Empirical research

4.1 Experimental process

This article uses SPSS 25 as an analysis tool. Due to the lack of some data, this article does not analyze the Tibet Autonomous Region.

First, according to the evaluation index system of industrial enterprises' innovation ability established in this paper, through reviewing the Statistical Yearbook of Scientific and Technological Activities of Industrial Enterprises, collate and calculate relevant data of industrial enterprises in 30 provinces (cities) in mainland China.

Second, import data in the SPSS software and standardize the data. Next, the factor analysis method is used to analyze the data. In order to verify the rationality of the experimental results, the KMO and Bartlett's Test was selected at the same time as the factor analysis.

Finally, the comprehensive evaluation value, that is, the estimated value equation of the total factor score is obtained. In this experiment, using the factor analysis function of SPSS, the three factor variable scores FAC1_1, FAC1_2 and FAC1_3 were saved, and the final score was calculated by the factor variance contribution rate.

The results are shown in Table 2. The KMO value is 0.814>0.6, and the Sig. value of the Bartlett's Test is 0.000<0.005, indicating that the validity test of the original data is passed. The data of this study is suitable for factor analysis.

Table 2. KMO and Bartlett test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.814
Bartlett's Test of Sphericity	Approx. Chi-Square	563.344
	df	55
	Sig.	.000

It can be seen from the variance explanation table (Table 3) that the cumulative contribution rate of the extracted three common factor interpretations is 91.136%, which can express most of the information carried by the data.

Table 3. Variance interpretation table

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.556	68.692	68.692	7.556	68.692	68.692	6.465	58.775	58.775
2	1.458	13.255	81.946	1.458	13.255	81.946	2.428	22.072	80.847
3	1.011	9.190	91.136	1.011	9.190	91.136	1.132	10.290	91.136
4	0.519	4.716	95.853						
5	0.229	2.079	97.932						
6	0.130	1.180	99.113						
7	0.045	0.407	99.519						
8	0.028	0.251	99.770						

Table 3 continuation

Total Variance Explained									
Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
9	0.012	0.108	99.878						
10	0.009	0.080	99.957						
11	0.005	0.043	100.000						
Extraction Method: Principal Component Analysis.									

The initial eigenvalues of all common factors extracted by factor analysis are shown in Figure 1:

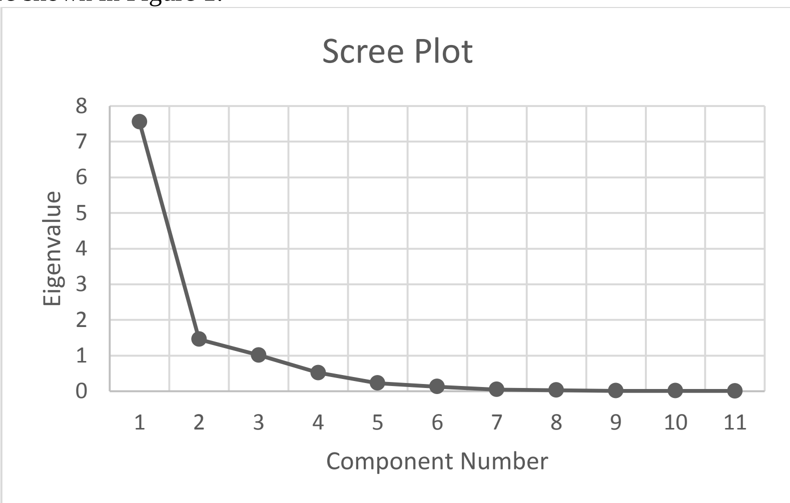

Figure 1: Gravel diagram

As shown in Table 4, the load distribution after rotation clearly shows the distribution of the various factors. x_1, x_2, x_3, x_4, x_5, x_6, x_7 is mainly explained by the first factor, x_8, x_9 is mainly explained by the second factor, and x_{10}, x_{11} is mainly explained by the third factor. The variables closely related to the first factor are mainly variables in innovation input (R&D personnel, R&D expenditure) and innovation output (patent and new product income), which can be named as "innovation input-output" factor. The main factor associated with the second factor is the government-funded variable, which can be named the "enterprise external innovation environment" factor. Closely related to the third factor is the proportion of R&D funds and the proportion of R&D personnel, which can be named as "intra-enterprise innovation environment" factor.

Table 4. Component matrix after rotation

Rotated Component Matrixa			
	Component		
	1	2	3
x_1	.959	.147	-.070
x_2	.940	.303	-.053
x_3	.283	.935	-.104
x_4	.947	.254	-.047
x_5	.932	.325	-.055
x_6	.932	.290	-.016
x_7	.246	.949	-.075
x_8	.818	.240	-.177
x_9	.864	.425	-.040
x_{10}	-.080	-.151	.960
x_{11}	-.684	.157	.384
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.			
a. Rotation converged in 5 iterations.			

4.2 Analysis of results

According to the basic idea of factor analysis, the three common factors in the research results are weighted and summed, and the comprehensive scores of the innovation ability of industrial enterprises in all provinces can be obtained.

The calculation formula is as follows:

$$F = \frac{0.58775 * FAC1\_1 + 0.22072 * \ FAC1\_2 + 0.1029 * \ FAC1\_3}{0.91136}$$

The variance contribution rates of the three rotated common factors are: 58.775%, 22.072%, 10.290%, and the comprehensive scores of the innovation ability of the company can be obtained. The ranking is shown in Table 5.

Table 5. Comprehensive score ranking

Province(City)	FAC1_1	FAC1_2	FAC1_3	Score	Ranking
Beijing	-0.60107	1.46567	1.01303	0.081707094	8
Tianjin	-0.20573	0.57901	-0.13358	-0.007531713	10
Hebei	-0.09336	-0.46153	-0.66914	-0.247537469	18
Shanxi	-0.29409	-0.91974	-0.25552	-0.441262968	22
Inner Mongolia	-0.29297	-1.07119	-0.81678	-0.540590805	27
Liaoning	-0.75718	1.16009	-0.23822	-0.23425465	17
Jilin	-0.22498	-1.1001	-0.49655	-0.467588068	25
Heilongjiang	-0.78842	0.57422	0.33372	-0.33171549	20
Shanghai	-0.32676	1.64808	-0.71902	0.107228614	7
Jiangsu	3.35568	0.18599	0.01077	2.210389819	1
Zhejiang	2.54987	-0.8783	-0.39519	1.387116689	3
Anhui	0.2544	0.27175	-0.2314	0.20375395	5
Fujian	0.26348	-0.8231	-1.00114	-0.142459147	15
Jiangxi	-0.41167	-0.46801	-0.23852	-0.405769309	21
Shandong	0.91541	1.48315	-0.03548	0.945556315	4
Henan	0.19603	-0.49592	-0.81124	-0.085278513	13
Hubei	-0.17653	0.23231	-0.06373	-0.064779957	11
Hunan	0.06931	0.36382	-0.54447	0.071336618	9
Guangdong	2.08172	1.49053	0.90252	1.805422687	2
Guangxi	-0.29744	-0.89365	-0.39181	-0.452493018	23
Hainan	-0.20866	-0.85988	4.14218	0.124865798	6
Chongqing	-0.13535	-0.57087	-0.67795	-0.302092964	19
Sichuan	-0.63027	1.15836	0.40821	-0.0798402	12
Guizhou	-0.36341	-0.79549	-0.24424	-0.454603095	24
Yunnan	-0.46175	-0.62256	-0.33829	-0.486761594	26
Shaanxi	-1.14829	2.34317	-0.47064	-0.226202402	16
Gansu	-0.20017	-0.91637	2.09646	-0.114318568	14

Table 3 continuation

Province(City)	FAC1_1	FAC1_2	FAC1_3	Score	Ranking
Qinghai	-0.8755	-0.50482	0.14991	-0.669958366	30
Ningxia	-0.70159	-0.67037	-0.07224	-0.622977841	29
Xinjiang	-0.49074	-0.90427	-0.21167	-0.559387895	28

From the index ranking, the most innovative ability is Jiangsu Province, and its industrial enterprises innovation environment, innovation investment and innovation output are among the highest in the country. The top four in the list of innovation capabilities are Jiangsu, Guangdong, Zhejiang and Shandong. In 2017, the GDP of these four provinces (billions of US dollars) were 1341.19, 1272.27, 1076.43, and 766.73, ranking the top four in the country, and the industrial output value accounted for the national economy. All of them were higher than the national average. The research selection method has credibility.

4.3 Cluster analysis

Cluster analysis is a way to divide data into different groups by identifying the data cluster structure, and members of each group have similar attributes.

Based on the results of factor analysis, this study clustered the innovation capabilities of industrial enterprises in 30 provinces (cities) in mainland China and classified them into three categories, as shown in Table 6.

Table 6. Cluster analysis results of 30 provinces (cities) industrial enterprises innovation ability

Classification	Score	Province	Creativity
The First Class	F>0	Jiangsu, Guangdong, Zhejiang, Shandong, Shanghai, Beijing, Tianjin, Hunan, Anhui, Hainan	Strong
The Second Class	-0.4<F<0	Chongqing, Hubei, Sichuan, Henan, Gansu, Fujian, Shaanxi, Liaoning, Hebei, Gansu, Heilongjiang	Weak
The Third Class	F<-0.4	Jiangxi, Shanxi, Guangxi, Guizhou, Jilin, Yunnan, Inner Mongolia, Xinjiang, Ningxia, Qinghai	Poor

5. Conclusions and recommendations

It can be seen from Table 6 that there is a big gap between the innovation capabilities of industrial enterprises in different regions of China, and the innovation capability of industrial enterprises in the southeast has a strong advantage over other regions. In particular, coastal provinces (cities) such as Jiangsu, Guangdong, Shandong, and Zhejiang are among the top industrial innovation capabilities.

Compared with the eastern provinces, Henan and Hubei in the central region have a certain gap, the industrial base is weak, the government support is not strong, and it is a region with weak innovation capability. In the western region, except for Sichuan and Shaanxi, which are weak in innovation, Ningxia, Xinjiang, and other provinces have always belonged to regions with poor innovation capabilities, with less investment in innovation, and the innovation capacity of industrial enterprises is generally low.

This paper evaluates the technological innovation capabilities of industrial enterprises in various provinces and cities in China, and puts forward the following suggestions for the evaluation results of technological innovation capabilities of industrial enterprises in various provinces and cities in China:

(1) In the southeastern coastal provinces, if they want to enhance their technological innovation capabilities, they should enhance the external innovation environment and increase government support.

(2) The central region should strengthen cooperation with scientific research institutions.

(3) The western region should simultaneously increase R&D funds and personnel input.

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