Empirical Measure of Shenyang Pillar Industries Scientific and Technological Innovative Power on the Basis of Principal Component Analysis

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Abstract Researching into the pillar industries of Shenyang, including equipment manufacturing industry, pharmaceutical and chemical industry, electronic information industry, agricultural product and by product processing industry, smelting and pressing of black metals and smelting and pressing of nonferrous metals, an evaluation index system was set up for their scientific and technological innovative power on which the principal component analysis model was built. Then examples are given to measure their scientific and technological innovative power on the basis of this principal component analysis model. Therefore, the empirical measure is available to provide fact basis and valuable reference for the relevant departments and organizations to make decisions.

Key words Pillar industry; Scientific and technological innovative power; Principal component analysis; Measure

1 Introduction

Scientific and technological innovative power is a main and decisive factor for regional economic growth and an industry competition. And its strength is the vital measure of a region or even an industry development potential and future competitive power. Therefore, how to measure the scientific and technological innovative power of an industry objectively and scientifically is of great realistic meaning, on which the development condition of this industry's innovative power can be mastered accordingly. This is available for relevant departments to have a better understanding of the essence and the rule of innovation, so that the experience of innovation may be summarized, and a new strategically idea for scientific and technological innovation can be reasonably adopted so as to maintain and upgrade the competitive power of this industry, resulting in obtaining the best economic and social benefits.

2 Technical Ideas and Model Construction

The principal component analysis is a kind of multivariate statistical method relying on a use of the correlation between the original variables. By using this method, the original variables can be explained by a handful of key combinations of the original variables to achieve reducing the dimensions. [1] The mathematical models are as follows:

$$\begin{cases} F_1 = a_{11}ZX_1 + a_{21}ZX_2 + \cdots + a_{p1}ZX_p \\ \cdots \\ F_p = a_{1m}ZX_1 + a_{2m}ZX_2 + \cdots + a_{pm}ZX_p \end{cases} \tag{1}$$

In these models, F stands for principal component, $a_{1i}, a_{2i}, \cdots, a_{pi}(i = 1, \cdots, m)$ are the eigenvectors which correspond to the eigenvalues of covariance matrix $\sum$ of X, and $ZX_1, ZX_2, \cdots, ZX_p$ are the standardized values of the original variables. $A = (a_{ij})p \times m = (a_1, a_2, \cdots, a_m)$, $Ra_i = \lambda_i a_i$, R is correlation coefficient matrix, λ_i, a_i are respectively corresponding eigenvalue and unit eigenvector, $\lambda_1 \geq \lambda_2 \geq \Lambda \geq \lambda_p \geq 0$. The specific steps of analysis on the principal component [2] [3] are as follows:

(1) The standardized index matrix Z_{ij} is obtained through standardizing the original data; $Z_{ij} = \dfrac{X_{ij} - \overline{X_j}}{S_j}$, in which $\overline{X_j}$ and S_j are respectively the average and variance of the j_{th} index.

(2) The related coefficient matrix R is to be obtained among the standardized index values;

(3) The eigenvalue, eigenvector and contribution rate of the correlation coefficient matrix R are to be obtained, and the very contribution rate is the weight of the principal component;

(3) The expression of the principal components $F_1, F_2, \cdots, F_m$ can be got according to the factor scores coefficient matrix;

(4) The scores can be got by calculating the $F_1, F_2, \cdots, F_m$ of each samples, and then the comprehensive evaluation values of each samples can be calculated by linear weighted model, that is each sample can be scored comprehensively by summarizing and calculating the weighed scores of m principal components which use the contribution rate of variance as the weight;

(5) The principal component is to be analyzed at last for its economic significance by which the comprehensive evaluation can be achieved.

The above principal component analysis can be realized by statistical software SPSS17.0

3 Empirical Measure of Shenyang Pillar Industry Scientific and Technological Innovative Power

3.1 The establishment of evaluation index system

Establishing a scientific evaluation index system is the foundation of the evaluation on the scientific and technological innovative power. There are many ways of evaluation on index system, but most of them require industry experts to bind the assignment with weights in each level of the question; thus they will be influenced by human factors in varying degrees. [4] This essay chooses two Rank Two indices and seven Rank Three indices to measure empirically on the scientific and technological innovative power of Shenyang pillar industries on the basis of the principles that the index system should be built systematically, scientifically, representatively and feasibly. As it is shown in Table 1:

Table 1 The Evaluation Index System Of Shenyang Pillar Industries Scientific And Technological Innovative Power

Rank One index	Rank Two indices	Rank Three indices	Calculating methods
Scientific and technological innovative power	Input into the scientific and technological innovation	The intensity of R&D input (X_1)	The proportion of R&D funds in sales revenue
		The structure of funds input into the scientific and technological activities (X_2)	The proportion of scientific and technological activities funds in GDP
		The intensity of personnel input into the scientific and technological activities (X_3)	The proportion of scientific and technological personnel in employees
		Personnel quality (X_4)	The proportion of scientists engaged in the scientific and technological activities
	Output of the scientific and technological innovation	Average patent number per capita (X_5)	The proportion of patent number in employees
		The sales revenue rate of the new product (X_6)	The proportion of new products sales revenue in all products sales revenue

3.2 The principal component analysis on scientific and technological innovative power

According to the relevant data of Shenyang statistical yearbook [6], the principal component analysis is made on Shenyang pillar industries scientific and technological innovative power by using the evaluation index system built in Table 1. It is shown in Table 2 as follows:

The correlation coefficient matrix can be got after standardizing the above data. Then the initial eigenvalue, variance contribution rate and accumulative variance contribution rate can be obtained successively. Next, principal components can be extracted to form components loading matrix by orthogonally rotating the maximum variance. In this way, the scores of each principal component can be got and the comprehensive score may be calculated by formula $F = \frac{\lambda_1}{\lambda_1 + \lambda_2} F_1 + \frac{\lambda_2}{\lambda_1 + \lambda_2} F_2$, it is shown in Table 3 as follows:

Table 2 The Statistical Table Of Shenyang Pillar Industries Scientific And Technological Innovative Power Indices

Index	X_1	X_2	X_3	X_4	X_5	X_6
The equipment manufacturing industry	0.0210	0.0150	0.4708	2.6965	23.6347e-4	1.4426
Pharmaceutical and chemical industry	0.0017	0.0013	0.0350	1.0220	0.0012	0.0500
Electronic information industry	0.0083	0.0006	0.1187	0.9922	0.0029	0.2863
Agricultural product and by product processing industry	0.0004	0.0002	0.0008	2.7879	0.00008	0.0113
Smelting and pressing of black metals	0.000005	6.2090e-8	0	0	0	0
Smelting and pressing of nonferrous metals	0.00006	0.00006	0.0058	1.3750	0	0.0113

Note: In order to keep consistent in statistics, the equipment manufacturing industry in this essay incorporates machinery equipment manufacturing industry, automobile and parts manufacturing industry and aerospace industry.

Table 3 The Statistical Table Of Eigenvalue, Variance Contribution Rate And Accumulative Variance Contribution Rate

Component	The initial eigenvalue	Variance contribution rate	Accumulative variance contribution rate
1	4.268	71.139	71.139
2	1.157	19.280	90.419
3	0.563	9.381	99.801
4	0.012	0.197	99.997
5	0.000	0.003	100.000
6	-2.276E-16	-3.794E-15	100.000

It can be seen from Table 3 that the accumulative variance contribution rate of first two principal components amounts to 90.419%, therefore, the original six indices can be substituted with the first two principal components, in which the information contained accounts for 90.419 percent of the original total amount, and the loss rate of information is only 9.581 percent. It also can be seen from the Rubble figure below that the original variables can be explained clearly by extracting the first two principal components.

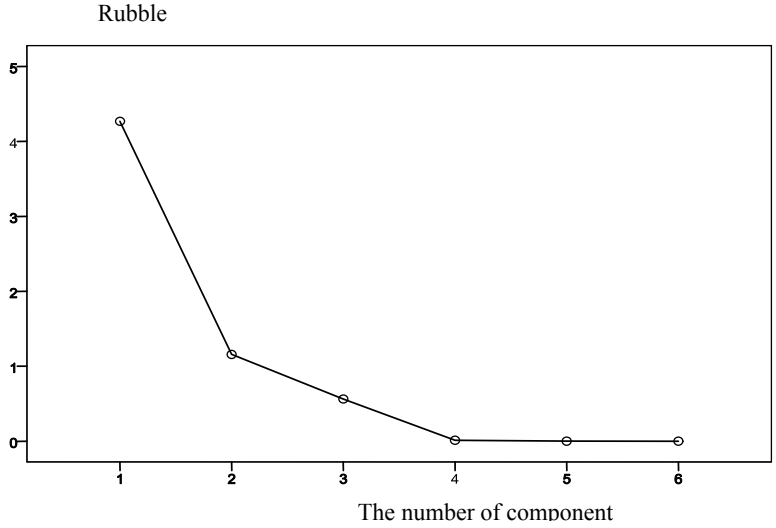

Figure 1 Rubble Figure

According to the two extracted principal components and the principal component model, the measure models for Shenyang pillar industries scientific and technological innovative power can be set up as follows:

$$\begin{cases} F_1 = 0.4661ZX_1 + 0.4763ZX_2 + 0.4773ZX_3 + 0.3035ZX_4 - 0.0736ZX_5 + 0.4797ZX_6 \\ F_2 = 0.2427ZX_1 - 0.0511ZX_2 + 0.1292ZX_3 - 0.4026ZX_4 + 0.8684ZX_5 + 0.0744ZX_6 \end{cases}$$

Table 4 The Initial Component Loading Matrix

	Component	
	1	2
The intensity of R&D input	0.963	0.261
The structure of funds input into the scientific and technological activities	0.984	-0.055
The intensity of personnel input into the scientific and technological activities	0.986	0.139
Personnel quality	0.627	-0.433
Average patent number per capita	-0.152	0.934
The sales revenue rate of the new product	0.991	0.080

The scores of each principle component can be got from the above model and the comprehensive score can be calculated by corresponding formula. It is shown in Table 5 as follows:

Table 5 The Statistical Table Of Principle Components Scores

Index	Component 1 score	Component 2 score	Comprehensive score	Rank
The equipment manufacturing industry	4.1409	-0.2078	3.2133	1
Pharmaceutical and chemical industry	-0.8741	0.3696	-0.6089	3
Electronic information industry	-0.2608	1.9209	0.2045	2
Agricultural product and by product processing industry	-0.5897	-1.1708	-0.7136	4
Smelting and pressing of black metals	-1.4173	-0.2031	-1.1583	6
Smelting and pressing of nonferrous metals	-0.9988	-0.4071	-0.8726	5

3.3 Analysis on measurement results

The equipment manufacturing industry ranks first with the comprehensive score of 3.2133. Compared with other industries, the equipment manufacturing industry invests much more funds in R&D and scientific and technological activities. However, there still exists a big gap for it to keep pace with the world average level. As to the R&D expenditure, its proportion is generally 5 to 10 percent in the main business revenue for common developed countries, and it is even more than 10 percent in the world 500-top enterprises. It is generally believed by the international business circle that the enterprise may be not competitive enough until its R&D expenditure accounts for more than 5 percent in its business revenue. The enterprise can only survive when the proportion is just 2 percent. If the proportion is less than 1 percent, the enterprise is hard to exist. But at the same time, there have been a great number of qualified staff in this industry engaging in the scientific and technological activities. Next to the equipment manufacturing industry, electronic information industry is at the second place. The highest score of component 2 exemplifies that the average patent number per capita of electronic information industry in Shenyang is comparatively grater than the other industries, which is in correspondence with the characteristics that can be classified into the hi-tech scope. Pharmaceutical and chemical industry also belongs to this scope with its score ranking third, and its score of component 2 is just second to electronic information industry. The comprehensive score and the scores of each principal component are all negative values for agricultural product and by product processing industry, smelting and pressing of black metals and nonferrous metals industries. Among them, the score of component 2 for agricultural product and by product processing industry is at the bottom, which means that the average patent number per capita in this industry is at low level. The lowest score of component 1 for smelting and pressing of black metals is an inevitable result of serious insufficient input from the aspect of science and technology, which can also be confirmed from the relevant data. Thus, it is really hard for this industry to achieve high sales revenue and to acquire competitive power.

4 Conclusion

In those Shenyang pillar industries, the scientific and technological innovative power of the equipment manufacturing industry and electronic information industry is above the whole industrial levels, and the input into the scientific and technological innovation for pharmaceutical and chemical industry as a hi-tech one needs to be further strengthened. The input and output concerning the scientific and technological innovation in the other three industries all fail to meet the whole industrial levels. In a

word, the scientific and technological innovative power of Shenyang pillar industries is not excellent and the innovation input and output are bare satisfactory, so there is much room in improving their overall competitive power.

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