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Research on the Performance Evaluation of the Regional Integration of Information and Industrialization Based on Factor Analysis and DEA

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The integration of informatization and industrialization is the inevitable choice of the road to new industrialization with Chinese characteristics, and is the inherent requirement of the transformation of economic development mode. It constructs the regional integration efficiency evaluation index system of inputs and outputs. Then, it uses factor analysis and DEA to carry out the empirical research to evaluate the regional efficiency of the fusion of information and industrialization integration. It provides ideas for the evaluation of the regional process of the integration of informatization and industrialization.

1. Introduction

In today's world, a new round of technological revolution and industrial revolution is being bred. And informatization has become a prominent feature of the world economic and social development. Giving industrial development the characteristics of the era of the information technology can promote the integration of informatization and industrialization in order to break the bottleneck of the development. Then we can achieve industrial restructuring and upgrading and promote the simultaneous development of the four modernizations. It has become a significant feature of the new path of industrialization with Chinese characteristics. In this context, the integration of informatization and industrialization has been carried out in China in order to speed up the development of social economy. With the advance of the integration of informatization and industrialization, the evaluation of the integration process of the integration of informatization and industrialization has been a hot research topic.

Scholars have studied on the evaluation of the integration of informatization and industrialization from different perspectives. Gong Bingzheng (2010) constructed a three degree evaluation model, which is composed of fusion environment, the level of integration and the benefit of integration. Hu Xin, Hui Tiaoyan and Liang Siyu (2011) analyzed the social environment for the integration of informatization and industrialization, and used the factor analysis to evaluate provinces' social environment of China. Wang Xiwei, Du Hao and Zheng Jianming (2011) discussed functional positioning and demand analysis of the measurement index system of the integration of informatization and industrialization, and they analyzed the theoretical basis of the establishment of the measurement index system from the perspective of scientific development, market economics, system engineering and industrial economics. Xie Kang et al. (2012) analyzed panel data of 31 provinces in China from the year of 2000 to 2009 by using stochastic frontier analysis method to discuss the quality of integration of Chinese informatization and industrialization. Zhi Yan, Bai Xuejie and Wang Leilei (2012) studied the degree of integration and its change characteristics of 15 major industries of the manufacturing industry on the basis of the input-output table of 2000-2007. Zhang Yilong and Cui Qiang (2013) used the cross efficiency evaluation model of the benevolent DEA to evaluate the efficiency of integration of industrialization and informatization in China from the year of 1997 to 2010. Zhang Yuke and Zhang Chunling (2013) discussed the development stage of Chinese regional integration of regional integration of informatization and industrialization by using analytic hierarchy process and fuzzy comprehensive evaluation method. Liu Liqiang and Feng Junwen (2014) evaluated the integration level of informatization and industrialization based on rough sets and neural network. In summary, the focus of the

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research has focused on the assessment of the development of the integration of informatization and industrialization. The input and output efficiency issues of the integration of informatization and industrialization need to been strengthened. In this paper, we use factor analysis and DEA to evaluate the performance of the regional integration of informatization and industrialization.

2. Research method

2.1 Factor analysis

Factor analysis is a data reduction method. It can describe a set of observable variables by a small number of common factors. The aim is to explain the correlation between the original variables. The dimension and structure of the variables can also be simplified.

Factor analysis can be expressed as:

$$\begin{aligned} X_1 &= a_{11}F_1 + a_{12}F_2 + \cdots + a_{1q}F_q + \varepsilon_1 \\ X_2 &= a_{21}F_1 + a_{22}F_2 + \cdots + a_{2q}F_q + \varepsilon_2 \\ &\cdots \\ X_p &= a_{p1}F_1 + a_{p2}F_2 + \cdots + a_{pq}F_q + \varepsilon_p \end{aligned} \tag{1.1}$$

$X_1, X_2, \cdots, Xp$ are the original variables. $F_1, F_2, \cdots, F_q$ ($q \le p$) are common factors. And equation (1.1) can be denoted as matrix form:

$$X = AF + \varepsilon \tag{1.2}$$

$A = \left(a_{ij}\right)_{p*q}$ is the factor load matrix, and a_{ij} is the load of the variable i on the factor j , and the value of a_{ij} means the dependence of X_i on the common factor F_j .

2.2 DEA

Data Envelopment analysis (DEA) is a non parametric method for evaluating the decision making units (DMU), which is based on the relative efficiency of the same type of DMU with the same inputs and outputs. The DEA CCR model with constant returns to scale is originated in the late 1970s (Charnes, Cooper and Rhodes (1978)). For any decision making unit DMU_0, the CCR model can be expressed as a formula (1.3):

$$Min\left[\theta - \varepsilon\left(e^T s^- + e^T s^+\right)\right]$$

$$\text{s.t.} \begin{cases} \sum_{j=1}^{n} X_j \lambda_j + s^+ = \theta X_0 \\ \sum_{j=1}^{n} X_j \lambda_j - s^- = Y_o \\ s^+ \ge 0, s^- \ge 0, \lambda_j \ge 0 \\ j = 1, 2, \cdots, n \end{cases} \tag{1.3}$$

N is the number of decision units. $X_i = \left(x_{1i}, x_{2i}, \cdots, x_{mi}\right)^T$ is the input vector, and $Y_j = \left(y_{1j}, y_{2j}, \cdots, y_{sj}\right)^T$ is the output vector. θ is the effective values of the DMU_0. In the case of $\theta = 1$ and $s^- = s^+ = 0$, then the decision making unit is DEA effective, which is located on the production frontier. If, however, the decision unit is weak DEA effective; if the decision unit is non DEA effective. If $\theta = 1$, but $s^- \ne 0$ or $s^+ \ne 0$, the decision unit is weak DEA effective. If $\theta < 1$, the decision unit is non DEA effective. The results of this DEA model may appear more than one effective decision making unit at the same time. Andersen and Petersen (1993)proposed the super efficiency DEA model, which mainly considers the efficiency of decision making units relative to other units. Compared with other DEA models, the reference set constructed by this model doesn't include the decision making unit itself which is being evaluated. The evaluation results obtained by the model may be more than 1, which can give a further analysis of those decision making units which are DEA effective.

3. Empirical analyses

3.1 Variable and data source

3.1.1 Variable processing

Using DEA method to carry out performance evaluation, the choice of input output indicators are very important. The input of regional integration of informatization and industrialization includes three aspects: human resources investment, capital investment and information environment. Based on the research results of previous researchers, number of Internet users per thousand, telephone penetration rate, percentage of R&D active personnel to scientific and technical personnel, percentage of total social R&D expenditure to

GDP, percentage of government technology grants to financial expenditure, percentage of corporate R&D funds to sales revenue, industrial fixed asset investment is selected as the input indicators. The information environment is reflected by number of Internet users per thousand and telephone penetration rate. Percentage of R&D active personnel to scientific and technical personnel reflects human resources investment. The rest of input indicators can describe capital investment.

The integration of informatization and industrialization is the only way to realize the new type of industrialization, and output indicators should be able to reflect the characteristics of new type of industrialization. So high-tech industry output value, percentage of high-tech industry output value to industrial output value above designated size, contribution of high-tech industry to the growth of industrial output value, number of patents authorized per 100 thousand population, labor productivity, newly increased GDP per 100 million yuan investment, amount of industrial dust per 100 million yuan GDP is selected as the output indicators. The output indicators of DEA are generally positive. But amount of industrial dust per 100 million yuan GDP is a reverse indicator. So we can change our thinking, and take its' reciprocal as an indicator to replace itself with the same name. High-tech industry output value, percentage of high-tech industry output value to industrial output value above designated size, contribution of high-tech industry to the growth of industrial output value reflects the industrial structure optimization and strategic industry development caused by the integration of informatization and industrialization. Number of patents authorized per 100 thousand population shows technological innovation generated by the integration of informatization and industrialization. Labor productivity and newly increased GDP per 100 million yuan investment means the economic growth and efficiency increased by the integration of informatization and industrialization. The last indicator can describe benefit of conserving energy and reducing emissions.

3.1.2 Data source

This paper takes 13 cities in Jiangsu Province as the research sample. The original data is taken from *Jiangsu statistical yearbook 2014*, *China urban statistical yearbook 2014* and statistical bulletin of the national economic and social development of the cities in 2013.

3.2 Factor analysis of input-output indicators

Using DEA method, it is generally required that the number of decision units is more than 2 times the sum of the input and output indicators. Therefore, factor analysis of the input and output indicators are carried out in order to generate the public factors of input and output indicators.

The input indicators are tested by KMO and Bartlett's test. The KMO value is 0.717 (greater than 0.6), and the significance of the Bartlett's test is 0. So the input indicators are suitable for factor analysis. Two common factors are obtained by using SPSS17.0 statistical analysis software for factor extraction. The characteristic value of those common factors is more than one, and the cumulative variance contribution is 87.214%. Then the varimax orthogonal rotation method is used to carry out the orthogonal rotation. The specific results are shown in Table 1.

Table 1: Rotated Component Matrix of Input Indicators

Input Indicators	Common Factors	
	1	2
number of Internet users per thousand percentage of R&D active personnel to scientific and technical personnel	.975	-.126
	.012	.992
percentage of total social R&D expenditure to GDP	.945	-.009
percentage of government technology grants to financial expenditure	.902	.092
percentage of corporate R&D funds to sales revenue	.815	.387
telephone penetration rate	.986	-.066
industrial fixed asset investment	.787	.179

The output indicators are tested by KMO and Bartlett's test. The KMO value is 0.728(greater than 0.6), and the significance of the Bartlett's test is 0. So the output indicators are suitable for factor analysis. Two common factors are obtained by using SPSS17.0 statistical analysis software for factor extraction. The characteristic

value of those common factors is more than one, and the cumulative variance contribution is 83.371%. Then the varimax orthogonal rotation method is used to carry out the orthogonal rotation. The specific results are shown in Table 2.

Table 2: Rotated Component Matrix of Output Indicators

Output Indicators	Common Factors	
	1	2
high-tech industry output value	.852	.257
number of patents authorized per 100 thousand population	.956	.063
percentage of high-tech industry output value to industrial output value above designated size	.753	.356
labor productivity	.919	.116
newly increased GDP per 100 million yuan investment	-.005	.960
contribution of high-tech industry to the growth of industrial output value	.906	-.232
amount of industrial dust per 100 million yuan GDP	.680	.561

According to table 1 and table 2, the two common factors of input indicators are named as environment-capital factor and human resource factor, and they are chosen to be input indicators of DEA. The two common factors of output indicators are named as technology industry factor and economic benefit factor, and they become the output indicators of DEA. So data dimension reduction of the input-output indicators is realized, and the majority of the original variables are preserved. The score of each common factor obtained by factor analysis may be negative, and this will let DEA can't be carried out. So we need to change the common factor score to the [1, 10] range by range variation method. The results are shown in table 3.

Table 3: Input-output Indicators after Normalized Treatment

No.	DMU	Input Indicator		Output Indicator	
		Environment-capital Factor	Human Resource Factor	Technology Industry Factor	Economic Benefit Factor
1	Nanjing	9.588048	3.369164	5.23718	7.167177
2	Wuxi	8.663575	8.166563	10	1
3	Xuzhou	2.354453	5.877397	3.354564	3.582459
4	Changzhou	7.771877	5.069272	6.140033	3.60154
5	Suzhou	10	3.120642	9.584729	8.706842
6	Nantong	5.510492	7.924185	5.316609	5.683834
7	Lianyungang	1.614193	5.95801	3.003389	2.263217
8	Huaian	1	2.281211	1.469949	6.56686
9	Yancheng	2.555297	10	2.379647	6.268364
10	Yanzhou	4.677524	1	4.252489	9.180537
11	Zhenjiang	5.409859	3.626699	5.048587	8.761562
12	Taizhou	3.355262	2.089535	3.824294	10
13	Suqian	1.005165	3.6682	1	2.424439

3.3. DEA evaluation and results analysis

Based on input oriented CCR model and super efficiency model, the input and output data of table 3 are calculated by the EMS1.3 software. And the performance evaluation results are shown in table 4.

Table 4: Results of the performance evaluation of the Integration of Informatization and Industrialization

No.	DMU	Value of CCR	Ranking	Value of Super Efficiency	Ranking
1	Nanjing	55.36%	13	55.36%	13
2	Wuxi	95.01%	6	95.01%	6
3	Xuzhou	90.18%	7	90.18%	7
4	Changzhou	68.89%	10	68.89%	10
5	Suzhou	99.37%	5	99.37%	5
6	Nantong	72.47%	9	72.47%	9
7	Lianyungang	100%	1	126.58%	3
8	Huaian	100%	1	220.34%	1
9	Yancheng	56.79%	12	56.79%	12
10	Yanzhou	100%	1	207.26%	2
11	Zhenjiang	81.08%	8	81.08%	8
12	Taizhou	100%	1	111.36%	4
13	Suqian	59.86%	11	59.86%	11

It can be seen that the result of CCR model is the same as that of super efficiency model when the value is less than 1.in table 4. And more information can be obtained from super efficiency model. According to the evaluation results, there are 4 cities which are DEA effective. According to the super efficiency value from big

to small, they are Huaian, Yangzhou, Lianyungang and Taizhou in turn. The efficiency value of Wuxi, Xuzhou and Suzhou is in [0.9, 1]. The efficiency value of Zhenjiang and Nantong is in [0.7, 0.9). The efficiency value of the rest is low than 0.7.

In general, the performance of the integration of informatization and industrialization in Jiangsu is not very good. There aren't many DEA effective cities, accounting for only about 30% of the total cities. Most cities are not DEA effective. From the spatial distribution, DEA effective cities are concentrated in Central Jiangsu and North Jiangsu. The cities in South Jiangsu are in the state of DEA invalid, and the average value of the super efficiency in South Jiangsu is 79.94%. The average value of the super efficiency in Central Jiangsu and South Jiangsu is 130.36% and 110.75% respectively. South Jiangsu is the most economically developed region in Jiangsu, and the low performance value indicates that South Jiangsu needs to focus on input-output efficiency.

4. Conclusions

In this paper, we make an empirical study on the performance of regional integration of informatization and industrialization by using the combination evaluation method based on factor analysis and DEA. The results show that the efficiency of the integration of informatization and industrialization is to be further improved. A lot of resources are used in the process of informatization and industrialization. In order to further improve the efficiency of resource allocation and production efficiency, we need to focus on the input-output efficiency. In this way, we can achieve the target of building a resource-saving and environment-friendly society.

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