Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(5):1676-1682

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

A research on the development indices for China’s large scientific instruments in the category of medical diagnoses and analyses

Chen Li, Lv Yongbo, Xuan Zhaohui and Chen Chi

School of Traffic and Transportation, Beijing Jiaotong University, China

---

ABSTRACT

In recent years, with the rapid development of domestic pharmaceutical industry, the development of China’s large scientific instruments in the category of medical diagnoses and analyses has been very fast. Based on the statistics and the computation methods of spatial Gini coefficient for 2008-2012, this paper has discovered that the density of regionally distributed Chinese medical diagnostic and analytical instruments has not changed much, with the eastern regions obviously outperforming central and western ones. A three-dimensional structure of Hall type has been used to build a development indices comprehensive evaluation model for China’s large scientific instruments in the category of medical diagnoses and analyses, and measurement and calculation have been made. According to the results, it is obvious that the eastern regions are better in terms of equipment and utilization levels, but the difference in the level of sharing is not obvious, and this shows that a higher level of configuration does not necessarily mean a higher level of sharing. This article ends with some relevant advices on policies for regions at different levels of development indices.

Key words: large scientific instrument, utilization, sharing, spatial Gini coefficient, a three dimensional structure of Hall

---

INTRODUCTION

THE RAISING OF QUESTIONS

In terms of industrial technology intensity, pharmaceutical industry is one of typical hi-tech industries. In recent years, global pharmaceutical industry has grown rapidly with the increasingly active transnational investment in it and academic community has conducted lots of related research into this sector[1]. And as an intermediary and a means of scientific research, equipment is a foundation and a condition for the development of science and technology, and it is one of the most basic and critical factor in scientific and technological innovation activity, ensuring national scientific and technological progress and innovation and providing material support [2].

The large scientific instruments for medical diagnoses and analyses (hereinafter referred to as “medical diagnostic and analytic instruments” for short, while “large scientific instruments refer to the equipment the original value of which is no less than RMB 500,000”) feature a high technological content, advanced technologies, expensive prices and rapidly upgraded replacements. If the life cycle of an instrument is divided into the three periods of being advanced, conventional and outdated, generally speaking, the advanced period would account for less than 1/3 of the entire life of the instrument[3]. Therefore, only a sufficient sharing can ensure that the advanced period is made use of, and reflect the value of large scientific instruments to its full extent. Otherwise, it will not only cause a huge waste of the limited technological resources in the country, but also restrict the level of scientific research to some extent in China.

Although some achievements in the construction and use of China's large scientific instruments have been made after decades of efforts, there are still many problems to be solved. For example, repeated constructions are built, and utilization and sharing rates are low. Our country's scientific instruments have outnumbered the 15 European Union countries in total, but many instruments'utilization rates are less than 25%, while many developed countries'equipment utilization rates are as high as 170% - 200%[4]. In addition, problems still exist such as scattered configuration, low operation efficiency; alack of the restrictions and guidance by laws and regulations; a sluggish construction of the platform for sharing; dim awareness about the idea of sharing; obstructed technical resources sharing information channels; a lack of supporting mechanism for training in talents etc.[5] So, it is necessary to make a multi-dimensional comprehensive evaluation of how the large scientific instruments for medical diagnoses and analyses are used and shared, and use the information about resources as a basis to put forward relevant recommendations on policies for future development..

The research in this paper concerns the multiple-dimensional evaluation of how China's large scientific instruments for medical diagnoses and analyses are regionally used and shared in all the areas at provincial level, and provides a macro-level analysis of measurement results and influential factors.

RESEARCH METHODOLOGIES

Spatial Gini coefficient:

The economic and geographic phenomenon of the concentration of industries, capitals and population in a certain location or region is called industry location clustering. Early in the 20th century, many economists conducted a research into the issue of industry location clustering. After 1980s, industry clustering went beyond national borders, growing up worldwide. The issue of industry location clustering drew attention from new economic geographers represented by Paul Krugman, who interpreted industry location clustering, using the economics of imperfect competition, incremental returns, path dependence and cumulative causation. In his study of competitive advantage of nations, Michael Porter[6] also emphasized the role of industry clustering in the international competitiveness of regional industries. Experts studying the issue of industry clustering put forward a series of methods for calculating the degree of industry agglomeration, such as concentration index, concentration ratio, spatial Gini coefficient etc. Spatial Gini coefficient is the most representative, whose computational formula is as below:

$$G_i = \frac{1}{2n^2\overline{S}}\sum_{j=1}^{n}\sum_{m=1}^{n}\left|S_j^i - S_m^i\right| \text{……………………Formula (1)}$$

G_i in the formula is the Gini coefficient of industry *i*, S_j^i is the proportion of the industry *i* in region j to the whole country's; S_m^i is the proportion of the industry *i* in region *m* to the whole country's; *n* is the number of regions; $\overline{S}$ is the national average proportion of industry *i*. The value of spatial Gini coefficient varies between 0 and 1. The closer to zero the coefficient is, the more evenly distributed industry *i* is; the closer to 1, the more concentrated industry *I* is. Krugman[7] once used the spatial Gini coefficient method to calculate the level of spatial agglomerationfor106 manufacturing industries in the U.S. in 1991. This paper will look at the level of location agglomeration and the features of the historical evolution of the allocation of medical diagnostic and analytical instruments in China's 30 regions at provincial level through calculating the spatial Gini coefficient of such industry in these regions.

Comprehensive Evaluation Model for Development Indices:

a. The selection of indices

The existence of targets is the premise of using and sharing large scientific instruments. For finding the solution to the contradiction between the scarcity of large scientific instruments resources and the need of scientific innovation activities, the first is to expand the supply of large scientific instruments to its full extent. But this method is feasible only in theory as the economic strength in any country is restricted. The second method is to not only encourage the sharing of existing large scientific instruments for increasing the rate of equipment utilization, and providing a platform for multi-subject comprehensive development, but also create better conditions for CEEUSRO(Cooperation Education of Enterprise、University and Scientific Research Organization) communication and interaction. Obviously, the second method is more strategic. Consequently, the rationality of using and sharing large scientific instruments should be evaluated from three perspectives including equipment level, utilization level and sharing level. The indices for equipment total original value and per capita value are used to evaluate regional equipment levels. The indices for effective working computer time and equipment utilization rate are used to evaluate regional utilization levels. The indices for sharing computer time and equipment sharing rate are used to evaluate regional sharing levels.

Total original value (10 thousand Yuan): the total original value of the large scientific instruments for medical diagnoses and analyses in a provincial-level region. This index reflects the total equipment level and the potential of utilizing and sharing all the large scientific instruments for medical diagnoses and analyses in this provincial level region.

Per capita value of equipment (yuan/Peron): the ratio between the total original value of the large scientific instruments for medical diagnoses and analyses and the population in region *i*. This index reflects the configuration level of the large scientific instruments for medical diagnoses and analyses in this region.

$$U_i^1 = \sum_j V_{ij}^1 \times V_{ij} \quad i = 1, 2, \cdots, I \qquad U_i^2 = \frac{U_i^1}{V_i^2} \quad i = 1, 2, \cdots, I \quad \text{……………………Formula (2)}$$

U_i^1 in the formula is the total original value of the medical diagnostic and analytical instruments in provincial-level region *i*, V_{ij}^1 is the original value of instrument *j*, V_{ij} is a criterion function of equipment-region attribution. U_i^2 in the formula is the per capita value of equipment, V_i^2 is the total population in region *i*.

Effective working computer time (100 million Yuan-hour): the sum of the annual effective working computer time weighted by original value for the equipment in region *i*. This index reflects how the equipment in this region operates as a whole.

Utilization rate of equipment (%): the utilization rate of a set of equipment is the proportion of the equipment's annual effective working computer time to its rated annual effective working computer time (which is 1600 hours per year, that is, 200 effective working days per year and 8 working hours per day[8]). The regional utilization rate of equipment is the utilization rate of each equipment weighted by its own original value in region *i*. This index reflects the overall equipment utilization level in this region.

$$U_i^3 = \sum_j \left(V_j^3 \times V_{ij} \times \frac{V_j^1}{10000} \right) \quad i = 1, 2, \cdots, I \qquad U_i^4 = \sum_j \left(\frac{V_j^3}{V_{j0}} \times \frac{V_{ij} \times V_j^1}{U_i^1} \right) \times 100\% \quad i = 1, 2, \cdots, I \quad \text{……Formula (3)}$$

U_i^3 in the formula is effective working computer time, V_j^3 is the annual effective working computer time of instrument *j*. U_i^4 in the formula is the utilization rate of equipment, V_{j0} is the rated effective working computer time which is 1600 hours per year.

Sharing computer time (100 million yuan-hour): the sum of the annual sharing computer time weighted by original value for the equipment in region *i*. This index reflects the overall scale of the service provided to the public with the equipment in this region.

Sharing rate of equipment (%): the sharing rate of a set of equipment is the proportion of the equipment's annual sharing computer time to the rated annual effective working computer time. The regional sharing rate of equipment is the total sharing rate of a set of equipment weighted by the proportion of its own original value to that in the region. This index reflects the overall sharing level of the equipment in this region.

$$U_i^5 = \sum_j \left(V_j^5 \times V_{ij} \times \frac{V_j^1}{10000} \right) \quad i = 1, 2, \cdots, I \qquad U_i^6 = \sum_j \left(\frac{V_j^5}{V_{j0}} \times \frac{V_{ij} \times V_j^1}{U_i^1} \right) \times 100\% \quad i = 1, 2, \cdots, I \quad \text{……Formula (4)}$$

U_i^5 in the formula is sharing computer time, V_j^5 is the annual sharing computer time of instrument *j*.

After the above 6 secondary indices have been calculated for all the regions, the method of benchmarking is used to treat them for non-dimensional normalization, and secondary indices are obtained, and after that, the comprehensive weighted method is used to calculate primary indices, and finally, the method of integrated weighting is used to calculate comprehensive indicators.

$$z_i = \sum_{k=1}^{3} \left[\sum_{l_k = N_{k-1}+1}^{N_k} \left(\frac{U_i^{l_k}}{U_{\max}^{l_k}} \times 100 \right) \times \beta_{l_k} \right] \times \alpha_k \quad i = 1, 2, \cdots, I \quad k = 1, 2, 3 \quad l_k = 1, 2, \cdots, 6 \quad \text{………………Formula (5)}$$

z_i in the formula is the comprehensive development index for region *i*, β_{l_k} is the weight of secondary index, α_k is the weight of primary index, $U_{\max}^{l_k} = \max_i \left\{ U_i^{l_k} \right\}$.

b. The construction of a 3-dimensional evaluation model of equipment-utilization-sharing type

Based on the previous analysis of the impacts of the large scientific instruments for medical diagnoses and analyses, we can build a 3-dimensional model to reflect how the large scientific instruments for medical diagnoses and analyses are used and shared using the analytical method of the three-dimensional structure of Hall type in the methodology for system engineering The 3-dimensional model is as shown in Fig.1.

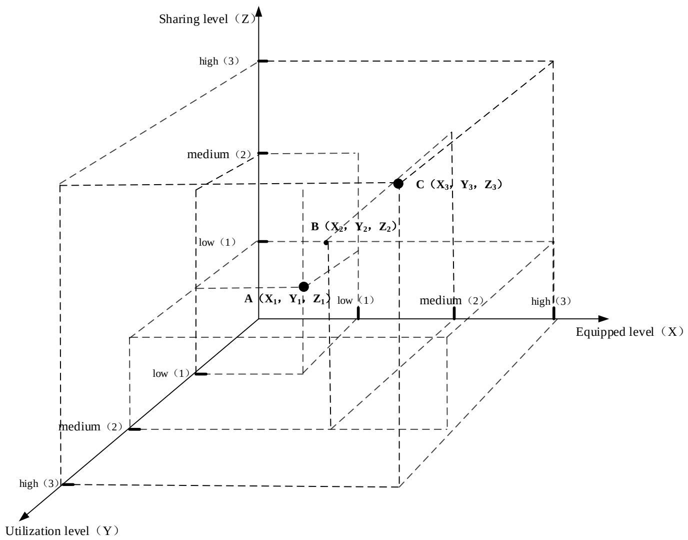

Fig.1 A3-dimensional model for evaluating how the large scientific instruments for medical diagnoses and analyses are used and shared

In the Fig.1, if each of the 3 dimensions of equipment level, utilization level and sharing level is given different values, the corresponding coordinates of the development status of different large scientific instruments for medical diagnoses and analyses could be found in the figure above. For example, the meanings of the 3 points of A, B and C in the figure are as follows:

A:(X1,Y1,Z1)=(lowequipment level, low utilization level, low sharing level)=(1,1,1)
B:(X2,Y2,Z2)=(mediumequipment level, medium utilization level, medium sharing level)=(2,2,2)
C:(X3,Y3,Z3)=(high equipment level, high utilization level, high sharing level)=(3,3,3)

ANALYSIS OF REGIONAL DISTRIBUTION AND GROWTH OF LARGE SCIENTIFIC INSTRUMENTS FOR MEDICAL DIAGNOSES AND ANALYSES

Table 1 Regional total original value of the large scientific instruments for medical diagnoses and analyses in China(2012)

Region	Total original value[1]（100 million Yuan）	Percentage of China[2]（%）	Region	Total original value（100 million Yuan）	Percentage of China（%）
Beijing	71.88	23.61%	Hunan	5.53	1.82%
Shanghai	42.49	13.95%	Yunan	4.43	1.45%
Guangdong	23.71	7.79%	Henan	4.41	1.45%
Jiangsu	21.07	6.92%	Gansu	4.29	1.41%
Zhejiang	14.38	4.72%	Chongqing	4.22	1.39%
Hubei	12.27	4.03%	Guangxi	3.90	1.28%
Shandong	11.67	3.83%	Hebei	3.90	1.28%
Tianjin	10.93	3.59%	Shanxi	2.58	0.85%
Liaoning	10.66	3.50%	Guizhou	2.27	0.75%
Jilin	8.31	2.73%	Hainan	2.10	0.69%
Sichuan	7.35	2.41%	Xinjiang	2.05	0.67%
Fujian	6.60	2.17%	Jiangxi	2.05	0.67%
Anhui	6.24	2.05%	Ningxia	1.19	0.39%
Shaanxi	6.12	2.01%	Inner Mongolia	1.14	0.38%
Heilongjiang	5.87	1.93%	Qinghai	0.91	0.30%
Total			304.50		

Notes: [1]indicates that the total original value of the large scientific instruments for medical diagnoses and analyses.
For the data is difficult to obtain, the data does not include Hong Kong, Macao, Taiwan and Tibet.

About the Regional Distribution of the Large Scientific Instruments for Medical Diagnoses and Analyses

Over the past decade, China's pharmaceutical industry has developed rapidly. In 2012, the numbers of enterprises and employees were 1.7 times and 2.1 times those of 2002[9], respectively. In terms of economic efficiency, the pharmaceutical industry showed a trend towards improvement. Proportion of its sales revenue to the total revenues of all the hi-tech enterprises going up from 17.1% in 2002 to 18.5% in 2012, and the proportion of its profits increasing from 29.8% to 33.2%. And the total original value of the large scientific instruments for medical diagnoses and analyses in China went up from 13529 million Yuan in 2008 to 30450 million Yuan in 2012. The annual average growth rate is 45.01%. The regional total original value of the large scientific instruments for medical diagnoses and analyses in China in 2012is as shown in the Table 1.

The total original value of the large scientific instruments for medical diagnoses and analyses in China in 2012 is 30450 million yuan, but the regional distribution is uneven. As the political, economic and cultural centre of China, Beijing has a lot of colleges, universities and research institutions. The total original value of the large scientific instruments for medical diagnoses and analyses in Beijing accounted for 23.61% of the national total. Beijing's share was higher by nearly 10 percentage points than Shanghai which ranked next to it. The total original value of the large scientific instruments allocated by central government for the medical diagnoses and analyses in Beijing reached up to 6077 million yuan, and on top of that, the allocation accounted for one-third of the national total which shows more policy support. Of the 30 provincial regions in China, the 4 of Beijing, Shanghai, Guangdong and Jiangsu have a combined total original value of the large scientific instruments for medical diagnoses and analyses that accounts for 52.27% of the national total. The technological and economic strength of central and western provincial regions is minuscule as compared to the rich ones in east coast provincial regions. In 2012, the sum of the total original values of the large scientific instruments for medical diagnoses and analyses in the 15 provincial regions with the smallest size accounted for 14.77% of the national total. 10 of the 15 provincial regions are located in the western part of China while5 of them in central China. In last decade, the huge regional differences of the distribution of the large scientific instruments for medical diagnoses and analyses were the general feature of fledgling pharmaceutical industry and even the entire community in China.

Review of Results of Five Years' Growth

The average growth rate per annum of the total original value of the large scientific instruments for medical diagnoses and analyses in China is 45.01% between 2008 and 2012. But were the regional distributions more clustered or dispersed? We used the total original value index in the foregoing formula (1) for computation, the results of which showed that in 2008, the spatial Gini coefficient of China's large scientific instruments for medical diagnoses and analyses was 0.58, belonging to the state of decentralized clustering. And the spatial Gini coefficients for the four years after 2008 were 0.56,0.55,0.55and 0.56. It showed that the regional distributions were always uneven. The annual variance ratio of spatial Gini coefficient is less than 2%, and it means the aggregation degree of the regional distribution of the large scientific instruments for medical diagnoses and analyses had not changed much. The total original values of the large scientific instruments for medical diagnoses and analyses in weaker provincial regions were growing all the time, but the gap between weak and strong ones has not narrowed.

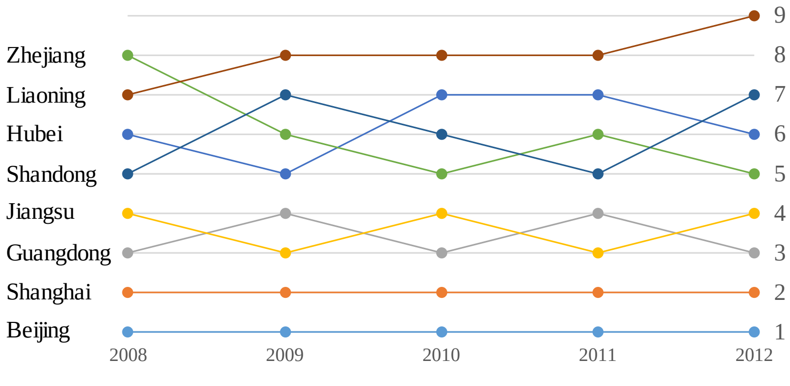

Fig.2 The ranking of the total original values of the large scientific instruments for medical diagnoses and analyses in selected provincial regions in China (2008-2012)

This phenomenon can also be seen from concentration ratios. Beijing and Shanghai had remained as the two provincial regions with the highest total original values of the large scientific instruments for medical diagnoses and analyses from 2008 to 2012. The sum of their total original values of the large scientific instruments for medical diagnoses and analyses has remained at the basic rate of 37% in relation to the national total. With 6 provincial regions(Guangdong, Jiangsu, Hubei, Zhejiang, Shandong and Liaoning) ranking 3nd-8th respectively over many years, nearly 70 percent of the total original value of the large scientific instruments for medical diagnoses and analyses in China was mainly distributed in a quarter of 30 provincial regions. The share of the remaining 22 provincial regions were just above 30%. Among the 22 provincial regions, the portion of the total original value of the large scientific instruments for medical diagnoses and analyses in every5 western provincial regions (Qinghai, Inner Mongolia, Xinjiang, Ningxia and Hainan) was less than 1%. A great number of government policies and funding should be needed for these provincial regions with small-scale pharmaceutical industry, if they look forward to a breakthrough in development.

RESULTS

Regional Development Index

The 3-dimensional evaluation model of equipment-utilization-sharing type can be used to calculate the scope of equipment, and utilization and sharing levels for each provincial region.

As known from the calculation results, in the equipment aspect (the distribution of dots which have different colors, E), the east provincial regions were better than the central and western ones. The result of k-means algorithm based on the equipment index shows that Beijing is at the first level (the red dot) and Shanghai whose equipment index is 55.53 is at the second level. All the rest regions are at the third level. In the utilization aspect (U), the result of k-means algorithm was similar to the equipment aspect. The difference is that Shanghai belongs to the first class and Beijing whose utilization index is 52.69 belongs to the second class. All the rest regions still belong to the third class. In the sharing aspect (S), the result is different from the above two. Although Shanghai still belongs to the first class, the sharing index for Beijing was just 14.69. The 5 provincial regions including Beijing, Jiangsu, Guangdong, Zhejiang and Chongqing belong to the second class. All the remaining 24 regions belong to the third class.

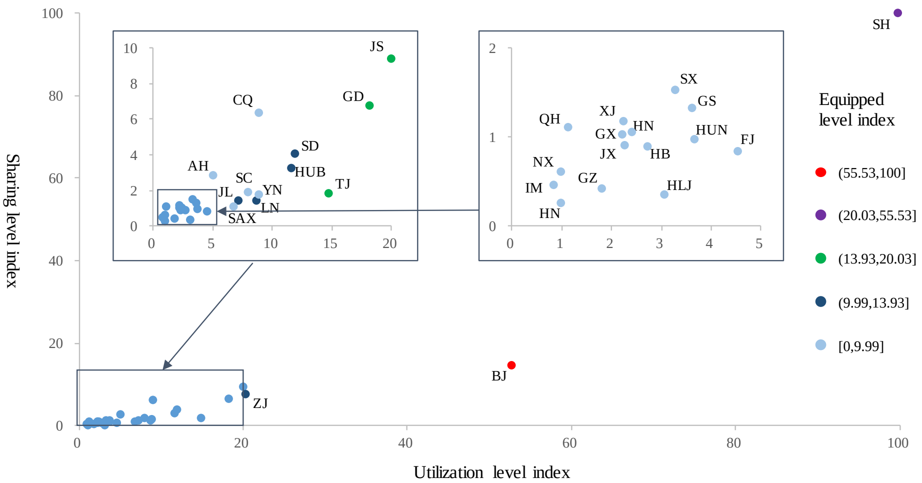

Fig.3 Regional distribution of equipment, utilization and sharing indices for the large scientific instruments for medical diagnoses and analyses in China (2012)

Region abbreviations: JS:Jiangsu; JX: Jiangxi; JL: Jilin; LN: Liaoning; SC: Sichuan; SD: Shandong; HEN: Henan; HUN: Hunan; AH: Anhui; IM: Inner Mongolia; QH: Qinghai; NX: Ningxia; TI: Tibet; XJ: Xinjiang; CQ: Chongqing; SX: Shanxi; GZ: Guizhou; HN: Hainan; YN: Yunnan; SAX: Shaanxi; TJ: Tianjin; ZJ: Zhejiang; HLJ: Heilongjiang; HB: Hebei; GX: Guangxi; GS: Gansu; FJ: Fujian; HUB: Hubei; GD: Guangdong; BJ: Beijing; SH: Shanghai.

After multiplying with the indices for equipment, utilization and sharing levels, we got the development indices expressed in δ for the large scientific instruments for medical diagnoses and analyses in each provincial region.

$$\delta_{(i,j,k)} = f(equipped\ level(i), utilization\ level(j), sharing\ level(k)) = E_i * U_j * S_k \text{ ……Formula (6)}$$

30provincial regions had been classified into 3 groups based on different development indices. And relevant policy advices should been given for each group. A table of development indices groups is as follows.

Table 2 The regional development indices groups for the large scientific instruments for medical diagnoses and analyses

Interval	Groups	Provincial Regions
$1 \le \delta \le 3$	high	Shanghai
$4 \le \delta \le 9$	medium	Beijing
$12 \le \delta \le 27$	low	Tianjin, Hebei, Shanxi, Inner Mongolia, Liaoning, Jilin, Heilongjiang, Jiangsu, Zhejiang, Anhui, Fujian, Jiangxi, Shandong, Henan, Hubei, Hunan, Guangdong, Guangxi, Hainan, Chongqing, Sichuan, Guizhou, Yunnan, Shaanxi, Gansu, Qinghai, Ningxia, Xinjiang

Countermeasures and Recommendations

Our country is vast in territory, the disequilibrium reflecting geographic differences of economic, technological and educational development has influenced the sharing of large scientific instruments to some degree. Policy-makers should make adjustments according to geographic differences. (1)The provincial regions with a high regional development index ($1 \leq \delta \leq 3$) have an advantage concerning scientific instruments resources. Policies should be made to further strengthen the resources integration for resources-pooling and technological innovation. (2)The provincial regions with a medium regional development index ($4 \leq \delta \leq 9$) have some advantage concerning scientific instruments resources. Arrangement and adjustment should be made to take a full advantage and improve abilities for resource sharing. (3)The provincial regions with a low regional development index ($12 \leq \delta \leq 27$)are weak in large scientific instruments. That means these areas have some disadvantages and technological innovation is restricted. Policies are meant to strengthen government financing, eliminate adverse factors and promote the sharing of regional S&T resources.

CONCLUSION

The past decade has witnessed a rapid development of China's pharmaceutical industry. the numbers of enterprises and employees had increased substantially. And the total original value of the large scientific instruments for medical diagnoses and analyses in China in 2012 has doubled in five years. But regional distribution is uneven. Beijing and Shanghai had a big lead. However, the total original value of the large scientific instruments for medical diagnoses and analyses in central and western provincial regions was generally less than the east coast. Unfortunately, the scattered distribution has not changed in recent years.

A three dimensional structure of Hall type is used to build the comprehensive evaluation model for development indices. According to the results, Beijing and Shanghai had a big lead in overall strength. The east regions were higher than the central and western ones in terms of equipment and utilization levels. But the picture looked different when it came to sharing. Chongqing ranks sixth in the list of sharing levels, Anhui and Sichuan were also among the top 10. It shows that not only the central and western provincial regions but also the east ones should strengthen and improve the sharing capability.

For those regions which have a high regional development index, the systematic integration of resources is needed. And for the regions with a low one, government support should be intensified for eliminating unfavorable factors and improving the regional development level relating to medical diagnostic and analytical instruments.

Acknowledgements
The author would like to thank his collaborators from and support of National Science & Technology Infrastructure Center(2013DDJ1ZY06), Science and technology evaluation and statistics work methods of Ministry of Science and Technology (2013SE-0603).

REFERENCES

[1]Li Liming; Liu Haibo, *China Soft Science*, **2013**, (6), 39-52.
[2]Xia Chunyang; Yuan Yubin; Wang Wei, *Science And Technology Management Research*, **2005**, 25(3), 18-19,24.
[3]Li Wenjun; Zhang Jiejun, *China Science & Technology Resources Review*, **2009**, 41(4), 19-23.
[4]Xu Jing; Wang Dazhou, *Journal Of Engineering Studies*, **2010**, 02(3), 209-216.
[5]Hu Xiaoping; Zhong Yelong; Xu Junming, *Experimental Technology and Management*, **2012**, 29(7), 215-217,220.
[6] Porter Michael E, *Competitive Strategy*, USA: Free Press. **1999**.
[7] Krugman Paul, *Geography and Trade*, China: Beijing University Press. **2001**.
[8]Ma Junxiao; Li Wei; Yang Zhijun; Tian Di; Qiu Chunlin, *Chinese Journal of Analytical Chemistry*, **2007**, 35(3), 466-468.
[9]Ministry of Science and Technology of the People's Republic of China, *China Science and Technology Indices* 2012, China: Scientific and Technical Documents Publishing House. **2013**, 294.