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Shanghai Industrial Enterprise R&D Development Level and Allocation Efficiency Research

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Abstract: *In the process of shanghai economy rapidly development, industrial enterprises play a important role, with the industrials upgrade and replacement, R&D gradually become a decisive factor to promote the development of the industry. In this paper, whole Shanghai districts are recommended to study. In order to make the result more comprehensive and accurate, the paper quote factor analysis and DEA method, separately calculates development level on R&D and allocation efficiency, and finally through the introduction of the Boston matrix to clearly reflect every districts development situation. Finally, according to different districts situation put forward targeted suggestions.*

Keywords: *Industrial enterprise, R&D, Allocation efficiency, DEA*

1. Introduction

Shanghai industrial is in the critical moment of transformation, R&D as an important index of industrial enterprises development. While industrial development process R&D index must be concentrated on study. Donglin Han, Qiongzhi Zhang and other scholars mainly through the DEA algorithm to measure and contrast the national 31 provinces industrial enterprise R&D input and output efficiency ; Miao Wang by using stochastic frontier production function (SFA) to study on the R&D of Shaanxi province. Shanghai Bureau of statistics Yu Song mainly uses the method of dynamic contrast Shanghai and Beijing in horizontal. Wei Zhang, Jun Cheng get R&D and GDP together, using the gray system theory to study. Through a great deal of discovered literature reading, found that current research of R&D is mainly concentrated on the level of inquiry and the allocation efficiency study, the relationship between R&D development and allocation efficiency has not yet been carried out. This paper mainly through the query "statistical yearbook of Shanghai" and "Shanghai statistical yearbook on science and technology", trying to establish a unified index system as far as possible to eliminate the error, use the factor analysis to evaluate the development level of R&D of every Shanghai district. based on the method of cluster analysis to rank hierarchy. DEA algorithm is used to evaluate the R&D allocation efficiency of each district in Shanghai , eventually by the Boston matrix to display factor results and DEA results, according to located area some suggestions will put forward[1].

2. Index System Construction and Data Process

In order to accurately analysis each district of Shanghai industrial enterprises R&D development level, Based on scientific, comprehensive, operational principles of index system construction, after repeated screening, Having selected the following ten economic indicators (Among X11 is an auxiliary calculation item).

X1 -- R&D employment (person)

X2 -- R&D expenditure (RMB)

X3 -- the number of patent applications (Piece)

X4 -- the number of scientific papers published (articles)

X5 -- new product sales (10000 RMB)

X6 -- R&D employment accounted for industrial enterprises in total employment (percent)

X7 -- R&D employment R&D per capita expenditure (RMB / person)

X8 -- R&D the number of patent applications per capital (Piece / person)

X9 -- R&D per capita technology the number of published papers (articles)

X10 -- R&D personnel per capital new product sales revenue (10000 RMB / person)

X11 -- Reflection of industrial enterprises in total employment (person)

All the above indicators data from the "Shanghai city science and Technology Statistics Yearbook 2012", and after the operation to obtain the data in table 1[2]. (The data in this table are based on the statistical data of Industrial Enterprises above designated size.)

Table1. *The districts of Shanghai Industrial Enterprises above Designated Size of each index statistics*

Index / District	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11
Huangpu	1147	25205.2	97	133	683035.9	0.055	21.975	0.085	0.116	595.498	21016
Xuhui	3761	104958.0	494	216	937862.4	0.075	27.907	0.131	0.057	249.365	50021
Changning	377	11205.5	110	28	163564.6	0.033	29.723	0.292	0.074	433.858	11384
Jingan	7	224.1	16	4	82086.2	0.005	32.014	2.286	0.571	11726.600	1298
Putuo	1360	24956.2	138	73	648365.0	0.039	18.350	0.101	0.054	476.739	34675
Zhabei	2437	135165.3	178	49	488038.1	0.110	55.464	0.073	0.020	200.262	22184
Hongkou	564	13481.6	118	12	113242.0	0.043	23.904	0.209	0.021	200.784	13199
Yangpu	3337	115148.9	254	156	4467676.4	0.091	34.507	0.076	0.047	1338.830	36630
Minhang	14281	484027.6	2884	362	7590199.6	0.041	33.893	0.202	0.025	531.489	351825
Baoshan	6738	546883.4	1751	722	4550291.4	0.053	81.164	0.260	0.107	675.318	128060
Jiading	11309	357951.9	1525	179	16117087.8	0.032	31.652	0.135	0.016	1425.156	348084
Pudong	28896	1094197.9	5817	803	31417557.8	0.044	37.867	0.201	0.028	1087.263	662861
Jinshan	4757	86295.8	1451	85	1198963.1	0.033	18.141	0.305	0.018	252.042	142279
Songjiang	11003	202926.3	1928	85	3491834.0	0.027	18.443	0.175	0.008	317.353	414420
Qingpu	4216	81150.4	1326	67	1562199.4	0.020	19.248	0.315	0.016	370.541	209291
Fengxian	4998	123785.7	1120	73	2567161.6	0.026	24.767	0.224	0.015	513.638	194884
Chongming	1110	30062.8	158	14	1642787.0	0.022	27.084	0.142	0.013	1479.988	51321

3. Each District of Shanghai Industrial Enterprises R&D Development Level Calculation

By using statistical analysis software SPSS16.0 for data processing, can output the corresponding results, the analysis results are as follows:

3.1. Factor Analysis Application Test

Table 2 shows the KMO value is 0.615, according to Kaiser has given KMO metrics (greater than 0.5) that know the primitive variables are suitable for factor analysis. Bartlett 's test of sphericity statistic observation value is 259.997, the corresponding P value close to the 0 reveal that there is a strong correlation between variables, suitable for factor analysis.

Table2. *KMO and Bartlett's Test*

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.615
Bartlett's Test of Sphericity	Approx. Chi-Square	259.997
	df	45
	Sig.	0.000

3.2. Characteristic Value Selection and Main Factor Determine

Table3. *The rotated factor loading matrix, Characteristic value, contribution rate, the total contribution rate statistics.*

Index	First main factor F1 R&D basis and total input-output	Second factor F2 R&D resource allocation factor	Third factor F3 R&D output capacity factor
X1	0,972	-0.129	0
X2	0.971	0	0.229
X3	0.974	-0.101	0
X4	0.843	0	0.439
X5	0.936	0	0
X6	-0.135	-0.412	0.753
X7	0.253	0.146	0.894
X8	0	0,978	-0.120
X9	-0.144	0.973	0
X10	0	0.976	0
Characteristic value	4.535	3.081	1.641
Contribution rate	45.354%	30.815%	16.408%
Total contribution rate	45.354%	76.169%	92.577%

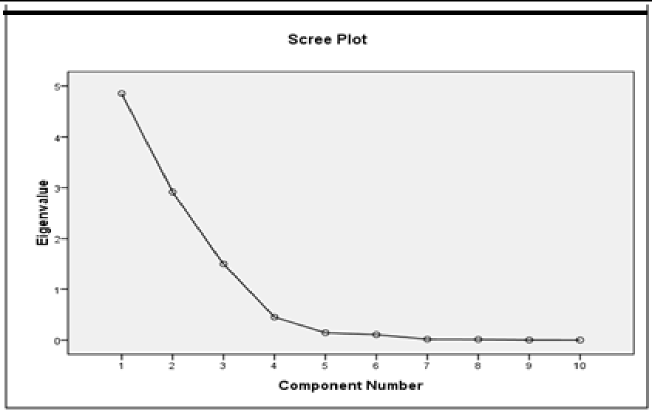

Fig1. *Stone figure index*

Select the feature values greater than 1 as the standard to choose factors. It can be seen from table 3, the former three factors characteristic value of the cumulative contribution rate achieve 92.577%, three main factors include the basic information of all the total ten index. In order to facilitate the explanation of factor, using the varimax method to make the difference between factors variance maximum, rotation results in Table 3, the main component of screen plot and the load scatter figure 1and figure 2.

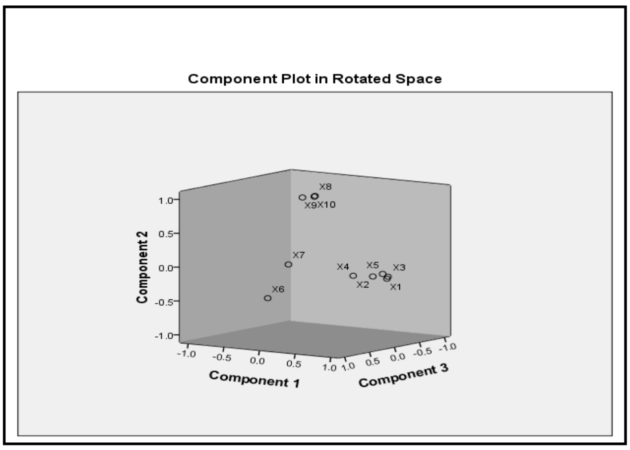

Fig 2. *Index load scatter*

From above tables and figures we delimit factors as follows : (1) index X1, X2,X3, X4, X5 have high load on the first main factor, and from different point of view to reflect R&D activity based situation and the total level of input and output ,so it can be referred to as basis R&D activity and total factor input and output; (2) index X8,X9, X10 have high load in the second main factors, and reflected the R&D personnel and per capital output, so we call it the R&D output capacity factor; (3)index X6, X7 have high load on the third main factors, and reflect the R&D resource allocation situation, so we call it the R&D resource allocation intensity factor.

3.3. Factor Score and Total Evaluation Score

The three main factors are respectively using the default regression analysis to calculate the score, and according to the main factor contribution to whole information rate, using the weights of a linear weighted contribution rate of three main factors to obtain the synthesis score, the formula: Z=45.354%*F1+30.815%*F2+16.408%*F3; three main factor score, ranking and the comprehensive factor score (Z) ,and the overall ranking in table 4:

Table4. *Factor score, the total evaluation score and ranking*

District	**First main factor F1 R&D basis and total input-output**		**Second factor F2 R&D resource allocation factor**		**Third factor F3 R&D output capacity factor**		**Comprehensive factor Z**	
	Score	Rank	Score	Rank	Score	Rank	Score	**Rank**
Huangpu	-0.637	14	-0.231	8	0.003	5	-0.360	**13**
Xuhui	-0.451	10	-0.407	16	0.557	4	-0.238	**9**
Changning	-0.665	15	-0.110	4	-0.223	8	-0.372	**14**
Jingan	-0.449	9	3.792	1	-0.297	9	0.916	**2**
Putuo	-0.603	13	-0.366	13	-0.510	12	-0.470	**16**
Zhabei	-0.791	17	-0.507	17	2.049	2	-0.179	**7**
Hongkou	-0.708	16	-0.397	14	-0.314	10	-0.495	**17**
Yangpu	-0.494	11	-0.357	12	1.014	3	-0.168	**6**
Minhang	0.954	2	-0.196	6	-0.089	7	0.358	**4**
Baoshan	0.690	4	0.422	2	2.481	1	0.850	**3**
Jiading	0.702	3	-0.163	5	-0.444	11	0.195	**5**
Pudong	3.269	1	0.020	3	-0.078	6	1.476	**1**
Jinshan	-0.192	8	-0.337	11	-0.801	15	-0.322	**11**
Songjiang	0.249	5	-0.406	15	-1.054	17	-0.185	**8**
Qingpu	-0.182	7	-0.266	9	-1.003	16	-0.329	**12**
Fengxian	-0.152	6	-0.285	10	-0.693	14	-0.271	**10**
Chongming	**-0.540**	**12**	**-0.204**	**7**	**-0.599**	**13**	**-0.406**	**15**

3.4. Development Level Cluster Analysis

Employing WARD (deviation square method) to separate comprehensive factor score, In accordance with the industrial enterprises R&D development levels to divide 17 districts of Shanghai into four categories, as shown in table 5:

Table5. *Shanghai industrial enterprises R&D development level classification*

Category	**District**
Category 1	Pudong
Category 2	Jingan、Baoshan
Category 3	Minhang、Jiading、Yangpu、Zhabei、Songjiang、Xuhui、Fengxian
Category 4	Jinshan、Qingpu、Huangpu、Changning、Chongming、Putuo、Hongkou

3.5. Analysis of Results and Suggestions

The first class of area is Pudong New Area, it is of the highest development level of R&D in industrial enterprises of Shanghai. As a comprehensive reform of the earliest test area, with excellent geographical advantage, economic conditions and policy environment, many foreign enterprise center, the earlier contact overseas and high technology, variety and quantity of production of high-tech products ranked first in Shanghai and even the whole country. Which we can see that the R&D foundation and the input-output gross factor in Shanghai is ranking first, R&D factor intensity of resource allocation is ranked the third ,but the R&D output capacity factor was ranked sixth, shows that the Pudong New Area in the output capacity should be further strengthened.

Second types of area includes Jingan and Baoshan districts. These areas belong to industrial enterprises higher development level of R&D . Definitely we can see that Jingan district is a very special district, R&D activity and total factor based input and output and R&D output ability factor are ranked ninth in Shanghai, however the R&D resource allocation intensity factor has reached the extreme, ranking first. Three aspects of Baoshan district are top, wherein the output factor ranking first. For Baoshan district needs to maintain a steadily good momentum. And although Jingan district comprehensive ranking second, whereas its own shortage is clearly visible, it must be strengthened in the basis R&D development situation and total factor input and output and R&D output capacity factors in the future.

Third types of area contains Minhang, Jiading, Yangpu, Zhabei, Songjiang, Xuhui and Fengxian districts. This kind of area belongs to industrial enterprise R&D medium level .In this category we can see the development of Minhang and Jiading two districts have a comparative balance, the indicators are ranked relatively former. The R&D output capacity in Yangpu, Zhabei, and Xuhui districts are ranked two ,three and four in turn. While the other two districts indicators are relatively ranked low, and later need to strengthen. Especially the Zhabei district R&D input-output fundamental resource factor and R&D allocation intensity factor both ranking final in Shanghai. Songjiang and Fengxian districts basic configuration level is very high, but the output factor ranking behind, which Songjiang district output capacity is the worst.

The fourth kinds of area include Jinshan, Qingpu , Huangpu, Changning, Chongming, Putuo and Hongkou districts. This kind of area three factors were relatively ranked low, in addition Changning district R&D resource allocation ranked fourth, no other index ranking former. So for such area should seize the favorable opportunity, and vigorously to create R&D foundation conditions, and on the basis of the efficient allocation of resources. Or make good use of the national challenge transformation and development.

4. Each District of Shanghai Industrial Enterprises R&D Comprehensive Allocation Efficiency Determination

4.1. Data Index Screening and Preparation

In order to compare the development level and allocation efficiency, reduce the error brought by the different index selection, so it takes same system of index. The calculation process take the first factor in R&D factor analysis input and output as the research target. In order to apply to software, the two index R&D expenditure and new product sales revenue units transform into ten millions RMB. Get table 6 index data into C^2R and C^2GS^2 model, using the LIP software to obtain the R&D resource allocation efficiency, the comprehensive efficiency θ*, technical efficiency δ*, and the return scale efficiency η*. as shown in table 7.

Table6. *Each district of Shanghai industrial enterprises R&D input-output data*

Index / District	Input index		Output index		
	R&D employment (person)	R&D expenditure (ten million)	Patent applications (Piece)	Scientific papers published (articles)	New product sales (ten million)
Huangpu	1147	25.21	97	133	683.04
Xuhui	3761	104.96	494	216	937.86
Changning	377	11.21	110	28	163.56
Jingan	7	0.22	16	4	82.09
Putuo	1360	24.96	138	73	648.37
Zhabei	2437	135.17	178	49	488.04
Hongkou	564	13.48	118	12	113.24
Yangpu	3337	115.15	254	156	4467.68
Minhang	14281	484.03	2884	362	7590.20
Baoshan	6738	546.88	1751	722	4550.29
Jiading	11309	357.95	1525	179	16117.09
Pudong	28896	1094.20	5817	803	31417.56
Jinshan	4757	86.30	1451	85	1198.96
Songjiang	11003	202.93	1928	85	3491.83
Qingpu	4216	81.15	1326	67	1562.20
Fengxian	4998	123.79	1120	73	2567.16
Chongming	1110	30.06	158	14	1642.79

4.2. Each of Shanghai Industrial Enterprises R&D Comprehensive Allocation Efficiency Results

Table7. *Each district of Shanghai industrial enterprises R&D allocation efficiency results*

Efficiency / District	θ^*	δ^*	η^*	$\sum\lambda_i$	**Returns to scale**
Huangpu	0.2902	1	0.2902	>1	Decreasing
Xuhui	0.1132	1	0.1132	>1	Decreasing
Changning	0.1374	1	0.1374	>1	Decreasing
Jingan	1	1	1	=1	Unchanged
Putuo	0.1609	0.8166	0.1970	>1	Decreasing
Zhabei	0.0352	0.2635	0.1336	>1	Decreasing
Hongkou	0.1204	0.6068	0.1984	>1	Decreasing
Yangpu	0.1142	1	0.1142	>1	Decreasing
Minhang	0.0884	0.9186	0.0962	>1	Decreasing
Baoshan	0.1875	1	0.1875	>1	Decreasing
Jiading	0.1215	1	0.1215	>1	Decreasing
Pudong	0.0927	1	0.0927	>1	Decreasing
Jinshan	0.2312	001	0.2312	>1	Decreasing
Songjiang	0.1306	0.9679	0.1349	>1	Decreasing
Qingpu	0.2247	1	0.2247	>1	Decreasing
Fengxian	0.1244	0.8162	0.1524	>1	Decreasing
Chongming	0.1465	1	0.1465	>1	Decreasing
Average	0.1952	0.9053	0.2157		

4.3. Analysis of Comprehensive Allocation Efficiency Results

By the comprehensive efficiency value θ* in table 7, maximum is 1, and minimum is 0.0352, the average is 0.1952. From the table can be seen that except Jingan district comprehensive efficiency value is 1, and other districts efficiency value are all low, the second efficiency values of Huangpu district is only 0.2902, the number of Jingan district R&D staff input is only 7 people, however the product income and other indicators have shown great efficiency. DEA algorithm itself reflect a relative value, so we consider it does not influence other areas efficiency value measure. By observing the data we can see that the efficiency value except Jingan other districts were distributed in the scope of 0-0.3, and we divide other 16 districts into four categories, effective, relatively effective, ineffective and invalid. Specific results are shown in table 8. The table 8 we can clearly see that Jingan district returns to scale is invariant, other districts are all hold in decreasing returns to scale, that is mean those districts should be appropriate to reduce the R&D size of investment, because in this scale if increase a certain percentage of the investment can only bring less than the proportion of the output. In theory those districts can only lower R&D investment to get the best scale and improve the efficiency level. The following specific DEA results analysis [3]:

4.3.1. The DEA Effective Districts Analysis

The specific point of view only Jingan district belong to effective area, however DEA method is based on the relative theory, so we consider relatively effective districts also belong to the effective area. It means Jingan, Huangpu, Jinshan and Qingpu districts. From table 7 we can see that Jingan district is effective, unless the increase of R&D personnel or funds or while adding two inputs, otherwise unable to add any existing R&D output. Huangpu, Jinshan and Qingpu districts technical efficiency δ* is equal to 1, η* below 1. Technology efficiency value of 1 indicates that the resource collocation is reasonable, the higher level of management, achieved the technology effective, and the scale ineffective explains the R&D input or output size does not good well, it has also led to the comprehensive efficiency of ineffective [4].

4.3.2. The DEA Ineffective Districts Analysis

According to the above classification, except Jingan district is effective, Huangpu, Jinshan and Qingpu districts are relatively effective, the remaining 13 areas belong to the DEA ineffective. Specifically speaking, it divides into two categories:

- The technology efficiency is effective but scale efficiency ineffective areas, including Xuhui, Changning, Yangpu, Baoshan, Jiading, Pudong, and Chongming districts. These districts technical efficiency value is 1,but the scale efficiency below 1,that means these regions have reasonable resource collocation, higher management level. The technology effective, but the scale is ineffective, these districts R&D input and output scale are not appropriate, it has also led to the comprehensive efficiency ineffective and invalid.
- The technology and scale effective both ineffective districts contain Putuo, Zhabei, Hongkou, Minhang, Songjiang and Fengxian districts. These regions industrial enterprises not only R&D technology efficiency is not high, but the scale also reflects none economy, that means at the same time there existence resource allocation and scale inappropriate questions. For these districts, based on their own specific circumstances, to find a reasonable input-output ratio and the process of ineffective, and then to find suitable input and output size to improve and adjust these situation.

5. R&D DEVELOPMENT LEVEL AND COMPREHENSIVE ALLOCATION EFFICIENCY COMPARISON

According to the factor analysis and DEA calculation results, draw the following development level and efficiency comparison table, and on this basis, according to the Boston matrix rule, with development level as the horizontal axis, from left to right represent the development level is from low to high. With the efficiency level of the vertical axis, from low to high represent efficiency increasing. Finally, based on table 8 data to draw the matrix figure, as shown in figure 3. (Note: the efficiency value represent relative values, so except the Jingan district is 1, efficiency value distribution between0 to 0.3, so divide into three grades.)

Table8. *Each district of Shanghai industrial enterprises R&D allocation efficiency and comprehensive level list*

DEA allocation efficiency list

District	θ*	Rank
Jingan	1	Effective
Huangpu	0.2902	Relatively effective
Jianshan	0.2312	
Qingpu	0.2247	
Baoshan	0.1875	Ineffective
Putuo	0.1609	
Chongming	0.1465	
Changning	0.1374	
Songjiang	0.1306	
Fengxian	0.1244	
Jiading	0.1215	
Hongkou	0.1204	
Yangpu	0.1142	
Xuhui	0.1132	
Pudong	0.0927	Invalid
Minhang	0.0884	
Zhabei	0.0352	

Factor analysis, comprehensive level list

District	Score	Rank	Level definition
Pudong	1.476	1	Highest
Jiangan	0.916	2	High
Baoshan	0.85	3	
Minhang	0.358	4	Medium
jiading	0.195	5	
Yangpu	-0.168	6	
Zhabei	-0.179	7	
Songjiang	-0.185	8	
Xuhui	-0.238	9	
Fengxian	-0.271	10	
Jinshan	-0.322	11	Low
Qingpu	-0.329	12	
Huangpu	-0.36	13	
Changning	-0.372	14	
Chongming	-0.406	15	
Putuo	-0.47	16	
Hongkou	-0.495	17	

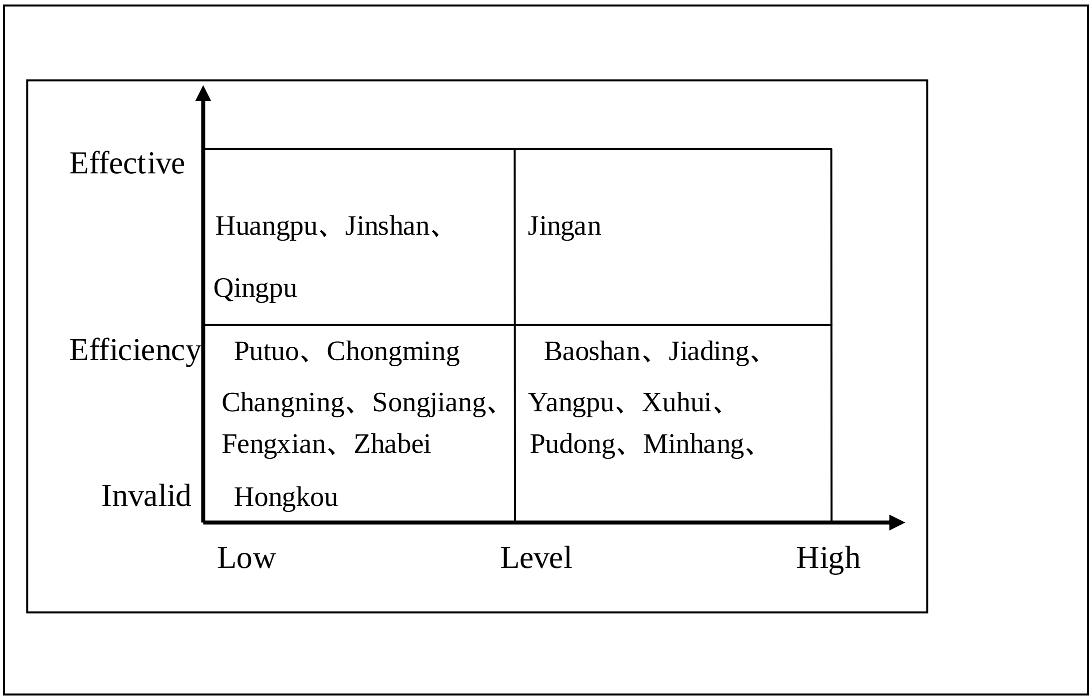

Figure3. *Boston matrix of each district of Shanghai industrial enterprises R&D allocation efficiency and comprehensive level*

Matrix from the allocation efficiency low and low development level area start, with rule of clock rotation, separately record the region I, II, III, IV district[5].

Region I, both development level and allocation efficiency locate in low area, which Chongming and Changning districts allocation efficiency value is 1,whereas scale efficiency below 1.It means that these two areas have reasonable resources collocation and higher level of management, achieving the technology effective, but the scale is ineffective; Putuo, Songjiang, Fengxian, Zhabei and Hongkou districts not only R&D input and output size is appropriate ,but also scale efficiency is not high. For these regions should increase R&D input, and accordingly to enhance the management level, if necessary to carry out the reform to eliminate the influence fundamental factors of R&D development level.

Region II, allocation efficiency effective and the low level of development, Huangpu, Jinshan and Qingpu districts, these three areas can be seen from the table the allocation efficiency of technology efficiency value is 1, but the scale efficiency value is less than 1. It means these areas have reasonable resources collocation, higher level of management, technology efficiency is effective, but the scale is ineffective, so these districts should enhance R&D input.

Region III, allocation efficiency and development level both in high level, but specific to see Jingan district, we will find the R&D is only 7 people, however the input and output hold a high level. These special phenomena closely associated to the area situation. Both development level and efficiency level locate in high level. Unless increase of R&D personnel funds or while adding two inputs, otherwise unable to add any existing R&D output. So for this area we should increase R&D personnel employment, and increase the input level, or at the same time increase the two inputs to better promote industrial development.

Region IV, the allocation efficiency ineffective but the development level is high, of which Minhang district R&D not only technology efficiency is low but also scale is also reflected not good, that means at the same time there both existence of the resources allocation and scale inappropriate questions. Baoshan, Jiading, Yangpu, Xuhui and Pudong districts are technical effective, but the scale is ineffective, the measures of these districts should increase R&D input level and enhance the allocation efficiency.

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