The Research on Performance of Industrial Innovation System

RECHERCHE SUR LA PERFORMANCE DU SYSTÈME D'INNOVATION INDUSTRIEL

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Abstract: The concept of industrial innovation system has been applied for explaining industrial development power. How about is operating ability and performance of an industrial innovation system? How evaluates performance of an industrial innovation system? Those problems raise attention of scholars and governors. The paper puts forward indicators system and method for evaluating performance of industrial innovation system. We evaluate 29 industrial innovation system applying those indicators and method. We conclude: 1st, Different industries have different operating ability and they have different performance. 2nd, If synthesizing ability of an industrial innovation system is stronger, this is not meaning its each part stronger. 3rd, There is not a model that can fit each industrial innovation system.
Key words: Industrial innovation system, Principal Component Analysis, Indicators

Résumé: Le concept de système d'innovation industriel a été appliqué pour expliquer la capacité de développement industriel. Comment sont la capacité opérationnelle et la performance d'un système d'innovation industriel ? Comment évaluer sa performance ? Ces questions attirent l'attention des savants et des gouverneurs. L'article présent propose un système d'indicateurs et une méthode pour l'évaluation de la performance du système d'innovation industriel. A la suite de l'évaluation de 29 systèmes d'innovation industriels qui appliquent ces indicateurs et méthode, on tire les conclusions suivantes : 1st, De différentes industries ont de différentes capacités opérationnelles. 2nd, Le fait que la capacité synthétique d'un système d'innovation industriel est grande ne signifie pas que chacune de ses parts est forte. 3rd, Il n'y a pas une méthode universelle qui peut s'adapter à touts les systèmes d'innovation industriels.
Mots-Clés: système d'innovation industriel, composante principale d'analyse

1. INTRODUCTION

There is very little innovation system literature about the performance of industrial innovation systems(IIS). There may be several reasons for this. One is certainly the difficulty of measuring performance of industrial innovation system: what indicators should be used? What indicates high or low performance? The second, this requires a lot of data that are difficult to obtain. The last, there is little formal modeling in the industrial innovation system literature. We still lack understanding of how to measure success. There are still much to be done. The purpose of this essay is analyzing the performance of industrial innovation system making use of Principal Component Analysis. For the sake of clarity, only the manufacturing industries will be considered. The paper is organized as follows. We begin with a discussion of the meaning of industrial innovation system. Next, we introduce indicators that can map the performance of industrial innovation system. Third, the method of Principal Component Analysis will be interpreted. The end, we analyze the performance of 29 industrial innovation systems in china.

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2. THE MEANING AND INDICATORS OF INDUSTRIAL INNOVATION SYSTEM

The systems approach to the analysis of economic and technological change is not new. A system may be defined as "a set or arrange of things so related or connected as to form a unity or organic whole". Industrial innovation systems(Breschi and Malerba,1997; Malerba and Orsenigo,1990,1993,1995) are based on the idea that different sectors and industries operate under different technological regimes which are characterized by particular combinations of opportunity and appropriability condition, degrees of cumulativeness of technological knowledge, and characteristics of the relevant knowledge base. Malerba(2002)points out that the industrial innovation system has a specific knowledge base, technologies, inputs and demand. The agents of the industrial innovation system, including individuals and organizations at various levels of aggregation, interact through processes of communication, exchange, co-operation, competition and command. An industrial innovation system undergoes change and transformation through the co-evolution of its various elements. Another system definition is built around the concept of local industrial systems as represented in AnnaLee Saxenian'(1994) study of the electronics industry in Silicom Valley in California and along Route 128 in Massachusetts. Here, the system definition is primarily geographical. The focus is on differences in culture and competition which have led to differences among the two regions in the degree of hierarchy and concentration, experimentation, collaboration, and collective learning which, in turn, have entailed differences in the capacity to adjust to changing circumstances in technology and markets.

An industrial innovation system has a number of different types of actors: firms, organization, policy bodies, venture capitalists, etc. To evaluate the performance of a industrial innovation system, we need choose a number of indicators that is available to measure ability of generation, diffusion and use of knowledge and technology.

We will focus four groups of aspects in the way to mapping and measuring the performance of industrial innovation systems. Those groups are as follows:

1st. Precondition for innovation

We will consider two sorts of innovation preconditions: first market conditions and next industrial foundation. Market conditions include indictors: revenue(X_1), margin(X_2), gross personnel(X_3). Industrial foundation includes indictors: industrial production value(X_4), gross capital(X_5), production value added(X_6).

2nd. Inputs into the system

A good supply of inputs is also a precondition for systems functioning well. We will take five indicators for inputs into the system: R&D personnel(X_7), R&D expenditure(X_8), the expenditure for foreign technology(X_9), the expenditure for absorbing foreign technology(X_{10}), the expenditure for domestic technology(X_{11}).

3rd. System structure

It has been known for long now that the characteristics of an industry affect the direction, nature, ability and intension of innovation. To understand well an industrial innovation system behavior it is pertinent to have information about how the economic activity is distributed among industries with different R&D and knowledge intensities. We will think about five indicators for system structure: the number of enterprises that innovate alone(X_{12}), the proportion of enterprises that innovate alone(X_{13}), the proportion of R&D personnel(X_{14}), the proportion of R&D expenditure(X_{15}).

4th. System outputs

The major outputs of a system have naturally to do with the performance of innovation system but also with diffusion, i.e. with the circulation and spreading of knowledge and new technologies among the different parts of the system. There are three indicators for system outputs: production value of new production(X_{16}), the amount of patent(X_{17}), exports(X_{18}).

3. THE METHOD OF PRINCIPAL COMPONENT ANALYSIS

Main processes:

3.1 constructing data matrix

The number of evaluating object that we suppose is *n*, The number of evaluating indicators is *k*. so we get data matrix *X*.

$$X = \begin{bmatrix} x_{11}x_{12}\ldots x_{1k} \\ x_{21}x_{22}\ldots x_{2k} \\ \ldots\ldots\ldots\ldots \\ x_{n1}x_{n2}\ldots x_{nk} \end{bmatrix}$$

3.2 Standardization of data

$$Z = \left[\tilde{x}_{ij} \right]_{n\times k}$$

其中： $\tilde{x}_{ij} = \dfrac{x_{ij} - \bar{x}_j}{s_j}$

其中：

$$\bar{x}_j = \frac{1}{n}\sum_{i=1}^{n} x_{ij} \quad s_j = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}\left(x_{ij} - \bar{x}_j\right)^2}$$

3.3 Correlation matrix

We can get correlation matrix from standardization matrix Z.

$$R = \left[r_{ij}\right]_{k\times k} = \frac{Z^T Z}{n-1}$$

其中：$r_{ij} = \frac{\sum_{t=1}^{n} Z_{it}.Z_{tj}}{n-1}$ i,j=1,2,…,k

3.4 Computing Eigenvalue

Based on equation of correlation matrix $\left|R - \lambda I_k\right| = 0$,we can get k eigenvalue,

$\lambda_1 \ge \lambda_2 \ge ... \ge \lambda_k \ge 0$.

3.5 Conforming principal component

According to $\sum_{j=1}^{m}\lambda_j \,/\, \sum_{j=1}^{k}\lambda_j \ge 0.85$, we confirm m principal component, based on eigenvalue, from bigger to smaller, we can get m eigenvectors. After standardization, we get linearity combination of each principal component: $F_1, F_2, \ldots F_m$.

3.6 Constructing synthetical evaluating function

Selecting m principal component, we can get synthetical evaluating function: $F = \frac{\lambda_1}{\sum_{i=1}^{m}\lambda_i} F_1 + ... + \frac{\lambda_m}{\sum_{i=1}^{m}\lambda_i} F_m$.

4. ANALYZING THE PERFORMANCE OF 29 INDUSTRIAL INNOVATION SYSTEMS

This section starts with a presentation of a principal component analysis for 29 industrial innovation systems. Table 1 below shows the data of each system indicators. (the sources of data come from china statistics yearbook 2006 and china industry economy statistics yearbook 2006).

4.1 Data processing

After Standardization of data, we can compute correlation coefficient table(see table 2)

We can see that there is stronger relativity between indicators revenue(X_1), industrial production value(X_4), gross capital(X_5), production value added(X_6) from table 2. This shows that there are redundant information between them.

Eigenvalues and variance cumulative see table 3.

4.2 Principal proponent linearity model

From table 3, we can see that the former 3 Eigenvalues cumulative is 89.788%≥85%, so we can take F_1 , F_2 , F_3 place of 18 indicators to evaluating performance of industrial innovation system. After standardization, corresponding indicators coefficient see table 4.

We can get principal component equation from table 4.

$$F_1 = 0.26 X_1 + 0.24 X_2 + 0.18 X_3 + 0.26 X_4 + 0.26 X_5 + 0.26 X_6 + 0.27 X_7 + 0.27 X_8 + 0.26 X_9$$
$$+ 0.25 X_{10} + 0.15 X_{11} + 0.24 X_{12} + 0.13 X_{13} + 0.21 X_{14} + 0.21 X_{15} + 0.26 X_{16} + 0.24 X_{17} + 0.23 X_{18}$$
$$F_2 = -0.24 X_1 - 0.13 X_2 - 0.3 X_3 - 0.23 X_4 - 0.18 X_5 - 0.23 X_6 + 0.08 X_7 + 0.03 X_8 - 0.07 X_9$$
$$+ 0.02 X_{10} - 0.17 X_{11} + 0.14 X_{12} + 0.55 X_{13} + 0.38 X_{14} + 0.4 X_{15} + 0.06 X_{16} + 0.14 X_{17} + 0.02 X_{18}$$
$$F_3 = 0.005 X_1 + 0.27 X_2 - 0.09 X_3 + 0.05 X_4 + 0.2 X_5 + 0.05 X_6 - 0.06 X_7 - 0.09 X_8 - 0.02 X_9$$
$$- 0.28 X_{10} + 0.6 X_{11} - 0.02 X_{12} + 0.24 X_{13} + 0.2 X_{14} + 0.12 X_{15} - 0.12 X_{16} - 0.32 X_{17} - 0.44 X_{18}$$

Principal component synthesizing model F:

$$F = \frac{\lambda_1}{\sum_{i=1}^{m}\lambda_i} F_1 + ... + \frac{\lambda_m}{\sum_{i=1}^{m}\lambda_i} F_m$$

=0.788F1+0.126F2+0.086F3

Among the Model F1, coefficients of X7, X8 and X16 are bigger than others, they are R&D personnel(X7), R&D expenditure(X8) and production value of new production(X16), so we can take F1 as input-output ability. Among the Model F2, coefficients of X13, X14 and X15 are bigger than others, they are the proportion of enterprises that innovate alone(X13), the proportion of R&D personnel(X14), the proportion of R&D expenditure(X15), so we can take F2 as optimizing ability of system structure. Among the Model F3, coefficients of X2 and X5 are bigger than others, they are margin(X2) and gross capital(X5), so we can take F3 as foundation condition of industrial innovation systems.

4.3 Compute synthesizing scores
(for details see table 5).

5. CONCLUSION

This research, based on the methodology of principal component analysis method and system theory, proposes a model and evaluating indicators system of industrial innovation system. We evaluated the performance of 29 industrial innovation systems. Combining the evaluating result and empirical finding, we can conclude:

Different industries have different operating ability and they have different performance.

If synthesizing ability of an industrial innovation system is stronger, this is not meaning its each part stronger.

There is not a model that can fit each industrial innovation system.

Table 1 The data of 29 industrial innovation systems

sector	X_1	X_2	X_3	X_4	X_5	X_6
food processing	10366.49	398.71	2225500	10614.95	5750.69	10614.95
food manufacture	3665.75	206.21	1210200	3779.39	3252.85	3779.39
beverage manufacture	3055.28	221.46	890000	3089.27	3513.79	3089.27
tobacco manufacture	2850.84	406.54	196700	2840.74	3261.78	2840.74
textile	12374.53	437.13	5909600	12671.65	10357.97	12671.65
costume shoes and cap manufacture	4780	206.16	3460600	4974.63	3188.77	4974.63
leather fur and feather and their goods	3315.94	138.5	2288400	3462.79	1955.44	3462.79
wood process and bamboo gross goods	1749.45	82.43	833300	1827.71	1338.73	1827.71
furniture manufacture	1387.39	61.89	712700	1427.26	1032.78	1427.26
paper making and paper goods	4034.25	194.04	1301400	4161.33	4660	4161.33
printing and intermediary	1386.55	93.19	669000	1442.96	1772.83	1442.96
culture and education manufacture	1437.53	52.47	1098000	1482.5	1014.56	1482.5
oil processing	12030.52	-119.27	744000	12000.49	6490.77	12000.49
chemical material and goods manufacture	16165.21	991.06	3399900	16359.66	15175.85	16359.66
medicine manufacture	4019.83	338.2	1234400	4250.45	5549.83	4250.45
chemical fiber manufacture	2567	46.2	426300	2608.39	2461.41	2608.39
rubber manufacture	2144.22	105.19	796400	2196.74	1956.28	2196.74
plastic manufacture	4944.73	215.79	1832800	5067.89	4432.38	5067.89
nonmetal mineral goods	8846.49	420.35	4181800	9195.24	10370.69	9195.24
black metal smelting and processing	21594.05	1067.44	2874900	21470.98	18950.65	21470.98
coloured metal smelting and processing	7845.56	426.83	1307400	7937.95	6569.49	7937.95
metal manufacture	6394.35	314.23	2232300	6556.76	4769.27	6556.76
standard equipment manufacture	10197.83	625.26	3551200	10610.37	9886.06	10610.37
special equipment manufacture	5932.97	324.65	2198900	6085.43	6391.13	6085.43
transportation equipment manufacture	15562.6	664.01	3524000	15714.86	16108.05	15714.86
electric machine and equipment manufacture	13363.92	640.17	3672100	13901.29	11062.69	13901.29
communication equipment and computer manufacture	26844.02	891.69	4396400	26994.38	18063.24	26994.38
instrument and official machine manufacture	2735	154.35	886800	2781.05	2226.09	2781.05
craftwork and other manufacture	1969.7	90.82	1255100	2035.68	1365.98	2035.68

Table 2 Correlation Matrix

Table 2-a

	x1	x2	x3	x4	x5	x6	x7	x8	x9
x1	1.000	.835	.697	1.000	.953	1.000	.829	.866	.879
x2	.835	1.000	.654	.838	.908	.838	.760	.777	.751
x3	.697	.654	1.000	.708	.724	.708	.618	.563	.458
x4	1.000	.838	.708	1.000	.954	1.000	.832	.866	.874
x5	.953	.908	.724	.954	1.000	.954	.850	.853	.843
x6	1.000	.838	.708	1.000	.954	1.000	.832	.866	.874
x7	.829	.760	.618	.832	.850	.832	1.000	.968	.891
x8	.866	.777	.563	.866	.853	.866	.968	1.000	.954
x9	.879	.751	.458	.874	.843	.874	.891	.954	1.000
x10	.801	.650	.486	.801	.728	.801	.884	.948	.917
x11	.595	.673	.269	.588	.686	.588	.442	.500	.602
x12	.692	.725	.714	.702	.767	.702	.872	.781	.601
x13	.197	.368	.009	.200	.305	.200	.489	.410	.278
x14	.556	.561	.163	.554	.609	.554	.774	.733	.687
x15	.483	.568	.290	.486	.583	.486	.800	.753	.622
x16	.801	.675	.529	.802	.793	.802	.960	.969	.919
x17	.695	.593	.543	.702	.657	.702	.878	.894	.749
x18	.708	.521	.479	.710	.590	.710	.794	.865	.813

Table 2-b

	x10	x11	x12	x13	x14	x15	x16	x17	x18
x1	.801	.595	.692	.197	.556	.483	.801	.695	.708
x2	.650	.673	.725	.368	.561	.568	.675	.593	.521
x3	.486	.269	.714	.009	.163	.290	.529	.543	.479
x4	.801	.588	.702	.200	.554	.486	.802	.702	.710
x5	.728	.686	.767	.305	.609	.583	.793	.657	.590
x6	.801	.588	.702	.200	.554	.486	.802	.702	.710
x7	.884	.442	.872	.489	.774	.800	.960	.878	.794
x8	.948	.500	.781	.410	.733	.753	.969	.894	.865
x9	.917	.602	.601	.278	.687	.622	.919	.749	.813
x10	1.000	.311	.677	.330	.633	.638	.903	.889	.960
x11	.311	1.000	.273	.181	.434	.401	.453	.182	.117
x12	.677	.273	1.000	.598	.652	.787	.750	.818	.608
x13	.330	.181	.598	1.000	.836	.809	.388	.446	.254
x14	.633	.434	.652	.836	1.000	.860	.735	.627	.525
x15	.638	.401	.787	.809	.860	1.000	.735	.733	.540
x16	.903	.453	.750	.388	.735	.735	1.000	.876	.818
x17	.889	.182	.818	.446	.627	.733	.876	1.000	.885
x18	.960	.117	.608	.254	.525	.540	.818	.885	1.000

Table 3 Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	12.737	70.760	70.760	12.737	70.760	70.760
2	2.040	11.336	82.096	2.040	11.336	82.096
3	1.385	7.692	89.788	1.385	7.692	89.788
4	.934	5.186	94.974			
5	.322	1.787	96.761			
6	.208	1.156	97.917			
7	.120	.666	98.583			
8	.106	.591	99.174			
9	.066	.364	99.538			
10	.035	.196	99.735			
11	.019	.105	99.839			
12	.014	.078	99.917			
13	.006	.034	99.951			
14	.005	.028	99.980			
15	.002	.013	99.992			
16	.001	.008	100.000			
17	1.91E-005	.000	100.000			
18	-7.23E-019	-4.01E-018	100.000			

Extraction Method: Principal Component Analysis.

Table 4 Corresponding indicator coefficient

	Factor 1	Factor 2	Factor 3
x1	0.26	-0.24	0.05
x2	0.24	-0.13	0.27
x3	0.18	-0.3	-0.09
x4	0.26	-0.23	0.05
x5	0.26	-0.18	0.2
x6	0.26	-0.23	0.05
x7	0.27	0.08	-0.06
x8	0.27	0.03	-0.09
x9	0.26	-0.07	-0.02
x10	0.25	0.02	-0.28
x11	0.15	-0.17	0.6
x12	0.24	0.14	-0.02
x13	0.13	0.55	0.24
x14	0.21	0.38	0.2
x15	0.21	0.4	0.12
x16	0.26	0.06	-0.12
x17	0.24	0.14	-0.32
x18	0.23	0.02	-0.44

Table 5 Synthesizing scores of 29 industrial innovation system

Industry	F1 score	ranking	F2 score	ranking	F3 score	ranking	F score	ranking
food processing (I1)	-1.12	13	-1.91	27	0.02	11	-1.12	16
food manufacture (I2)	-2.13	23	-0.08	13	-0.25	18	-1.71	22
beverage manufacture (I3)	-1.8	17	0.69	9	0.001	12	-1.33	17
tobacco manufacture(I4)	-1.57	16	1.88	4	1.11	4	-0.9	13
textile(I5)	0.97	8	-2.25	28	-0.15	14	0.47	9
costume shoes and cap manufacture(I6)	-2	20	-1.45	25	-0.66	24	-1.82	23
leather fur and feather and their goods (I7)	-2.71	24	-1.2	24	-0.77	26	-2.35	25
wood process and bamboo gross goods(I8)	-3.01	27	-0.16	15	-0.57	23	-2.44	26
furniture manufacture(I9)	-3.24	29	-0.41	19	-0.76	25	-2.67	29
paper making and paper goods(I10)	-1.98	19	-0.3	18	-0.19	17	-1.61	21
printing and intermediary(I11)	-3.01	28	-0.23	17	-0.52	21	-2.44	27
culture and education manufacture(I12)	-2.99	26	-0.18	16	-0.81	28	-2.45	28
oil processing(I13)	-1.04	12	-0.83	22	-0.05	13	-0.93	14
chemical material and goods manufacture(I14)	3.53	5	-0.97	23	1.28	3	2.77	5
medicine manufacture(I15)	0.65	9	3.16	1	1.29	2	1.02	8
chemical fiber manufacture(I16)	-2.02	21	1.5	5	0.2	10	-1.39	18
rubber manufacture(I17)	-2.1	22	1.01	7	-0.17	16	-1.54	19
plastic manufacture(I18)	-1.91	18	-0.64	21	-0.33	20	-1.61	20
nonmetal mineral goods(I19)	-0.05	11	-1.59	26	-0.15	15	-0.26	11
black metal smelting and processing(I20)	5.35	3	-3.08	29	3.85	1	4.16	3
coloured metal smelting and processing(I21)	0.08	10	0.53	11	0.71	7	0.19	10
metal manufacture(I22)	-1.15	14	-0.54	20	-0.3	19	-1	15
standard equipment manufacture(I23)	2.68	6	0.69	10	0.3	8	2.23	6
special equipment manufacture(I24)	1.05	7	2.32	2	0.74	6	1.18	7
transportation equipment manufacture(I25)	7.01	2	1.24	6	0.88	5	5.75	2
electric machine and equipment manufacture(I26)	4.58	4	0.77	8	-0.79	27	3.64	4
communication equipment and computer manufacture(I27)	12.08	1	0.08	12	-3.66	29	9.22	1
instrument and official machine manufacture(I28)	-1.35	15	2.06	3	0.28	9	-0.78	12
craftwork and other manufacture(I29)	-2.83	25	-0.12	14	-0.52	22	-2.29	24

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