Measuring the Tech-Innovation Efficiency of Chinese Low-Tech Manufacturing Industries

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Abstract As the main body of Chinese national economy, Chinese low-tech manufacturing industries get into the scrapes of poor tech-innovation efficiency while contributing more than sixty percent of gross domestic product at present, which bring a great threat to the development and upgrading of low-tech manufacturing industries. On the basis of defining the range of Chinese low-tech manufacturing industries, the paper analyzes its tech-innovation mode, adopts the cross-section data of *China Statistical Yearbook on Science and Technology* (2009) to measure the tech-innovation efficiency of Chinese low-tech manufacturing industries with the method of principal component analysis, and provides the improving measures in view of the above results finally.
Key words Low-tech manufacturing industries; Technological innovation; Efficiency measurement; Principal component analysis

1 Introduction

Chinese manufacturing industries are mainly concentrated on labor-intensive industries, capital-intensive industries and the labor-intensive links of tech-intensive industries, which can be known as low-tech manufacturing industries. Huge low-tech manufacturing industries cluster is one of the fundamental realities of Chinese economy, the development and upgrading of low-tech industry is the principal contradiction in the evolution of Chinese manufacturing industries. Since the 20th Century, technological introduction and transfer from the developed countries has been the main technological source of Chinese low-tech manufacturing industries, and the poor tech-innovation efficiency has hindered Chinese low-tech manufacturing industries from developing healthily. On the basis of defining the range of Chinese low-tech manufacturing industries, this paper aims to analyze its tech-innovation mode, adopt the cross-section data of *China Statistical Yearbook on Science and Technology* (2009) to measure the tech-innovation efficiency of Chinese low-tech manufacturing industries with the method of principal component analysis, and provide the improving measures in view of the above results finally.

2 Definition of Chinese Low-tech Manufacturing Industries

The low-tech manufacturing industry refers to the industry with ripe technology. There is no unified criterion of the high, middle and low technical industry so far. Organization for Economic Cooperation and Development (OECD) has classified the industries according to the content of research and development (R&D), namely the expenditure on R&D as a percentage of total revenue from the sale of products[1]. It belongs to the low-tech industry when R&D content is less than 1%, it belongs to the middle-tech industry when R&D content is during 1～3%, it belongs to the high-tech industry when R&D content is more than 3%. According to the definition of OECD, the characteristic of low-tech industries of China's national economy is very obvious. According to the cross-section data of "China Statistical Yearbook on Science and Technology (2009)", there are 23 manufacturing industries of 29 Chinese manufacturing industries belong to the range of low-tech manufacturing industries[2], as shown in Table 1.

The main tech-innovation content of Chinese low-tech manufacturing industries is to introduce, apply and absorb the core and patented industrial technologies, which are mainly sourced from the technological introduction and transfer of the developed countries[3]. A lot of Chinese low-tech manufacturing companies have ignored the link of digesting and absorbing the technologies while putting a large amount of money into introduce foreign technologies blindly, thus some enterprises fall into the vicious circle "introduce- backward - reintroduce" gradually after developing for many years, they take out a small quantity of the patent on key technologies, and suffer from a poor tech-innovation efficiency[4]. For this reason, this paper adopt the cross-section data of *China Statistical Yearbook on Science and Technology* (2009) to measure the tech-innovation efficiency of Chinese low-tech manufacturing industries with the method of principal component analysis, and provide the improving measures in view of the above results finally.

Table 1 Range of Chinese Low-tech Manufacturing Industries

Code	Name of Manufacturing Industries	Code	Name of Manufacturing Industries
H_1	Processing of Food from Agricultural Products	H_{13}	Processing of Petroleum, Coking, Processing of Nucleus Fuel
H_2	Manufacture of Foods	H_{14}	Manufacture of Chemical Raw Material and Chemical Products
H_3	Manufacture of Beverage	H_{15}	Manufacture of Chemical Fiber
H_4	Manufacture of Tobacco	H_{16}	Manufacture of Rubber
H_5	Manufacture of Textile	H_{17}	Manufacture of Plastic
H_6	Manufacture of Textile Wearing Apparel, Footware and Caps	H_{18}	Manufacture of Non-metallic Mineral Products
H_7	Manufacture of Leather, Fur, Feather and Its Products	H_{19}	Manufacture and Processing of Ferrous Metals
H_8	Processing of Timbers, Manufacture of Wood, Bamboo, Rattan, Palm, Straw	H_{20}	Manufacture and Processing of Non-ferrous Metals
H_9	Manufacture of Furniture	H_{21}	Manufacture of Metal Products
H_{10}	Manufacture of Paper and Paper Products	H_{22}	Manufacture of General Purpose Machinery
H_{11}	Printing, Reproduction of Recording Media	H_{23}	Manufacture of Artwork, Other Manufacture
H_{12}	Manufacture of Articles for Culture, Education and Sport Activity		

3 Data and Methodology

3.1 Index system and original data

The basic thought of efficiency measurement is a proportion of output and input, namely regard various technological resources as the input while regarding various outcomes as the output. When it comes to measure the tech-innovation efficiency of Chinese low-tech manufacturing industries, this paper designs the input indexes and output indexes according to data availability and the relevant research results, as shown in Table 2.

Table 2 Index System of Measuring the Tech-innovation Efficiency

Input index X	Intramural Expenditures on S&T Activities（ten thousands Yuan） X_1
	Total Expenditures on R&D（ten thousands Yuan） X_2
	Personnel Engaged in S&T Activities（person） X_3
	Personnel in S&T projects（person） X_4
Output index Y	Gross Industrial Output Value of New Products（ten thousands Yuan） Y_1
	Gross Revenue from the Sale of New Products（ten thousands Yuan） Y_2
	Projects for S&T Activities（item） Y_3
	Invention Patents（item） Y_4

According to the cross-section data of *China Statistical Yearbook on Science and Technology* (2009), the original data of the above output and input indexes of Chinese low-tech manufacturing industries are shown in Table 3.

3.2 Measuring Method

Now we will construct a proper model to carry out a comprehensive comparison between input indexes and output indexes on the basis of the above index system, and then analyze the final efficiency of resource distribution. The basic expression formula of this model is as follows:

$$E_i=C_i/T_i \qquad (1)$$

Among them，$C_i=\lambda_1C_{i1}+\lambda_2C_{i2}+\lambda_3C_{i3}+\lambda_4C_{i4}$，$T_i=\theta_1T_{i1}+\theta_2T_{i2}+\theta_3T_{i3}+\theta_4T_{i4}$.

C_i refers to the comprehensive index value of technological output of i industry, C_{ij} is the value of each tech-innovation output index of i industry, j =1,2,3,4; λ_j is the weight of each output index; T_i refers to the comprehensive index value of technological input of i industry , T_{ij} is the value of each tech-innovation input index of i industry, θ_j is the weight of each input index.

Through the above-mentioned model, after confirming the proper weight, we can calculate the comprehensive value of the output indexes and input indexes respectively, and then carry out a comparison to get the tech-innovation efficiency value E_i of each industry. The bigger E_i often means the better resource distribution efficiency. Moreover, we can carry out a comparison to the difference of tech-innovation efficiency of each industry.

Before doing concrete calculation, there are two problems needing to be solved such as non-dimensionalizing the index value and confirming weight of each index. The non-dimensionalization make the index value with different units can be add together, the formula is as follows:

$$ratio_{index\ L}=0.1+0.9*[(L-L_{min})/(L_{max}-L_{min})] \quad (2)$$

L_{max} and L_{min} refer to that the maximum and minimum of this index value respectively during all Chinese low-tech manufacturing industries, L refers to the actual value of this index. The method of principal component analysis (PCA) is adopted to confirm the weight in this paper. The modulus of factor loading is regarded as the weight to measure every factor, and then get a total measuring value after adding up the weighted average of every factor.

Table 3 Index Value of Chinese Low-tech Manufacturing Industries

Industry	X_1	X_2	X_3	X_4	Y_1	Y_2	Y_3	Y_4
H_1	872649	39975375	42438	32130	9303111	8001268	4087	629
H_2	627235	25357163	33278	23017	5197314	4826025	3766	745
H_3	781148	37051396	37771	28628	4880853	4645039	4236	253
H_4	286605	9448529	8691	6114	3464578	3422858	1443	277
H_5	1337249	60141019	95500	74776	13194058	12654835	8661	1023
H_6	310015	13545337	22454	17416	3388443	3225255	2313	259
H_7	176249	6273519	15623	13099	2835485	2733939	2246	95
H_8	189042	8290771	14051	9625	1906106	1866262	1108	230
H_9	112413	4486156	8164	5758	1262711	1158425	745	158
H_{10}	629175	28183310	28652	21591	6418951	5851966	1776	268
H_{11}	170774	7238639	12771	10177	1297344	1267542	1407	118
H_{12}	172214	7239067	12098	9673	1189407	1127151	2064	243
H_{13}	612626	29512280	28972	20116	9205564	9324010	2308	239
H_{14}	4609985	227846377	215482	159130	30821131	29900863	18188	4116
H_{15}	616971	32372156	24091	20074	6793393	6664587	1235	231
H_{16}	688667	34737058	30600	22807	5568531	5461351	4430	257
H_{17}	725623	36422319	46926	37956	6019819	6145504	4230	711
H_{18}	1461132	60843283	92476	67248	9147644	8893444	7155	1194
H_{19}	6585616	304563891	168087	119012	57079748	57735657	10397	1400
H_{20}	2057573	99034654	83225	62831	17888271	17384212	5643	1432
H_{21}	1080863	55246781	67034	52489	9352604	8754617	6145	1219
H_{22}	3932265	216760387	238392	175867	34879755	33455469	26778	3323
H_{23}	182218	9156839	16419	13515	1645507	1638801	1811	400

Resource: China Statistical Yearbook on Science and Technology (2009)

4 Results

According to the above model, this paper non-dimensionalize the relevant index value of Chinese low-tech manufacturing industries. On the basis of the above-mentioned data, we analyze four input indexes and output indexes separately with PCA, in order to confirm their own weights. The PCA result of tech-innovation input indexes is as follows: The value of KMO and Bartlett's Test is 0.728, the contribution rate of the first principal component is 95.246%, and the component matrix is as follows:

Table 5 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.728
Bartlett's Test of Sphericity	Approx. Chi-Square	283.803
	df	6
	Sig.	.000

Extraction Method: Principal Component Analysis.

Table 6 Component Matrix [a]

	Component
	1
X2	.969
X3	.982
X4	.979
X1	.974

a. 1 components extracted.

Because of only one principal component, we can get their weights only through making the load coefficient of input index divide by the sum of all the coefficients, the calculating result is: $\theta_1=0.2495$, $\theta_2=0.2482$, $\theta_3=0.2515$, $\theta_4=0.2508$.

Table 7 Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.810	95.246	95.246	3.810	95.246	95.246
2	.188	4.693	99.939			
3	.002	.051	99.989			
4	.000	.011	100.000			

Extraction Method: Principal Component Analysis.

In the same way, we can get the value of KMO and Bartlett's Test of output indexes is 0.678, the contribution rate of the first principal component of output indexes is 84.764%, the weights of output indexes including: λ_1=0.2439, λ_2=0.2548, λ_3=0.2520, λ_4=0.2493. Now we can calculate out the value of tech-innovation efficiency E_i of every Chinese low-tech manufacturing industry, the result is shown in Table 8:

Table 8 Value of Tech-innovation Efficiency E_i of Chinese Low-tech Manufacturing Industries

Industry	H_1	H_2	H_3	H_4	H_5	H_6	H_7	H_8	H_9
E_i	0.9872	1.0680	0.8119	1.2141	0.8706	0.9777	1.0448	1.0006	1.0394
Industry	H_{10}	H_{11}	H_{12}	H_{13}	H_{14}	H_{15}	H_{16}	H_{17}	H_{18}
E_i	0.8957	0.9436	1.0578	1.0617	0.8550	0.9037	0.9398	0.9033	0.7925
Industry	H_{19}	H_{20}	H_{21}	H_{22}	H_{23}				
E_i	0.8250	0.9002	0.9366	0.9141	1.0472				

5 Conclusion

Taken as a whole, it’s far from satisfaction for the tech-innovation efficiency of Chinese low-tech manufacturing industry. Only 8 of 23 Chinese low-tech manufacturing industries have the tech-innovation efficiency beyond 1, there are even six Chinese low-tech manufacturing industries which tech-innovation efficiency is beneath 0.9.

There is great disparity in innovative resource capacity and disposing efficiency during all kinds of Chinese low-tech manufacturing industries. Moreover, there is a relation of inverse proportion between innovative resource capacity and tech-innovation efficiency of Chinese low-tech manufacturing industries, the less innovative resource capacity often brings higher tech-innovation efficiency while the more innovative resource capacity often means poorer tech-innovation efficiency. For example, some low-tech manufacturing industries such as H_2, H_4, H_7, H_8, H_9, H_{12}, H_{13} and H_{23} own the least innovative resource but have the highest tech-innovation efficiency, while other low-tech manufacturing industries such as H_3, H_5, H_{10}, H_{14}, H_{18} and H_{19} have the most innovative resource but suffer the poorest tech-innovation efficiency.

Various input for technological innovation should be increased in order to promote the competitiveness of Chinese low-tech manufacturing industries. The key point of improving the tech-innovation efficiency of Chinese low-tech manufacturing industries does not lie in reducing innovation input, but lie in offering good market environment for innovation output to promote the industrialization of innovative achievement and the commercialization of innovative products.

References

[1] OECD. OECD Science, Technology and Industry Outlook[M]. Scientific or Technical Literature Press, 2003 (In Chinese)

[2] National Bureau of Statistics of China, the Ministry of Science and Technology of China. China Statistical Yearbook on Science and Technology (2009)[M]. China Statistics Press, 2009 (In Chinese)

[3] Zhang Hong, Li Yanyi. Thoughts on the Development and Upgrading of Chinese Low and Middle Technology Industries[J]. Science & Technology Progress and Policy, 2000, 17(11): 14-15 (In Chinese)

[4] You Guangrong. Low and Middle Technology Still Monopolize Chinese Industries[J]. Science & Technology Information of China, 2001, 3(4): 47-48 (In Chinese)