Construction and Empirical Analysis of Innovation Index System of Zhengzhou-Luoyang-Xinxiang Self-dependent Innovation Demonstration Area

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Abstract. As the main cities of the Central Plains Urban Agglomeration, Zhengzhou, Luoyang, Xinxiang has established evaluation index system which is based on innovative environment, innovation inputs and innovation outputs. Determining of the one-level index weight by Analytic Hierarchy Process (AHP), and using the entropy weight method to determine the two-level index weight. By analyzing the results, obtained the following conclusions: Zhengzhou has a distinct advantage in the innovation environment, innovation inputs and innovation outputs, but there is a downward trend in innovation environment and innovation input; Luoyang is in a stable stage basically, and with great advantages in terms of innovation output. Xinxiang at a disadvantage in the three regions, but its better environment for innovation, innovation inputs continued to increase, innovation output tends to increase.

Keywords. Zhengzhou-Luoyang-Xinxiang self-dependent innovation demonstration area, innovation index, index system.

1 Introduction

In April 2016, the State Council approved that Zhengzhou-Luoyang-Xinxiang national high tech Zone to build the national independent innovation demonstration zone, and to carry out scientific and technological system and mechanism innovation actively, and exploration in some aspects as follows: scientific research projects and funds management, equity incentive, the combination of technology and finance, the use of intellectual property and protection, personnel training and introduction, scientific and technological achievements, technological evaluation. As of July 2016, the State Council officially approved the 17 National Innovation Demonstration Zone. National Independent Innovation Demonstration Zone play an important lead, radiation and drive role in further improve the mechanism of scientific and technological innovation system, accelerate the development of strategic emerging industries, promote innovation-driven development, accelerate the transformation of economic development mode and so on. Furthermore, National Independent Innovation Demonstration Zone has become a great supporting strength of China's economic development, industrial transformation and upgrading, and innovation-driven development, under the condition of Chinese New Normal. After several years of development, some national independent innovation demonstration zone, such as Zhongguancun, Zhangjiang, Donghu, has become the main driving force of regional economic development, and the

model of China's National Innovation Demonstration Zone. The gross value of industrial output of Zhongguancun is 410 billion 410 million yuan, accounts for 51.1% of the city. The number of patent applications of Zhongguancun enterprises reached 27966, accounts for 32.9% of the city. Silicon Valley initiated a science, technology, production of three-dimensional integrated development model, with small and medium-sized enterprises as the core. It has created a global scientific and technological innovation, transformation of scientific and technological achievements and the development of high-tech industry model, becoming the world's most dynamic economic region. Tsukuba, Bangalore, Hsinchu Taiwan, China, and other world famous high-tech Industrial Development Zone has provided a good experience for the good development of China's National innovation demonstration zone. Considering the difference of regional economic development, we put forward to the development model of national independent innovation demonstration zone, which government-led, cluster development of electronic information, advanced manufacturing, new materials and other strategic emerging high-tech industry, the industrial-academic-research collaborative development.

Creativity is the soul of a nation's progress. With the implementation of the strategy of innovation-driven development, China's major innovation index has reached the leading level of the world. But the self-innovation capability still faces a severe test. Similar to the function of high-tech park, National Innovation Demonstration Zone is mainly to accelerate the development of strategic emerging industries, promote the strategy of innovation-driven, accelerate the transformation of the mode of economic development. In our country, the national innovation demonstration zone has the functions of strengthening financing, innovation incentive, risk aversion and achievement transformation as well.

In the case of the United States, foreign scholars N. Link Albert and T. Scott John study the impact of Science and Technology Park on the university. They believe that once the establishment of science and Technology Park, the University and other resources near to the science and technology parks will have a huge impact, may make university turn to applied research from basic research directly [1]. Francis C.C. Koha, Winston T.H. Koh and Feichin Ted Tschanga proposed framework includes growth mechanism, technical ability and global role and market integration, analyzed the Silicon Valley, Hsinchu, Cambridge Science and Technology Park, Singapore Science Park, they believe that technological capability, especially R&D which is the primary driving force to promote the development of science and technology parks [2]. Through the study of the Greek Science Park, Yiannis L Bakourosa, Dimitri, C Mardasb and Nikos and C Varsakelise found that the enterprise and universities in Science and Technology Park are generally built with informal contact, and synergy only appear in business transactions and social interaction, while in scientific research is not [3]. The domestic scholar Sha Dechun make comparative study of Silicon Valley index and evaluation index system of national high-tech Zone, and conclude that the two have significant differences in the design idea, index content, system structure, making subject and the index function [4]. Taking Silicon Valley and Hsinchu Science Park as an example, Lin Lijian, Teng Tangwei studied the difference and convergence of the fusion of first-class Science Park. [5] Hu Shuhua through the construction of "four-three structure" model, take Wuhan East Lake national innovation demonstration zone as an example to analyze the input and output, the main body of innovation, innovation content and innovation output, and puts forward three measures of the independent innovation project [6]. According to the analysis of complex network structure, Gong Yuhuan propose that the innovation capability of Zhongguancun industrial cluster is highly dependent on a small number of large enterprises [7]. Zhou Hongyu make comparative study to the innovation capability of Zhongguancun, Donghu and Zhangjiang, by construct the evaluation model of innovation capability of National Independent Innovation Demonstration Zone, which is regard innovative input, innovative talents, innovation output, innovation body and innovation environment as the as the indicator information [8].

2 Contruction of index system

The index theory originated from the price index, and later was widely used in the field of economic statistics, such as CPI, PPI, import and export price index, etc. With the development of economy and society, innovation has become one of the main indicators of national economic development and comprehensive national strength. Innovation index is a comprehensive index to reflect the degree of change of science and technology innovation, and it is used to reflect the relative number of technological innovation and technological innovation ability [9]. The typical innovation index

includes: the innovation alliance score card, the global innovation index(GII), the global competitiveness index(GCI) and the Silicon Valley index. Among them, the innovation alliance score card is used to analyze the innovation advantages and disadvantages of EU countries. It includes three one-level indexes such as Innovation vitality, innovation activity and innovation output, and 29 two-level indexes such as human resources, business investment, economic performance, etc. On the basis of comprehensive analysis, furthermore, it divides the EU member states into leaders, followers, general and low innovation countries. In China, the relatively authoritative indices are as follows: national innovation index, national high tech Zone Innovation Index, China Innovation Index, and some indexes that reveal the National Innovation Demonstration Zone such as Zhongguancun index, Zhang Jiang innovation index, Hangzhou innovation index, etc. Overall, from the aspects of scientific objectivity and feasibility principle the evaluation index system establishes tree evaluation index system, and uses a large number of statistical indicators of science and technology, economic indicators, according to the research emphases. Zhengzhou-Luoyang-Xinxiang National Innovation Demonstration Zone studied in this paper is composed of Zhengzhou high-tech Industrial Development Zone, Luoyang high-tech Industrial Development Zone, Xinxiang high-tech Industrial Development Zone. It is a National Innovation Demonstration Zone that takes the city group as the basic unit. While the South of Jiangsu national independent innovation demonstration zone is composed of eight High-tech Industrial Development Zone and Suzhou Industrial Park, is China's first National Independent Innovation Demonstration Zone that tack the city group as the unit. Therefore, when establishing the evaluation index system of Zhengzhou-Luoyang-Xinxiang the National Independent Innovation Demonstration Zone, this paper refers to the relevant research on the innovation index system of Independent Innovation Demonstration Zone in South of Jiangsu by Zhou Yong, Ge Lufei and others [10] .

Table 1. Index and weight of all levels.

one-level index	two-level index	weight
Innovation environment (0.1104)	Number of students per million include graduate and above(10 000 persons)	0.2237
	Number of legal units in industrial agglomeration area(individual)	0.1980
	Per capita GDP(10 thousand yuan)	0.2084
	Number of R & D institutions(individual)	0.1488
	Number of high-tech enterprises identified in the year(individual)	0.2212
Innovation investment (0.3230)	R&D funds accounted for the proportion of GDP(%)	0.2142
	activity personnel of R&D(persons)	0.2110
	the proportion of local financial expenditure on science for total financial expenditure(%)	0.3290
	R&D expenditure(100 million yuan)	0.2459
	Invention patent authorization amount(pieces)	0.2355
Innovation output (0.5666)	Number of published scientific papers(pieces)	0.0725
	sales revenue of new product(100 million yuan)	0.0218
	labor productivity in above-scale enterprise(10 thousand yuan/person)	0.2262
	Ratio of patent license and patent application(%)	0.2108
	the proportion of high-tech industrial output value for above-scale output valu	0.2333

2.1 The index system of innovation index

According to the research above, we can establish an index system of innovation index, which is consisted of 3 one-level indexes such as Innovation environment, innovation investment and innovation output, and 15 two-level indexes such as the number of undergraduates per million, Per Capita GDP, the proportion of total social research funding for GDP, invention patents authorization amount, and the proportion of high-tech industrial output value for above-scale output value etc.See Table 1.

2.2 Determination of the one-level index weight

Due to the one-level target only contains the three aspects content of innovation environment, innovation input and innovation output, so we use Subjective Weight-assign Method when determine the weight of the first-level target. The popular subjective weighting approach includes analytic hierarchy process (AHP), expert investigation method (Delphi method), TACTIC, least square method and two coefficient method, etc.AHP is the most commonly used methods in practical application, and it is able to simplify and layering the complex issue. Thus to use the analytic hierarchy process to determine the one-level index weight.

Design the questionnaire that intercomparison between innovation environment, innovation investment and innovation output, and ask experts in related fields to make a comparative judgment. And then, organize relevant results according to the Saaty scale table. Finally obtain a comparison matrix A of one-level index, as shown in Table 2. In the third rows and second columns of comparison matrix of the one-level index, there is a number 5, which is express that innovation investment has a significant effect on the overall innovation, compared with the innovation environment.

Table 2. comparison matrix of one-level index.

	innovation environment A ₁	innovation investment A ₂	innovation output A ₃
innovation environment A ₁	1	1/5	1/3
innovation investment A ₂	5	1	1/3
innovation output A ₃	3	3	1

Solve the maximum eigenvalue of the matrix by using MATLAB

$$[x,y]=eig(A)$$

(1)

$$\lambda_{\max}=\max(abs(sum(y)))$$

(2)

Then solve the normalized feature vector that corresponding to $\lambda_{\max}$

$$\omega=x(:,1)/sum(x(:,1))$$

(3)

According to the $\lambda_{\max}=3.2948$ solved by Formula (2) and (3), the normalized feature vector that corresponding to $\lambda_{\max}$ is $\omega=(0.1104,0.3230,0.5666)^T$.

During the construction of the comparison matrix A, we do not consider the consistency of the matrix, and therefore, according to the consistency checking procedure proposed by Saaty [11], the consistency check of the comparison matrix is carried out. The procedures are as follows.

- (1)Calculating the consistency index: C.I.; C.I.= $(\lambda_{\max}-n)/(n-1)=0.1474$;
- (2)Calculating the average random consistency index R.I, and find the R.I.=0.58 by looking for the past data.
- (3)Calculate the consistency ratio: C.R.: C.R.=C.I./R.I.=0.254. When C.R.<0.3, the consistency of the matrix is acceptable, otherwise it is necessary to revise the matrix. Therefore, It can be considered that the consistency is betterIt can be learned that the weight of the three one-level index are:0.1104、0.3230、0.5666.

2.3 Determination of the two-level index weight

Given the artificial subjective factors are not easy to determine and the two-level index contains too many indicators, thus to use the objective weighting method to determine the one-level index weight. Using historical data to study the relationship between indicators, objective weighting method excluding the impact of objective human factors. At present, the main methods of objective weighting are entropy weight method, least square method, variation coefficient method,

multi objective programming method, principal component analysis method and CRITIC method. Because of the superiority of entropy weight method in determining the weight of each evaluation index of multi-decision making problem, and its maturity of usage, we using entropy weight method to determine the weight of the two-level indicators

The procedures are as follows.

$$r_{ij} = [x_{ij} - \min(x_i)] / [\max(x_i) - \min(x_i)] \quad (4)$$

According to the definition of information entropy in information theory, calculate the information entropy of every two-level index.

$$E_j = -(\ln n)^{-1} \sum_{i=1}^n p_{ij} \ln p_{ij} \quad (5)$$

For the $p_{ij} = r_{ij} / \sum_{i=1}^n r_{ij}$ in formula (5), if $p_{ij} = 0$, then $\lim_{i \rightarrow n} p_{ij} \ln p_{ij} = 0$.

Confirming the weight of each two-level index:

$$\omega_j = E_j / \sum_{j=1}^t E_j \quad (6)$$

In the formula above is the number of two-level index for each one-level index. This model is based on the two-level index of innovation environment such as the number of undergraduates per million, the number of legal units in industrial agglomeration area, Per Capita GDP, number of R & D institutions, the number of high-tech enterprises identified in the year as an example. T value is 5. According to the analysis above, we can obtain the weight of each two-level index. See Table 1.

3 Empirical analysis

3.1 Calculation method and data collection

After the analysis above, we can solve the innovation index that correspond to one-level index and two-level index in each region. Calculating the one-level index fraction by weighted methods, the calculation formula is as follows:

$$Y_{ij} = \sum_{i=1}^t \sum_{j=1}^3 r_{ij} \cdot \omega_i \quad (7)$$

In the formula (7), i is the number of two-level index, t is the number of two-level index that correspond to one-level index, j represents years, ω_i is the weights that correspond to two-level index.

Based on the formula (7), we can calculate the total innovation index of a region by using the one-level index's weights that concluded in 3.2. The calculation formula is as follows:

$$Y_t = \sum_{i=1}^3 Y_{ij} \cdot \omega_a \quad (8)$$

In this formula, t represents the three regions, ω_a is one-level index weight.

As used herein, the data from the "Henan Statistical Yearbook --2013,2014,2015", Zhengzhou, Luoyang and Xinxiang 2012 - 2014 National Economic and Social Development Statistics Bulletin and open government website, the part of the data collected in the Ministry of Science and Technology torch High-tech industry development Center Web site. Due to differences in statistics, some indicators used in the three cities is the data used to replace of cities, such as per

capita GDP, the whole society to R & D expenditure as a percentage of GDP, etc. And when identify the indicators of high-tech enterprises, we used the statistics results of Zhengzhou, Luoyang, Xinxiang three national high-tech zones, which are lie in the list of passed high-tech enterprise identify that yearly batch released by Henan province.

First of all, according to the formula 4, Standardizing the data of the 15 two-level index of the three regions of Zhengzhou, Luoyang and Xinxiang. The standardization eliminates the difference of measurement units and numerical value in the evaluation of multi index. Limited to space, this paper uses the range of processing methods, and obtain a standard matrix. See Table 3.

Table 3. Standard matrix.

	Zhengzhou			Luoyang			Xinxiang		
	2012	2013	2014	2012	2013	2014	2012	2013	2014
1	0.87	0.92	1.00	0.00	0.07	0.11	0.46	0.59	0.71
2	0.96	0.90	1.00	0.00	0.26	0.27	0.34	0.49	0.59
3	0.75	0.89	1.00	0.38	0.43	0.47	0.00	0.06	0.11
4	0.84	0.93	1.00	0.00	0.02	0.05	0.17	0.22	0.20
5	1.00	0.91	0.00	0.64	0.45	0.27	0.27	0.27	0.09
6	0.00	0.13	0.15	0.35	0.20	0.24	0.92	0.97	1.00
7	0.65	0.85	1.00	0.15	0.20	0.22	0.00	0.04	0.07
8	1.00	0.93	0.38	0.81	0.83	0.86	0.00	0.15	0.22
9	0.69	0.87	1.00	0.24	0.25	0.29	0.00	0.04	0.09
10	0.53	0.60	0.88	0.63	0.48	1.00	0.00	0.04	0.36
11	1.00	0.92	1.00	0.01	0.01	0.00	0.07	0.04	0.08
12	0.12	0.84	1.00	0.00	0.03	0.02	0.00	0.01	0.02
13	0.20	0.45	0.99	1.00	0.61	0.72	0.00	0.04	0.46
14	0.00	0.00	0.13	0.71	0.51	1.00	0.14	0.10	0.83
15	0.57	0.79	1.00	0.02	0.04	0.00	0.63	0.72	0.52

And then, according to the above analysis, calculate the three regions of the total innovation index and the horizontal and vertical analysis of the innovation index.

3.2 Overall analysis of innovation index

Based on the formula and the method of 3, we can get the total index of innovation in Zhengzhou, Luoyang and Xinxiang, as well as the growth rate in 2012 as a benchmark. The details are shown in Table 4.

Table 4. Total innovation index and growth rate of 2012-2014.

region/year	2012	2013	2014	2013	2014
	innovation index	innovation index	innovation index	growth rate	growth rate
Zhengzhou	0.5171	0.6248	0.7288	0.1076	0.1040
Luoyang	0.4650	0.5532	0.6695	0.0882	0.1163
Xinxiang	0.1950	0.4549	0.6185	0.2599	0.1636

From Table 4, it is not difficult to see that Zhengzhou has been ahead of Luoyang and Xinxiang in the overall innovation index. Zhengzhou lead and promote economic restructuring and upgrading support innovation and development in Henan, and is of great significance to speed up the rise of the Central Plains, Henan revitalization and enriching Province. From the angle of growth rate, Zhengzhou is in a relatively stable position. This is because Zhengzhou has been concerned about innovation, and the policy of committed to leading innovation in Henan development. And Luoyang is showing a larger increase, its 2014 growth was even exceeds Zhengzhou. Although the growth rate of Xinxiang has slowed down, the growth rate is still large, ahead of Zhengzhou and Luoyang.

As a whole, Zhengzhou's innovation ability is the strongest, Luoyang is in the chase phase, Xinxiang is weak, and its growth rate has slowed down.

3.3 Index analysis of one-level index

Table 5 is the index of innovation environment, innovation investment and innovation output of the three cities Zhengzhou, Luoyang and Xinxiang during 2012-2014. From the point of view of innovation environment in Table 5, we can see that Zhengzhou has been in a leading position, Xinxiang is in a period of rapid growth, while Luoyang is in the volatility. From the point of view of innovation investment, there are fluctuations in Zhengzhou but in absolute advantage, Xinxiang, Luoyang are showing growth potential, while the larger growth rate in Xinxiang. From the point of view of innovation output, Luoyang and Zhengzhou are in a period of rapid growth. This is mainly due to the development of the information industry and the transformation of traditional enterprises. In Henan Province, the second batch of high-tech enterprises to be identified in the list of 62 enterprises in Zhengzhou, the transformation of traditional industries in the field of 26. And Luoyang has to be identified 22 high-tech enterprises, the transformation of traditional industries in the field of 13. To a certain extent, it shows that the transformation and upgrading of traditional enterprises have a greater promotion effect on the output of high -tech enterprises.

Table 5. The index of innovation environment, innovation investment and innovation output in 2012-2014.

	region/year	2012	2013	2014
Innovation environment	Zhengzhou	0.8877	0.9093	0.7788
	Luoyang	0.2192	0.2609	0.2422
	Xinxiang	0.2560	0.3333	0.3479
Innovation investment	Zhengzhou	0.6360	0.7264	0.6115
	Luoyang	0.4349	0.4222	0.4536
	Xinxiang	0.1961	0.2766	0.3214
Innovation output	Zhengzhou	0.3776	0.5119	0.7867
	Luoyang	0.5305	0.3686	0.6099
	Xinxiang	0.1469	0.1683	0.1222

4 Conclusion and discussion

Based on the above analysis, we can draw the following conclusions. Zhengzhou has a clear advantage in terms of innovation environment, innovation investment and innovation output, but the innovation environment and innovation input has a declining trend. Luoyang is basically in a stable stage, and has a greater advantage in terms of innovation output, as a result of the increase of traditional industrial transformation and upgrading. Xinxiang are basically at a disadvantage in the three regions, but the innovation environment for good performance. Its innovation investment continued to increase, and the innovation output showing a growing trend as well. It has a greater potential in the green environmental protection household electrical appliances, biological new medicine and other industries.

In this paper, the statistical data of Zhengzhou, Luoyang and Xinxiang are used to analyze the innovation ability of the three places. We have reached the index of innovation environment, innovation investment and innovation output, which is in line with the actual development. As the main park of Zhengzhou-Luoyang-Xinxiang National Innovation Demonstration Zone, its innovative ability is related to the innovation and development of the whole demonstration area. The analysis of this paper can be used as policy guidance. In the future we can establish a system suitable for the overall innovation index evaluation, based on the innovation index evaluation system of Independent Innovation Demonstration Zone in other countries and the data of Zhengzhou-Luoyang-Xinxiang. This is the direction of the future need to work hard as well.

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