Regional Balanced Index Measurement of Chinese High-Tech Industry's Science and Technology Resource Allocation

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ABSTRACT
High-tech industry's science and technology resource allocation has a characteristic of regional concentration, and optimizing the allocation is conductive to balanced development of regional high-tech industry. By constructing the measurement indicator system of the science and technology resource allocation level based on human resource, material resource and financial resource, doing sample empirical analysis on the data of science and technology resource allocation indicators of high-tech industry of 31 regions in China from 2005 to 2009, an important conclusion is drawn that the balanced index of science and technology resource allocation of high-tech industry of our country is relatively small, and regional high-tech industry's science and technology resource allocation is extremely unbalanced.
Keywords: *high-tech industry, science and technology resource allocation, region, balanced index, measurement*

1. INTRODUCTION

The development of high-tech industry has become an important factor of impacting regional and industrial competitiveness, and has been an important guarantee of building an innovate country. China follows and slights adjusts to the category methods of high-tech industry by the OECD (1994), dividing high-tech industry into 6 categories which are: pharmaceutical manufacturing, aerospace manufacturing, electronics and communications equipment manufacturing, computer and office equipment manufacturing and medical equipment and instrument manufacturing[1]. High-tech industry is active in innovation of science and technology, its efficiency of innovation is important for the development of industry [2]. The achievement of innovation is based on the input resource of science and technology, the development of high-tech industry is dependent greatly on its scientific and technological resource allocation. Meanwhile, as high-tech industry has the feature of high-tech innovation frequency, and the innovation has an aggregation feature, which is because of the occurrence of the effects of sharing and spillover of scientific and technological resources that causes the linkage in adjacent regionals of innovation, which finally results in the special aggregation feature in the development of high-tech industry in our country, and its behavior is the unbalanced development of regional high-tech industry.

One of the important reasons of the unbalanced development of regional macro economy is the unbalanced development of regional high-tech industry, the latter will lead directly to increased differentiation of the rich and the poor, the obvious contradiction between the east and the west, a negative impact to build a harmonious society. At present, many scholars have recognized the aggregation feature of regional high-tech industry development and carried out the research of scientific measurement, such as Wang Zilong et. al.(2006) propose that the overall aggregation level of Chinese high-tech industry has been increasing, industrial concentration and and localization has been growing[3]; Xu Xiaodi et al. (2007) discover that high-tech industry of our country has shown a strong geographic concentration in the special layout, and the concentration consists of local monopoly characteristic[4]; Zhao Yulin et. al. (2008), based on the provincial panel data of high-tech industry of our country between 1995 and 2006, make use of entropy index and industry concentration degree to measure accurately the aggregation degree of our country's overall high-tech industry and its subsidiaries [5]. Xiong Ying et al (2010), by the analysis of the performance data of high-tech industry of our country, discover that high-tech industry concentrates in eastern China, while the central and western areas are at a distinct disadvantage, seriously impacting the balanced development of our country's high-tech industry; Xiao Zelei et al (2010) research on the provincial high-tech industry's scientific and technological resources, by constructing a comprehensive entropy calculation model and evaluation index system, measures respectively the entropy value of our country's provincial six big high-tech industry.

By studying the relevant data of our country, it is found that: firstly, the regional unbalanced problem of high-tech industry development has been attracting scholars' attention; secondly, the current method of measuring unbalanced development of high-tech industry are mainly entropy index, industry concentration degree, but these methods have limitations when measuring balance; thirdly, a largely number of research results focus on the operations balance analysis of high-tech industry, but few pay attention to the root cause, which is the non-balance problem of scientific and technological resource allocation of high-tech industry. Hence, this article uses the measurement principal of Gini coefficient, builds regional balance index, carries out scientific measurement of balance status of scientific and technological resource allocation of high-tech industry in 32 provinces or cities of our country between 2005 and 2009 (there is no separate statistical related to science and technology resources of high-tech industry in "Statistical Yearbook of Science and Technology" in 2004), provides a more scientific and rational basis for decision making of policy design and optimization of our country's high-tech industry's development.

2. MODEL FRAMEWORK DESIGN

Science and technology resource is the summary of the software and hardware elements engaged in science and technology activities such as human resource, material resources, financial resources and organization, management and information, or the collection of some of the elements. It provides material protection for science and technology activities, and also provides the basic conditional protections for science and technology management, decision making and scientific research. It is an important national strategic resource [8]. The science and technology resource allocation ability is the ability of utilizing and integrating the resources efficiently in a country, reflecting the regional coordination and distribution capability of the resources in a country [9]. National high-tech industry's science and technology resource allocation status has a direct impact on regional high-tech industry's development. Measuring the balance index of the science and technology resource allocation of high-tech industry, to a certain extent, will predict the regional balance status of the future high-tech industry's development and alert the early warnings.

According to the content of scientific and technological resources, this paper will carry out science and technology resource balance measurement from the 3 resource factors: human resource, material resource and financial resource. In order to conduct a comprehensive reflection of science and technology resource of different regional human resources, it needs to choose scientific evaluation methods to evaluation the level of different regional science and technology resource allocation, then based on its result, measure regional balance index. Hence, in this paper, the index measurement is divided into two phases: the first stage, building an evaluation index system from human resources, material resource and financial resources, selecting the entropy TOPSIS method to calculate respectively the balance index of science and technology resource allocation in 31 provinces or cities between 2005 and 2009; the second stage, using the Gini coefficient calculation method, calculating the balance index within the period. The adavantage of Entropy TOPSIS method lies in the ability to eliminate the subjectivity of weight determination and to strengthen the differences of regional scientific and technological resource allocation, enabling the effective distinguish of those differences; Gini coefficeinet method measures balance index from the view of difference uniform distribution, compared to entropy index, industry concentration degree which are from the view of no difference, it is more scientific and has more practical value –the high-tech industry's scientific and technological resource allocation levels of 31 provinces or cities of China cannot be totally the same and it is unnecessary to be the same, the national resource allocation balance object is just to reach relatively difference balance, which is to avoid excessive non-balance, while the Gini coefficient could well reflect such content, and is more advantageous than entropy methods in measuring balance index.

Accordingly, this paper builds regional balance index measurement mdoel of high-tech industry science and technology resource allocation as Figure 1.

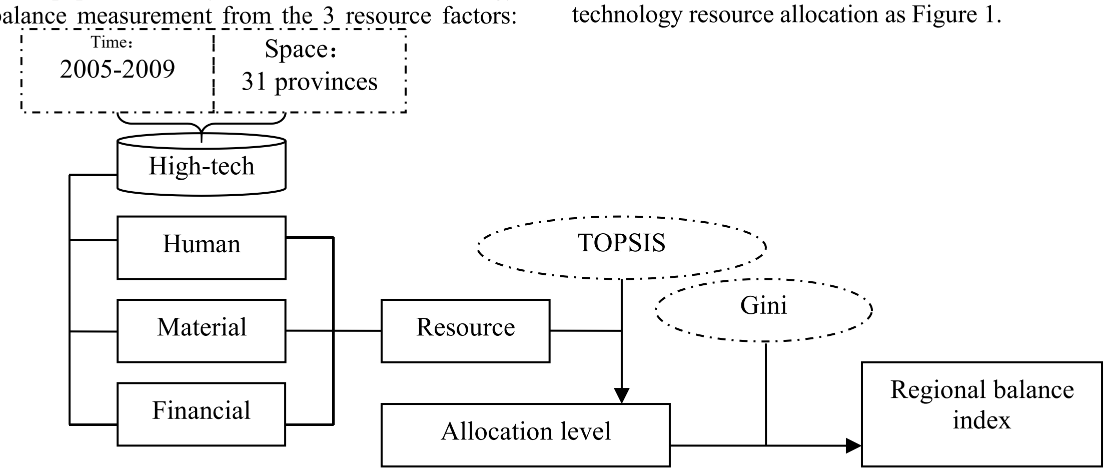

Figure 1 regional balance index measurement model of high-tech industry science and technology resource allocation

3. INDICATOR, DATA AND METHOD

3.1. Indicator

The measurement indicator of science and technology resource allocation level of high-tech industry is composed of human resources, material resources and financial resources. Human resources mainly include practitioners, professional and technical personnel, science and technological activities personnel, R&D personnel etc.; material resources mainly include patents, fixed assets etc.; financial resources mainly include R&D expenses, technology acquisition and renovation expenses etc. In order to ensure the operability of the data of measurement indicator, the indicator system design must meet the statitics of the National Bureau of Statistics, for which, this paper refers to the statistical indicators of the "National Science and Technology Statistics Yearbook", designs the measurement indicator of science and technology resource allocation level of high-tech industry as Table 1.

Table 1 Measurement indicator system of science and technology resource allocation of high-tech industry

First level indicator	Second Level indicator	Third Level indicator	Indicator content
High-tech industry science and technology resource allocation level C	Human Resource H	Average number of practitioners（person）H_1	Average number of practitioners of beginning and end of year, which reflects the total human resource scale of high-tech industry.
		R&D personnel（person year）H_2	Number of R&D activities personnel, which reflects the number of R&D people in high-tech industry
	Material resource M	Invention and patent number（item）M_1	Number of inventions and patents, which is the reflection of the innovation capability of high-tech industry
		Newly added fixed assets（100 million RMB）M_2	Reflects the fixed assets investment capability in high-tech industry, which is the basis to increase the innovation capability of science and technology in high-tech industry
	Financial resource F	R&D internal expenses（10 thousand RMB）F_1	Reflects the input capability of the R&D expenses of high-tech industry, which is very important to innovation
		Technology acquisition and renovation expense（10 thousand RMB）F_2	Reflects the funding input for external technology acquisition and renovation of high-tech industry, together with R&D expense, serve as the main source of science and technology innovation funding input

3.2. Data

The original data of indicators of this paper are mainly derived from "China Statistical Yearbook", "Chinese Science and Technology Statistical Yearbook", and "China Science and Technology Statistical Information" between 2006 and 2010, and the website of the Ministry of Science and Technology. Due to the space limitations, Table 2 only lists the original data of indicators in 2009. As lack of the data in Xi Zang between 2005 and 2007, there are only 30 provinces or cities when calculating regional balance index for year 2005 to 2007, while 31 for year 2008 to 2009.

Table 2 Science and technology resource allocation level in 31 provinces or cities of China in 2009

Indicator / Provinces Or cities	H_1	H_2	M_1	M_2	F_1	F_2
Beijing	238984	13458	2725	17.7	454719	40864.8
Tianjin	200280	6401	918	56.0	189530	168911.6
Hebei	144490	6337	455	115.4	77716	31294.1
Shanxi	93724	1817	91	19.8	18882	7563.3
Neimenggu	23293	255	16	27.9	4685	2500.5
Liaoning	215211	6279	744	188.1	222594	130479.1
Jilin	107673	2614	329	148.8	35677	49484.6
Heilongjiang	75737	6225	207	44.8	137497	104412.4
Shanghai	475240	21453	2960	35.2	633021	142407.2
Jiangsu	1923840	59676	3012	780.5	1275731	775287.6
Zhejiang	553078	31245	2790	84.5	621601	295515.3
Anhui	114639	4566	410	92.7	65741	38408.6

Fujian	270506	14114	541	58.7	315701	180803.1
Jiangxi	185719	6422	241	215.2	111392	51225.3
Shandong	523435	17681	1758	214.8	600638	259271.7
Henan	196213	9385	413	173.4	121773	173701.7
Hubei	195742	11007	1506	113.5	229747	41661.0
Hunan	129107	4850	527	81.6	137948	106167.1
Guangdong	3124661	127449	18991	230.7	2975035	321925.2
Guangxi	80973	1219	210	32.2	22056	69161.2
Hainana	10723	675	33	0.9	13850	8461.4
Chongqing	79949	3818	382	32.2	53560	68852.6
Sichuan	278478	15416	392	291.2	281434	220679.3
Guizhou	67722	2841	431	10.8	61160	42898.6
Yunan	25576	902	156	6.4	13685	5456.7
Xizang	1282	339	10	0.1	2342	0.0
Shanxi	195119	11143	790	78.2	221235	153169.1
Gansu	25740	872	21	5.8	12117	9218.1
Qinghai	5197	156	14	1.3	2262	263.0
Ningxia	6634	540	33	1.6	5608	4296.2
Xinjiang	6463	66	64	0.6	2280	8127.0

As different indicators have different dimension units, it is necessary to process raw data without dimensions, this paper uses linear converting method to preprocess indicator data, its formula is shown below[10]:

$$x_{ij}^{'} = \frac{x_{ij} - \min_i x_{ij}}{\max_i x_{ij} - \min_i x_{ij}} \tag{1}$$

$x_{ij}^{'}$ is indicator data after non-dimension processing, $\min x_{ij}$ and $\max x_{ij}$ are respectively the min and max value of the jth indicator on different measuring objects (31 provinces or cities). i=1,…,31 means 31 provinces or cities, j=1,…,6 means 6 indicators.

3.3. Method

The methods involved in this paper include entropy TOPSIS method and Gini coefficient method. The basic steps of entropy TOPSIS method are as below[11]:

(1) Calculate the weight of 6 indicators using entropy method

$$\omega_j = \frac{1 + \sum_{i=1}^{31}\left[\left(x_{ij} / \sum_{i=1}^{31} x_{ij}\right) * \ln\left(x_{ij} / \sum_{i=1}^{31} x_{ij}\right)\right] / \ln (31}{\sum_{j=1}^{6}\left\{1 + \sum_{i=1}^{31}\left[\left(x_{ij} / \sum_{i=1}^{31} x_{ij}\right) * \ln\left(x_{ij} / \sum_{i=1}^{31} x_{ij}\right)\right] / \ln (3\right.} \tag{2}$$

(2) Determine the ideal solution and negative ideal solution

$$X = \left\{\left(\max_{1 \le i \le 31} x_{ij}^{'} \mid j = 1, \cdots, 6\right), \left(\min_{1 \le i \le 31} x_{ij}^{'} \mid j = 1, \cdots, 6\right)\right\} \tag{3}$$

(3) Calculate distance. Suppose there are m third level indicators under certain second level indicator, then

$$d_i^{+} = \left[\sum_{j=1}^{m} \omega_j \left(x_{ij}^{'} - X_j^{+}\right)^2\right]^{1/2}$$

$$d_i^{-} = \left[\sum_{j=1}^{m} \omega_j \left(x_{ij}^{'} - X_j^{-}\right)^2\right]^{1/2} \tag{4}$$

(4) Calculate the relative proximity. Evaluate the relative proximity to the ideal solution of object I on its second level indicator

$$C_i = d_i^{-} \Big/ \left(d_i^{+} + d_i^{-}\right) \tag{5}$$

(5) High-level indicators evaluation repeat step ① and ④. When the indicators of evaluation object are invided into different levels, it needs to uses multi-level evaluation model to evaluate. The multi-level model is derived from single level evaluation model, its result C_i, which takes the relative proximity of each evaluation object as the indicator of the upper level, and compose C_i into the evaluation matrix of the upper level, then use the above steps to evaluate the relative proximity evaluation matrix to get the total relative proximity, which is the science and technology resource allocation level of regional high-tech industry of our country between 2004 and 2009.

In order to study the income distribution among citizens, in 1907, American statistician Lorenz proposed the famous Lorenz Curve, since then, as an easy and graphical solution method of summarizing income and wealth distribution, Lorenz Curve had been widely used[12]. Based on that, Italian economist Gorrado Gini proposed the concept of Gini Coefficient in 1912, which has become an important analyzing indicator internationally to examine the difference of distribution of income within the citizens. Take A as the area between actual income distribution curve and income distribution absolute equal curve, B as the area of the lower right of actual income distribution curve. Take A divided by (A+B) as the unequal degree, which is Gini Coefficient, G[13]. The smaller G is, the evener the distribution is; the bigger G is, the more concentrated the distribution is. In order to measure the balance degree of our country's regional high-tech industry science and technology resource allocation, this paper extends Gini coefficient, asends the allocation levels of 31 provinces or cities between 2005 and 2009, carries out distribution curve fitting, and calculates the integral value of the distribution curve to obtain B[14], and then calculates the Gini coefficient (GINI) of the annual resource allocation level. To ensure the regional balance index follows the nature that the bigger the indicator, the more balanced the allocation, the regional balance index HTCI could be defined as: HTCI (High-tech industry's technological resource collocation regional balance index) = 1 – GINI.

4. EMPIRICAL ANALYSIS

First, calculate the indicator entropy for each year between 2005 and 2009 according equation (2), to make the final measurement results comparable in time series, take the average weight value of 5 years as the indicator weight. Entropy is calculated as Table 3.

Table 3 Indicator Entropy

Indicator / Year	H_1	H_2	M_1	M_2	F_1	F_2
2005	0.182	0.131	0.230	0.142	0.183	0.132
2006	0.195	0.147	0.184	0.160	0.196	0.119
2007	0.180	0.164	0.201	0.154	0.175	0.125
2008	0.176	0.164	0.218	0.137	0.175	0.129
2009	0.179	0.171	0.227	0.125	0.183	0.115
average	0.182	0.156	0.212	0.144	0.182	0.124

Then, according to equation (3) to equation (5), calculate relative proximity, which is the measurement result of the science and technology resource allocation level of regional high-tech industry of each year, shown as Table 4.

Table 4 Science and technology resource allocation level of regional high-tech industry between 2005 and 2009

Year / Region	2005	2006	2007	2008	2009
Beijing	0.139	0.155	0.219	0.159	0.107
Tianjin	0.296	0.231	0.206	0.150	0.093
Hebei	0.058	0.042	0.035	0.040	0.065
Shanxi	0.008	0.014	0.016	0.014	0.017
Neimenggu	0.004	0.003	0.002	0.003	0.014
Liaoning	0.094	0.095	0.060	0.064	0.117
Jilin	0.025	0.038	0.019	0.036	0.076
Heilongjiang	0.130	0.077	0.048	0.046	0.059
Shanghai	0.372	0.331	0.309	0.204	0.161
Jiangsu	0.467	0.488	0.513	0.536	0.547
Zhejiang	0.262	0.301	0.212	0.219	0.213
Anhui	0.042	0.031	0.045	0.059	0.054
Fujian	0.145	0.166	0.142	0.109	0.112
Jiaoxi	0.068	0.127	0.070	0.045	0.109
Shandong	0.247	0.180	0.183	0.211	0.201
Henan	0.073	0.096	0.071	0.063	0.120
Henan	0.091	0.085	0.063	0.077	0.087
Hunan	0.041	0.030	0.019	0.045	0.070
Guangdong	0.954	0.927	0.908	0.844	0.722
Guangxi	0.018	0.014	0.013	0.021	0.037
Hainan	0.000	0.001	0.001	0.003	0.005
Chongqing	0.043	0.040	0.028	0.035	0.040
Sichuan	0.141	0.176	0.202	0.190	0.179
Guizhou	0.049	0.045	0.034	0.020	0.027
Yunnan	0.014	0.014	0.017	0.011	0.007
Xizang	−	−	−	0.001	0.001
Shanxi	0.198	0.154	0.123	0.086	0.096

Gansu	0.018	0.010	0.008	0.010	0.007
Qinghai	0.000	0.000	0.001	0.000	0.001
Ningxia	0.005	0.037	0.016	0.005	0.003
Xinjiang	0.005	0.001	0.004	0.004	0.004

According to the theory of Gini coefficient calculation, the allocation level should be in ascending order after being normalized, with the ordered result the Lorenz curve could be drawn as Figure 2. Measuring the area of A and B in Lorenz curve, it could be calculated gradually the balance indicator HTCI, as shown in Figure 3.

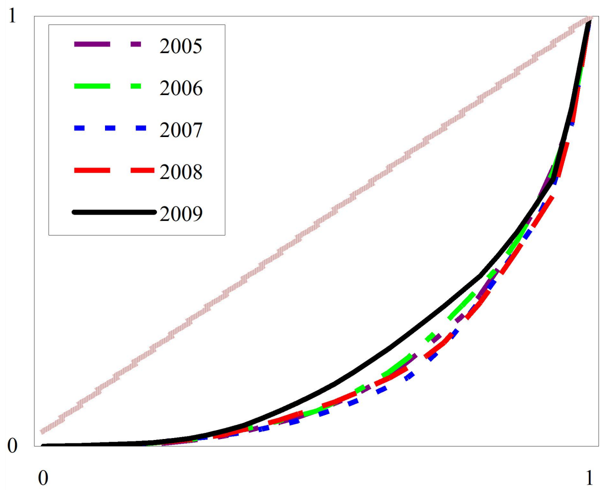

Figure 2 Lorenz curve of high-tech industry science and technology resource allocation

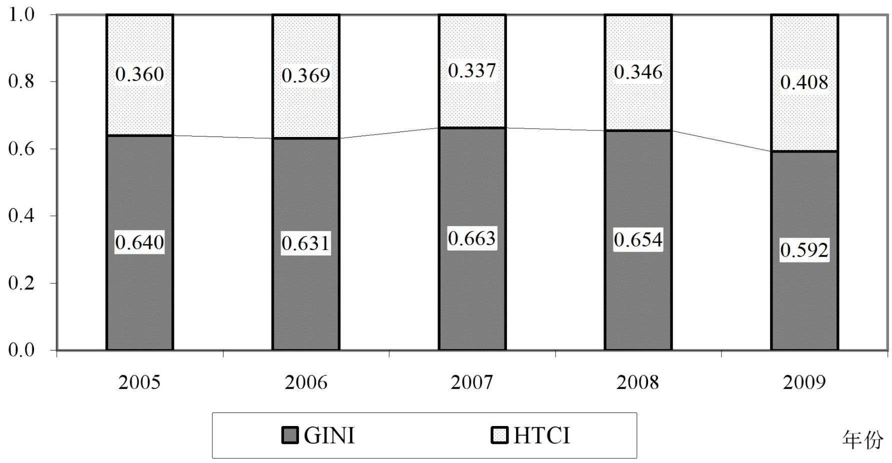

Figure 3 GINI and HTCI of science and technology resource allocation of high-tech industry between 2005 and 2009

5. CONCLUSION

According to empirical results, we can get the following main conclusions:

Each indicator of science and technology resource allocation has changed between 2005 and 2009, but the range of change is relatively small, which makes the entropy of each indicator between 2005 and 2009 basically the same, there was no big change. It can be found through further analysis that the change of the amount of the resource of regions is a slow accumulating growth, and that a sudden change could not happen, which is in line with the gradient development mode of high-tech industry of a region.

There exists huge difference in the science and technology resource allocation level of high-tech industry, it could be known from Table 4 that, Guangdong provinces has been more advantageous in the resource allocation level, which is more than 0.9 during 2005 and 2007, but the resource allocation level of Hainan, Qinghai et al. is less than 0.001 during the same period. The huge difference is the reason that causes the regional balance index to be small. Therefore, relative limit on the resource allocation to the provinces where high-tech industry is relative developed such as Guangdong, Jiangsu etc., and the support to the ones with less developed high-tech industry such as Hainan, Qinghai etc., are very important for a balance development of regional high-tech industry in our country.

It can be known from Lorenz curve that, there is small change in the difference of science and technology resource allocation of regional high-tech industry between 2005 and 2009, the 5 curves are basically overlapping. But it could also been seen that, the resource allocation balance in 2009 has greatly increased, which illustrates the regional balance status will gradually become more balance under the guidance of policy.

It can be seen from Figure 3 that, the GINI coefficients of resource allocation each year are greater than 0.59, far more than GINI coefficient alert standard (less than 0.4) in macro economy, which shows regional extremely unbalanced status, which resembles the point of views proposed by many researchers that is the aggregation development of high-tech industry. Therefore, it is necessary that the resource allocation balance status should be greatly adjusted in the future, in order to promote the regional balance of the development of high-tech industry, and enhance the overall level of the development of high-tech industry in our country.

In summary, the regional balance index of science and technology resource allocation of high-tech industry of our country is relatively small, the resource allocation is the same with the high-tech industry itself, shows a regional aggregation characteristic. On one hand, this benefits high-tech industry that drives each other in clusters and achieves rapid development, but in the other hand it is not good for the regional balanced development of high-tech industry, results in a growing gap in regional development, causes the regional correlations unable to be maintained but break up, which is not conductive to the comprehensive and sustainable development of high-tech industry. This paper builds regional balance index measurement model of science and technology resource allocation of high-tech industry, provides a strategic guiding tool for making and optimizing resource allocation policies and is important to the balanced development of high-tech industry of our country.

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