Research on the horizontal layout of patents based on intuition-fuzzy analytic hierarchy process

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Abstract: The three-dimensional analysis model of the patent horizontal layout is an intuitive and visual comprehensive evaluation model. By analyzing the positioning of the patentee's horizontal layout of the patent, it guides the patentee to formulate corresponding improvement strategies and manage patent activities more efficiently. In recent years, some scholars have devoted themselves to building a scientific patent evaluation system in order to provide reasonable suggestions for the development of university patents, but there are still some shortcomings. This paper designs a questionnaire based on the intuition-fuzzy analytic hierarchy process, invites senior experts to score the indicators, calculates the weight of each indicator to the overall level of patents, and builds a quantity-quality-management three-dimensional analysis model. Taking Jiangsu University of Science and Technology as an example, the three-dimensional analysis model reveals the development track of the patent level of Jiangsu University of Science and Technology from 2004 to 2016.

1. Introduction

In early 2020, China and the United States signed the Economic and Trade Agreement between the Government of the People's Republic of China and the Government of the United States of America (hereinafter referred to as the "Agreement") in Washington, the United States. In the first chapter of the "Agreement", China and the United States agreed on intellectual property rights. At present, my country is transforming from an important intellectual property consumer country to an important intellectual property producer. As the main base for the training of national innovative talents, colleges and universities are also important organizations for basic research and technology development, and they are the key players in implementing the national innovation strategy. Important roles. In recent years, the number of patent applications in Chinese universities has shown a large increase. Among them, Tsinghua University, Shenzhen University, South China University of Technology, and Dalian University of Technology have ranked among the top 10 PCT educational institutions in the world in terms of PCT applications, reflecting the good performance of some universities. awareness of overseas patent layout.

When the number of applications reaches the expected level, the relevant state departments adjust their strategies and are committed to improving the quality of university patents and improving the unfavorable situation of "emphasizing quantity over quality". However, relevant survey reports show that most university patents are still There are structural problems such as short maintenance period, low industrialization, and insufficient awareness of overseas layout. In addition, most universities lack professional patent management personnel and institutions, and rely too much on external resources. Therefore, incomplete professional knowledge reserves and insufficient management experience have become the main obstacles restricting the development of patents in universities. In recent years, some scholars have devoted themselves to building a scientific university patent evaluation system, in order to provide reasonable suggestions for the development of university patents. Based on this, through

discussions with a number of senior experts, based on the intuitionistic fuzzy AHP and Min-Max normalization method, by constructing a three-dimensional patent horizontal layout model for quantity, quality and management, this paper refines the spatial area in the model, and uses an intuitive, It proposes improvement suggestions for each spatial area in a visual form to avoid false quantitative lead caused by the prominence of a single indicator.

2. Indicators and weights

2.1. Indicator selection

After reading a number of relevant documents and having in-depth discussions with a number of senior patent practitioners, three second-level indicators, quantitative index A, quality index B and management index C, were formed under the first-level index layer. Characterized by three tertiary indicators, as shown in Table 1.

Table1 Indexes of patente valuation

first indicator	Secondary indicators	three-level indicator
target layerD	Quantitative indicatorsA	Total number of patent applicationsA1
		Total number of authorized invention patentsA2
		Number of inventorsA3
	Quality IndexB	Number of claimsB1
		Number of Patent CitationsB2
		Invention patent grant timeB3
	management indicatorsC	Invention Patent Grant RateC1
		Annual maintenance rate of authorized invention patentsC2
		Number of patent operationsC3

2.2. Weight calculation method

On the basis of intuition-fuzzy AHP, in order to quantitatively describe the relative importance of attribute indicators and make them standardized, we define the scale of attributes, see Table 2.

Table2 Scaletableofimportance

Index evaluation level	Importance scale
factor i is extremely important compared to factor j	(0.90,0.10,0.00)
factor i is much more important than factor j	(0.80,0.10,0.10)
factor i is significantly more important than factor j	(0.70,0.20,0.10)
factor i is slightly more important than factor j	(0.60,0.30,0.10)
equally important	(0.50,0.50,0.00)
factor j is slightly more important than factor i	(0.30,0.60,0.10)
factor j is much more important than factor i	(0.20,0.70,0.10)
factor j is significantly more important than factor i	(0.10,0.80,0.10)
factor j is slightly more important than factor i	(0.10,0.90,0.00)

2.2.1 Consistency check

Using the intuitive fuzzy analytic hierarchy process to calculate the weight of indicators still cannot completely avoid the limitations of human decision-making. In order to make the decision more objective and accurate, this paper adopts the group decision-making model, that is, by inviting a number of senior experts to evaluate the upper target layer (criteria layer) of each indicator.) to compare the importance of each pair, and after establishing the intuitionistic fuzzy complementary judgment matrix, combined with the judgment weights of each expert, calculate the distance measure of the intuitionistic fuzzy complementary judgment matrix under group decision-making, and then carry out the consistency test.

Definition 1：

$$\mathrm{d}=\frac{1}{3}\left[\sqrt{\frac{\left(u_A(x)-u_B(x)\right)^2+\left(v_A(x)-v_B(x)\right)^2}{2}}+\left|u_A(x)-u_B(x)\right|+\left|v_A(x)-v_B(x)\right|\right]$$

The similarity measure is:

$$\mathrm{S}=1-\frac{1}{3}\left[\sqrt{\frac{\left(u_A(x)-u_B(x)\right)^2+\left(v_A(x)-v_B(x)\right)^2}{2}}+\left|u_A(x)-u_B(x)\right|+\left|v_A(x)-v_B(x)\right|\right]$$

Definition 2：

$$q_{\mathrm{ij}}=\left(u_{\mathrm{ij}},v_{\mathrm{ij}}\right);u_{\mathrm{ij}}=\sum_{k=1}^{l}\xi_k u_{\mathrm{ij}}^{(k)};v_{\mathrm{ij}}=\sum_{k=1}^{l}\xi_k v_{\mathrm{ij}}^{k};$$

$$u_{\mathrm{ii}}=v_{ii}=0.5(i=1,2,\ldots,n);\xi_1,\xi_2,\cdots,\xi_1$$

The similarity measure is:

$$\mathrm{S}(Q_k,Q)=1-\frac{1}{3n}\sum_{i=1}^{n}\left[\sqrt{\frac{(u_{ij}-u_{ij}^k)^2+(v_{ij}-v_{ij}^k)}{2}}+\left|u_{ij}-u_{ij}^k\right|+\left|v_{ij}-v_{ij}^k\right|\right]$$

2.2.2. weight calculation

Definition 3：

$$(\omega^{(\mathrm{l})})^{\mathrm{T}}=[\omega_1^{\mathrm{k}},\omega_2^{\mathrm{k}},\cdots,\omega_{\mathrm{n}}^{\mathrm{k}}]=\left[\frac{\Sigma_{\mathrm{j}=1}^{\mathrm{n}}\alpha_{1\mathrm{j}}^{(\mathrm{k})}}{\Sigma_{\mathrm{i}=1}^{\mathrm{n}}\Sigma_{\mathrm{j}=1}^{\mathrm{n}}\alpha_{\mathrm{ij}}^{(\mathrm{k})}},\cdots,\frac{\Sigma_{\mathrm{j}=1}^{\mathrm{n}}\alpha_{\mathrm{nj}}^{(\mathrm{k})}}{\Sigma_{\mathrm{i}=1}^{\mathrm{n}}\Sigma_{\mathrm{j}=1}^{\mathrm{n}}\alpha_{\mathrm{ij}}^{(\mathrm{k})}}\right]=$$

$$\left[\left(\frac{\Sigma_{\mathrm{j}=1}^{\mathrm{n}}\mathrm{u}_{\mathrm{ij}}^{(\mathrm{k})}}{\Sigma_{\mathrm{i}=1}^{\mathrm{n}}\Sigma_{\mathrm{j}=1}^{\mathrm{n}}\mathrm{u}_{\mathrm{ij}}^{(\mathrm{k})}},\frac{\Sigma_{\mathrm{j}=1}^{\mathrm{n}}\mathrm{v}_{2\mathrm{j}}^{(\mathrm{k})}}{\Sigma_{\mathrm{i}=1}^{\mathrm{n}}\Sigma_{\mathrm{j}=1}^{\mathrm{n}}\mathrm{v}_{\mathrm{ij}}^{(\mathrm{k})}}\right),\ldots,\left(\frac{\Sigma_{\mathrm{j}=1}^{\mathrm{n}}\mathrm{u}_{\mathrm{nj}}^{(\mathrm{k})}}{\Sigma_{\mathrm{i}=1}^{\mathrm{n}}\Sigma_{\mathrm{j}=1}^{\mathrm{n}}\mathrm{u}_{\mathrm{ij}}^{(\mathrm{k})}},\frac{\Sigma_{\mathrm{j}=1}^{\mathrm{n}}\mathrm{v}_{\mathrm{nj}}^{(\mathrm{k})}}{\Sigma_{\mathrm{i}=1}^{\mathrm{n}}\Sigma_{\mathrm{j}=1}^{\mathrm{n}}\mathrm{v}_{\mathrm{ij}}^{(\mathrm{k})}}\right)\right]$$

Definition 4：

$$\lambda^{\mathrm{T}}=(\lambda_1,\lambda_2,\cdots,\lambda_{\mathrm{n}})\begin{bmatrix}\omega_1^{(1)} & \omega_2^{(1)} & \cdots & \omega_{\mathrm{n}}^{(1)}\\ \omega_1^{(2)} & \omega_2^{(2)} & \cdots & \omega_{\mathrm{n}}^{(2)}\\ \vdots & \vdots & \ddots & \vdots\\ \omega_1^{(1)} & \omega_2^{(1)} & \cdots & \omega_{\mathrm{n}}^{(1)}\end{bmatrix}=$$

$$\left[\sum_{k=1}^{l}\xi_k\omega_1^{(k)},\sum_{k=1}^{l}\xi_k\omega_2^{(k)},\cdots,\sum_{k=1}^{l}\xi_k\omega_n^{(k)}\right]$$

Definition 5：To obtain the weights, we define a new scoring function as: $H(\lambda_i)=\frac{1-v_i}{1+\pi};H\left(\lambda_i\right)\in[0,1]$

Normalized: $\sigma_i = \frac{H(\lambda_i)}{\Sigma_{i=1}^{n} H(\lambda_i)}; (i = 1,2, \ldots, n)$

Comprehensive weighting of the weight of the first-level attribute relative to the weight of the second-level attribute: $\sigma^{(2)} = \left(\sigma^{(1)}\right)^T \sigma$, Comprehensive weights of available secondary indicators。

2.2.3. data normalization

This paper adopts the Min-Max normalization method, and the Min-Max normalization method is as follows:

$$x^* = \frac{x - m}{m - m}$$

2.2.4. Weight determination

This paper invited four senior experts to evaluate each indicator, and the experts have the right to evaluateThe weights are 0.22, 0.26, 0.26, 0.26. With the help of the intuition-fuzzy analytic hierarchy process, the weights of the questionnaires fed back by the experts are calculated, and the consistency test is carried out to ensure the rationality of the selection of indicators. The final realization is based on the intuitionistic fuzzy analytic hierarch process.Establish the intuitionistic fuzzy complementary judgment matrix of the criterion layer and the index layer, integrate the comprehensive intuitionistic fuzzy complementary judgment matrix, calculate the distance measure of the two, and test the consistency of the intuitionistic fuzzy complementary judgment matrix. The results are shown in the table3.

. Table 3 Complementary judgment matrices all passed the consistency test

Consistency Check Results			
$S(Q_D, Q_1) = 0.9157$	$S(Q_A, Q_1) = 0.9319$	$s(Q_B, Q_1) = 0.9926$	$S(Q_C, Q_1) = 0.9482$
$S(Q_D, Q_2) = 0.9264$	$\mathrm{s}(Q_A, Q_2) = 0.9313$	$s(Q_B, Q_2) = 0.9831$	$\mathrm{s}(Q_C, Q_2) = 0.8879$
$s(Q_D, Q_3) = 0.9141$	$S(Q_A, Q_3) = 0.8925$	$s(Q_B, Q_3) = 0.9831$	$s(Q_C, Q_3) = 0.9056$
$s(Q_D, Q_4) = 0.8513$	$s(Q_A, Q_4) = 0.9177$	$\mathrm{S}(Q_B, Q_4) = 0.9697$	$s(Q_C, Q_4) = 0.9430$

It is easy to see from Definition 1 and Definition 2 that the larger the similarity measure, the better the consistency. When the similarity measure is equal to 1, it means that the intuitionistic fuzzy matrices are exactly the same. According to the table results, they all pass the consistency test. The weight of the criterion layer relative to the target layer is calculated by definition 3, definition 4, and definition 5:$\sigma_D = (0.3245,0.3115,0.3640)$

Similarly:

$\sigma_A(0.3841,0.3051,0.3107), \sigma_B(0.4258,0.2593,0.3150), \sigma_C(0.3319,0.2910,0.3771)$

The weight matrix of each element in the index layer relative to each element in the criterion layer can be obtained as: $\sigma_X = (\sigma_A, \sigma_B, \sigma_C)$

3. Patented Horizontal Layout Model

This paper constructs a three-dimensional patent horizontal layout model with quantitative indicators, quality indicators and management indicators as the X, Y and Z axes, and determines the thresholds of each dimension through the intuitionistic fuzzy analytic hierarchy process and the comprehensive index

method, and divides eight regions as follows: A (backward area); B (technical area); C (active area); D (passive area); E (active area); F (economic area); G (potential area); H (advanced area).

It can be seen that the three-dimensional patent horizontal layout can refine multiple spatial areas, and display the shortcomings of each spatial area intuitively and visually, which not only enables universities or enterprises to understand their own competitiveness in the competition with patents in the same field. In addition to the horizontal positioning, it can also provide clear suggestions for improvement, which is a highly visible, highly contrastive, and very impressive form of expression, and has significant practical guiding significance.

4. Empirical Analysis

The evaluation object of this paper is Jiangsu University of Science and Technology. The fuzzy analytic hierarchy process and the three-dimensional patent horizontal layout are used to analyze the overall situation of the patents of Jiangsu University of Science and Technology from 2004 to 2016. The combination of quantitative and qualitative analysis methods focuses on analyzing the current status of patent output, patent quality and patent maintenance in Jiangsu University of Science and Technology, in order to objectively reflect the current situation of intellectual property development in Jiangsu University of Science and Technology, and provide an evaluation basis for the development of intellectual property in universities.

4.1. Data Sources

The data investigated in this paper are invention patents and utility model patents of Jiangsu University of Science and Technology from 2004 to 2016. The data sources are DerwentInnovationIndex and Patsnap. The details of Jiangsu University of Science and Technology are shown in the table4.

Table 4 Patent indexes data of Jiangsu University of Science and Technology

index / Year	A1	A2	A3	B1	B2	B3	C1	C2	C3
2004	14	2	2.93	2.93	0.57	2.93	40%	100%	1
2005	26	10	2.81	2.88	1.42	2.95	91%	90%	10
2006	26	6	2.23	3.65	0.77	2.41	43%	100%	11
2007	52	21	2.83	4.13	1.31	2.60	66%	100%	27
2008	98	51	3.03	4.08	1.16	2.45	64%	100%	39
2009	100	50	3.73	4.07	0.66	2.20	67%	100%	35
2010	112	64	3.44	3.37	3.07	2.31	75%	100%	35
2011	161	89	4.22	3.06	3.28	2.05	65%	98.88%	29
2012	333	215	4.20	3.92	4.07	2.31	67%	99.53%	36
2013	419	317	4.89	4.00	4.35	2.19	81%	94.32%	74
2014	368	256	4.65	5.44	4.09	2.16	79%	95.31%	75
2015	510	315	4.96	5.57	4.28	2.16	73%	92.38%	88
2016	740	452	4.92	6.19	4.94	2.13	69%	98.67%	124

It can be seen from the table that the nine indicators basically show a clear growth trend over time. On the one hand, it reflects the improvement of the overall scientific and technological innovation strength of Jiangsu University of Science and Technology, and more and more scientific and technological talents are participating in scientific and technological innovation activities; Under the special background of colleges and universities, the patent operation will be brought into play to a higher level.

4.2. data analysis

According to the above index value, index weight and min-max normalization processing method, the standardized data of each index of Jiangsu University of Science and Technology is obtained, see Table 5.

Table 5 Standardized data and regional division of Jiangsu University ofScience and Technology

Year	A	B	C	Regional division
2004	0.0797	0.0134	0.2910	A
2005	0.0778	0.0504	0.3595	A
2006	0.0091	0.2999	0.3412	A
2007	0.1013	0.3272	0.5399	E
2008	0.1687	0.3644	0.5637	E
2009	0.2488	0.4209	0.5709	E
2010	0.2316	0.4354	0.6230	E
2011	0.3632	0.4990	0.5069	E
2012	0.5374	0.5655	0.5604	H
2013	0.7306	0.6344	0.6163	H
2014	0.6349	0.8147	0.6352	H
2015	0.7853	0.8427	0.5508	H
2016	0.9953	0.9721	0.8181	H

It can be seen from the data that from 2004 to 2016, the patents of Jiangsu University of Science and Technology have shown a steady upward trend in terms of quantitative indicators, quality indicators or management indicators. First of all, from 2006 to 2007, management indicators took the lead in completing the transformation from quantitative change to qualitative change, and it can be seen that after 2007, the management indicators have remained stable and slightly improved, while the quantitative indicators and quality indicators have achieved quantitative changes in 2012.

The transformation of qualitative change, the level of patent layout has changed from the active area to the leading area, and in the following period, the three indicators have developed in coordination, and the patent level has been continuously improved, which reflects the deep investment and high importance of Jiangsu University of Science and Technology in intellectual property.

5. Conclusion

On the basis of discussing the research status of comprehensive patent evaluation methods, this paper conducts some basic research on the patent level evaluation system from the aspects of index design, combination, classification, construction, etc. The model, through TI and Patsnap retrieval, analyzes the patents of Jiangsu University of Science and Technology from 2004 to 2016, and gives an objective positioning of its comprehensive level of patents. From the weak overall awareness of patents and poor performance of indicators in the early stage, to the improvement of the level of patent management in the mid-term, the improvement of quantitative indicators and quality indicators is driven by high-level patent management capabilities. The development trajectory of the comprehensive level of patents. The patent level evaluation system and model constructed in this paper have good practicability, operability and intuitiveness. It is an evaluation method with strong relativity and high degree of objectivity. It can also be used for comprehensive evaluation of patent level in other fields. The model has been appropriately improved on the basis of the previous research, and there are inevitable deficiencies, which need further research and improvement, so as to enrich the patent level evaluation system.

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