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Research on the Construction and Development Trend of Productive Service Industry Index System

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ABSTRACT. *With the development of industrialization, socialization, marketization, and urbanization, the emergence of a productive service industry with modern service economic characteristics with professional services, information services, and financial services as the main content has promoted the upgrading and upgrading of the industrial economy. Effective development of other economies. This paper combines statistical professional knowledge to build a set of general evaluation index system of productive service industry functional areas from the five aspects of regional productive service industry development scale, development momentum, development foundation, development environment, and development potential. The fuzzy comprehensive evaluation method is used to quantify the indicators and establish an evaluation model of the development level of productive services. An AHP-fuzzy comprehensive evaluation model of the productive service industry is proposed. Based on the actual situation of Hebei Province, this paper uses the above evaluation index system and evaluation model to conduct an example analysis, and verifies the feasibility and scientificity of the evaluation model.*

KEYWORDS: *Productive service industry; Indicator system; Analytic hierarchy process; Fuzzy comprehensive evaluation*

1. Introduction

Introduction: The term “productive services” first appeared in the early 1960s, during which some foreign scholars conducted exploratory research.[1] Domestic scholars' research on the productive service industry started late. Since the 1980s, the global industrial structure has begun to transition from an “industrial economy” to a “service economy”. The development of the service industry has become an economic growth An important impetus is also an important sign of modernization.[2] At the same time as the three industries have undergone a structural evolution, the internal sector structure of the service industry is also quietly changing. The productive service industry with modern economic characteristics, with financial services, information services, and professional

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services as its main content, has emerged. The productive service industry has gradually become an important category of the service industry, and its position and role in the overall service industry and the national economy have continued to rise.[3] This article starts from the concept of the productive service industry and the basis of competitiveness theory, and seeks the connotation of the competitiveness of the productive service industry. Then, it establishes an evaluation index system of the productive service industry competitiveness, and uses AHP-fuzzy comprehensive evaluation method for productive services Comparative analysis of the industry competitiveness, and make corresponding tests in combination with the actual situation of Hebei Province.[4-6]

2. Evaluation Index System of Production Service Industry

Based on the in-depth study of the competitiveness of the productive service industry and reference to previous research results, the comprehensive competitiveness of the productive service industry is defined as five aspects, which are the development scale, development momentum, and development foundation of the productive service industry Development environment and development potential. The established indicator system is shown in Table 1. The system includes five aspects and 24 indicators.

Table 1 Evaluation Index System for Competitiveness of Productive Services

First-level indicators	Secondary indicators	Tertiary indicators
Comprehensive strength	Development foundation D_1	GDP growth rate per capita D_{11}
		Proportion of science and technology expenditure in fiscal expenditure D_{12}
		Proportion of education expenditure in fiscal expenditure D_{13}
		Proportion of government public service expenditure in fiscal expenditure D_{14}
		Per capita value added of the secondary industry D_{15}
		Tertiary industry added value per capita D_{16}
	Development scale D_2	Value added of productive services to GDP D_{21}
		Added value of production and service industries per capita D_{22}
		Proportion of Productive Services in Tertiary Industry Value Added D_{23}
		Proportion of employees in productive services

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		to all employees D_{24}
	Development motivation D_3	Productive Services Labor Productivity D_{31}
		Annual growth rate of the tertiary industry D_{32}
		R&D funding D_{33}
		Producer Services Fixed Investment D_{34}
		Professional skill worker D_{35}
		Foreign direct investment D_{36}
	Development Environment D_4	Degree of marketization D_{41}
		Highway mileage average growth rate D_{42}
		Urbanization rate D_{43}
		Openness D_{44}
		Telephone penetration D_{45}
	Development potential D_5	Proportion of value added in the financial industry D_{51}
		Proportion of value added in the real estate industry D_{52}
		Proportion of value added in transportation, storage and postal services D_{53}

2.1 Explanation of Some Indicators

Because in the evaluation index system for the competitiveness of the productive service industry, the data of some indicators cannot be directly obtained and must be obtained through simple calculations, some explanations are given for these indicators.

(1) Per capita GDP growth rate: an important indicator reflecting the regional economic foundation and economic development status, which is equal to the per capita GDP of the current year minus the per capita GDP of the previous year and then divided by the per capita GDP of the previous year multiplied by 100%.[7-9] In this article, in order to better reflect the growth rate of per capita GDP in each region, the data used is the average growth rate of per capita GDP from 2014 to 2018.

(2) Proportion of employees in the productive service industry to all employees: It is an important indicator reflecting the employment absorption capacity of a region's productive service industry, and it is also an important indicator of whether the productive service industry has development potential.[10] It is generally measured by the sum of the number of employees in various industries in the productive service industry divided by the total number of employees in each industry.

(3) R&D funding: An important indicator to measure the scientific and technological strength and core competitiveness of a region. It refers to the capital invested for systematic and innovative scientific and technological activities. This article uses the 2018 research and experimental development (R&D) activities of large and medium-sized industrial enterprises to measure this indicator.

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(4) Degree of marketization: A quantitative indicator that reflects the level of marketization and openness of a region. It is usually expressed by the proportion of private enterprises and individual employment among all employees in all employment.[11]

(5) Urbanization rate: It is an important quantitative indicator to measure the degree of urbanization development in each region. Generally, it is expressed by the proportion of the urban population in a region to the total population of the region.

(6) Openness: Also known as economic openness, it usually refers to the ways and degrees of allowing other countries' economies to penetrate into their own economies. This article uses a more general and simple method, that is, the proportion of total imports and exports to GDP. [12-15]

(7) Telephone penetration rate: During the reporting period, the average number of telephones per 100 people in an administrative area, including mobile phones and fixed phones. That is, the total number of telephones divided by the total population of the administrative area multiplied by 100%.

(8) Average growth rate of the financial industry: The main indicator for measuring the development of the financial industry in a region, in this article refers to the average growth rate of the value added of the financial industry in 2014-2018.[16-17] In addition, the average growth rate of the real estate industry and the average growth rate of the transportation, warehousing and postal industries use the average growth rate of the industry from 2014 to 2018.

3. Construction of AHP-Fuzzy Comprehensive Evaluation Model

The AHP fuzzy comprehensive evaluation model established in this paper is an organic combination of AHP and fuzzy comprehensive evaluation method to comprehensively evaluate the functional area of the productive service industry, that is, to determine the sub-objectives and the weights of various indicators through the analytic hierarchy process.[18] The fuzzy comprehensive evaluation method comprehensively evaluates the functional areas of the productive service industry. The two methods complement each other and jointly improve the reliability and effectiveness of the evaluation. The technical route is as follows:

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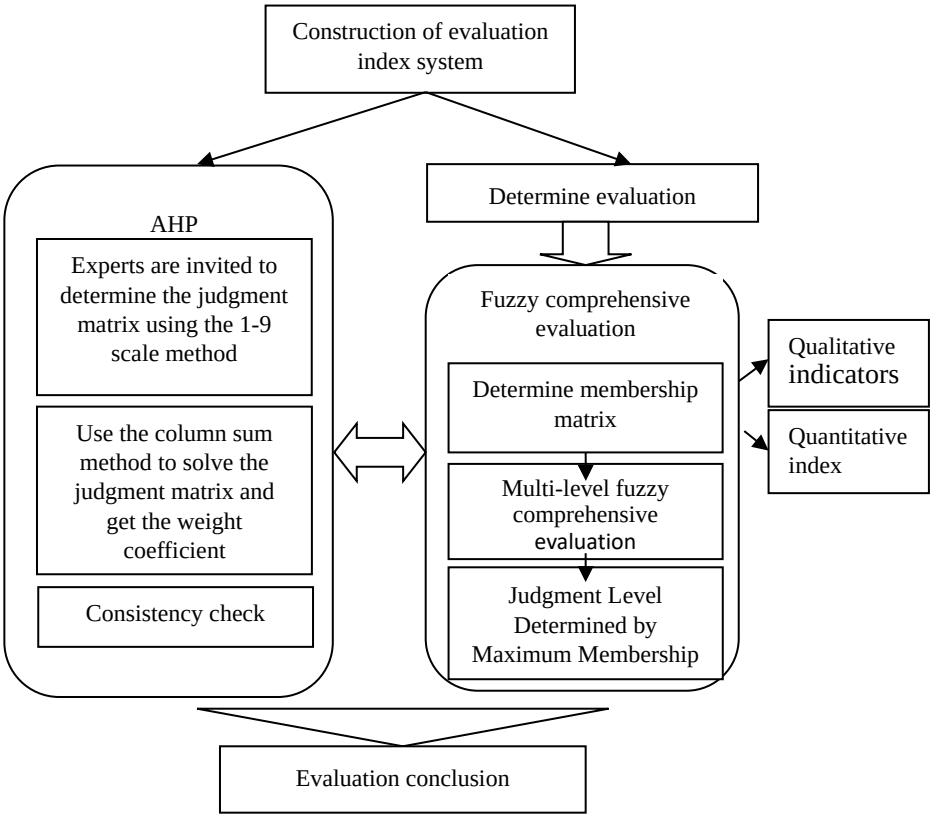

Figure. 1 AHP-fuzzy comprehensive evaluation model

3.1 Determination of Comprehensive Evaluation Factor Set

This article analyzes the degree of influence of each influencing factor on the functional area, distinguishes its importance by setting the weight of various influencing factors, uses the basic theoretical membership of fuzzy mathematics to quantify fuzzy information, reasonably selects the factor domain value, and then Quantitative evaluation of multiple factors using traditional mathematical methods to scientifically draw evaluation conclusions. According to the fuzzy evaluation theory, the above index system is composed of a two-level and three-level fuzzy evaluation model for comprehensive evaluation of the productive service industry functional area. The specific process is as follows:

First, determine the comprehensive evaluation factor set of the productive service industry functional area. Establish the evaluation factor set based on the evaluation index system, and set the first-level evaluation factor set $D=\{D_1,D_2,\cdots,D_i\}$, $i=5$ in this article, The factor set is

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$D=\{D_1, D_2, D_3, D_4, D_5\}$. The secondary evaluation factors are represented by $D_i=\{D_{i1}, D_{i2}, ..., D_{ij}\}$, Where represents the j-th secondary indicator below the i-th primary indicator. In this paper, there are 6 secondary indicators under the first primary evaluation indicator, which is denoted as $D_1=\{D_{11}, D_{12}, D_{13}, D_{14}, D_{15}, D_{16}\}$, 3 secondary indicators under the fifth primary evaluation indicator, which is denoted $D_5=\{D_{51}, D_{52}, D_{53}\}$, and so on.

3.2 Establishing Evaluation Levels

The evaluation level set is a set indicating the degree of pros and cons of the evaluation target. Expressed as $V=[v_1, v_2, ..., v_k]$. In this paper, according to the requirements of the comprehensive evaluation of the productive service industry functional area, a four-level evaluation method can be adopted, that is, $k=4$ and $V=[v_1, v_2, ..., v_k]=[excellent, good, medium, poor]$.

3.3 Determine the Weight Set of Evaluation Factors

This paper uses the analytic hierarchy process (AHP) to determine: the expert survey method constructs a comparative judgment matrix, finds the eigenvectors and eigenroots of the matrix, and performs consistency checks to obtain the weight values of each factor.

(1) Construction of judgment matrix

Based on Saaty's number 1-9 and its reciprocal as a scale for judging the relative importance of the two factors, the importance of the two indicators is determined by the scores of industry veterans and experts and scholars.[19] After evaluation, the qualitative problems will be determined. Quantification constitutes the judgment matrix A:

$$A=\begin{bmatrix} a_{11} & a_{12} & ... & a_{1n} \\ a_{21} & a_{22} & ... & a_{2n} \\ ... & ... & ... & ... \\ a_{n1} & a_{n2} & ... & a_{nn} \end{bmatrix}=(a_{ij})_{n\times n}$$, among them $a_{ij}>0, a_{ij}=1/a_{ij}, a_{ii}=1$

a_{ij} indicates the relative importance of the i-th goal and the j-th goal.

(2) Use the column sum method to solve the judgment matrix.

That is, each column is normalized, and then the normalized judgment matrix of each column is added by rows, that is, the arithmetic mean of the n column vectors is used as the weight vector. which is:

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$$w_i = \frac{1}{n}\sum_{j=1}^{n}(a_{ij} / \sum_{k=1}^{n} a_{kj})$$

(3) Consistency inspection.

First, calculate the maximum feature root:

$$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n}\frac{(AW)_i}{W_i}$$

Among them, $(AW)_i$ represents the i-th component of the vector AW .

Then, the consistency of the matrix A is checked by the consistency ratio $CR = CI / RI$. When CR <0.1, the matrix A passes the consistency test, and the feature vector may not be used to represent the weight. Otherwise, perform a pairwise comparison and adjust the elements of the matrix until the consistency check is passed. Among them, CI is the consistency index:

$$CI = \frac{\lambda_{\max} - n}{n-1}$$

RI is the average random consistency index, as shown in Table 2:

Table 2 Random Consistency Values of n-th Order Matrices

dimension	1	2	3	4	5	6	7	8	9
RI	0	0	0.59	0.9	1.12	1.24	1.32	1.41	1.45

3.4 Determine the Membership Matrix

In this paper, Delphi method expert scoring method is used to determine the affiliation of qualitative indicators. Industry experts judge a level within each secondary index based on the evaluation level, and then count the expert approval rate of each index under each comment and treat it as the membership of the comment set P for each indicator. R_i fuzzy relation matrix A is established based on the membership relationship of the evaluation set P to the secondary evaluation factors.

$$R_i = \begin{bmatrix} r_{i11} & r_{i12} & \cdots & r_{i1k} \\ r_{i21} & r_{i22} & \cdots & r_{i2k} \\ \cdots & \cdots & \cdots & \cdots \\ r_{ij1} & r_{ij2} & \cdots & r_{ijk} \end{bmatrix}$$

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Where r_{ijk} represents the degree of membership of the j-th secondary evaluation index relative to the k-th evaluation level under the i-th primary evaluation index, and $\sum_{K=1} r_{ijk} = 1$.

In determining the membership of quantitative indicators, this paper uses the linear analysis method. First determine a series of values with a cut-off point on a continuous interval, and then process the actual indicator value by a linear interpolation formula to obtain the membership degree corresponding to the indicator value. At the same time, the semi-trapezoidal distribution function is used as the membership function.

The membership functions corresponding to the four levels in the comment set for each factor are:

$$r_1 = \begin{cases} 0 & 0 \le X \le p_2 \\ \dfrac{X - p_2}{p_1 - p_2} & p_2 < X < p_1 \\ 1 & X \ge P_1 \end{cases} \qquad r_2 = \begin{cases} 0 & X \ge p_1 \text{或} X \le X_3 \\ \dfrac{p_1 - X}{p_1 - p_2} & p_2 < X < p_1 \\ 1 & X = p_2 \\ \dfrac{X - p_3}{p_2 - p_3} & p_3 \le X \le p_2 \end{cases}$$

$$r_3 = \begin{cases} 0 & X \ge p_2 \text{或} X \le p_4 \\ \dfrac{p_2 - X}{p_2 - p_3} & p_3 < X < p_2 \\ 1 & X = p_3 \\ \dfrac{X - p_4}{p_3 - p_4} & p_4 \le X \le p_3 \end{cases} \qquad r_4 = \begin{cases} 0 & X \ge p_3 \\ \dfrac{p_3 - X}{p_3 - p_4} & p_4 < X < p_3 \\ 1 & 0 \le p_4 \end{cases}$$

3.5 Multilevel Fuzzy Comprehensive Evaluation

(1) First-level fuzzy evaluation

Let the weight of the first-level evaluation factors be assigned as $W = (W_1, W_2, ..., W_i)$, the weight of the second-level evaluation factors be assigned as $W_i = (w_{i1}, w_{i2}, ..., w_{ij})$, and w_{ij} is the weight of the j-th second-level index under the i-th first-level index, that is, $\sum w_{ij} = 1$. Set factors D_i for comprehensive evaluation respectively. Using the fuzzy evaluation matrix R_i, a comprehensive evaluation vector B_i of each factor is obtained:

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$$B_i = W_i R_i = (w_{i1}, w_{i2}, ..., w_{ij}) \begin{bmatrix} r_{i11} & r_{i12} & \cdots & r_{i1k} \\ r_{i21} & r_{i22} & \cdots & r_{i2k} \\ \cdots & \cdots & \cdots & \cdots \\ r_{ij1} & r_{ij2} & \cdots & r_{ijk} \end{bmatrix} = \sum (w_{ij} \times r_{ijk}) = (b_{i1}, b_{i2}, ..., b_{ik})$$

(2) Secondary fuzzy evaluation

Using the results of the first-level fuzzy evaluation, comprehensively evaluate the factor set D to obtain the fuzzy evaluation matrix R of the target layer.

$$R = \begin{bmatrix} B_1 \\ B_2 \\ \cdots \\ B_i \end{bmatrix} = \begin{bmatrix} b_{11} & b_{12} & \cdots & b_{1k} \\ b_{21} & b_{22} & \cdots & b_{2k} \\ \cdots & \cdots & \cdots & \cdots \\ b_{i1} & b_{i2} & \cdots & b_{ik} \end{bmatrix}$$

The comprehensive evaluation of the evaluation object is:

$$B = WR = (w_1, w_2, ..., w_i)(B_1, B_2, ..., B_i)^T = (b_1, b_2, ..., b_k)$$

3.6 Analysis of Comprehensive Evaluation Results

Applying the principle of maximum membership in fuzzy mathematics, if $b_m = \max\{b_1, b_2, ..., b_k\}$, then the comprehensive evaluation of the model is v_m. That is, if b_2 is the largest in $(b_1, b_2, ..., b_k)$, the evaluation result is the second rank. According to the evaluation results, you can determine the level of the evaluation object, analyze the advantages and disadvantages of the evaluation object in the development, so as to improve the shortcomings, consolidate the highlights, and help policy makers and management to formulate strategic goals in line with actual conditions.

4. Application and Analysis of Comprehensive Evaluation of Productive Service Industry Functional Areas

In this paper, a survey was conducted on the functional areas of the productive service industry in Hebei Province. A large number of relevant data on the development of functional areas were collected. Based on this, Delphi method was used to survey and consult relevant experts to obtain a fuzzy evaluation matrix for the functional area. Obtain the weight of each evaluation factor through the analytic hierarchy process, apply the above evaluation model, and make an empirical study on the comprehensive level of the functional area of the productive service industry based on the previously designed index system, as follows:

4.1 Calculation of Indicator Weights

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Experts are invited to compare the importance of each factor in the evaluation at all levels, and the results of the comparison are used to establish the distribution weight of the AHP judgment matrix. In order to obtain a quantified judgment matrix, a 1-9 scale method is adopted, and the relative importance of the A-layer factors and the inner factors is examined separately through expert consultation to obtain a judgment matrix.

Calculate the weight of each indicator and consistency check. The results are shown in Table 3.

Table 3 Indicator Weight and Consistency Check

matrix	W normalized results	λ max	CI	RI	CR	Consistency check
$A-A_{ij}$	W=(0.11,0.21,0.29,0.17,0.22)	5.1364	0.041	1.12	0.04	passing
A_1-A_{ij}	W=(0.16,0.19,0.19,0.05,0.12, 0.29)	6.35	0.070	1.24	0.06	passing
A_2-A_{ij}	W=(0.42,0.27,0.12,0.19)	4.07	0.024	0.9	0.03	passing
A_3-A_{ij}	W=(0.11,0.15,0.34,0.32,0.04,0.04)	6.43	0.086	1.24	0.07	passing
A_4-A_{ij}	W=(0.26,0.12,0.37,0.08,0.17)	5.09	0.023	1.12	0.02	passing
A_5-A_{ij}	W=(0.33,0.33,0.33)	3	0	0.58	0	passing

4.2 Determine the Membership Matrix

According to the comment set $V=[v_1,v_2,...,v_k]=[excellent, good, medium, poor]$, experts are asked to rate the various indicators of the productive service industry functional area and normalize the scoring results to obtain a fuzzy comprehensive evaluation matrix as follows:

$$R_1=\begin{bmatrix} 0.15 & 0.35 & 0.40 & 0.10 \\ 0.30 & 0.40 & 0.25 & 0.05 \\ 0.15 & 0.20 & 0.55 & 0.10 \\ 0.25 & 0.50 & 0.20 & 0.05 \\ 0.25 & 0.35 & 0.25 & 0.15 \\ 0.20 & 0.35 & 0.45 & 0.00 \end{bmatrix}$$

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$$R_2 = \begin{bmatrix} 0.25 & 0.25 & 0.40 & 010 \\ 0.30 & 0.40 & 0.25 & 0.05 \\ 0.20 & 0.35 & 0.30 & 0.15 \\ 0.15 & 0.40 & 0.35 & 0.10 \end{bmatrix}$$

$$R_3 = \begin{bmatrix} 0.20 & 0.40 & 0.30 & 0.10 \\ 0.35 & 0.45 & 0.20 & 0.00 \\ 0.15 & 0.25 & 0.40 & 0.20 \\ 0.20 & 0.30 & 0.45 & 0.05 \\ 0.15 & 0.35 & 0.40 & 0.10 \\ 0.15 & 0.25 & 0.40 & 0.20 \end{bmatrix}$$

$$R_4 = \begin{bmatrix} 0.15 & 0.25 & 0.45 & 0.10 \\ 0.25 & 0.40 & 0.25 & 0.10 \\ 0.20 & 0.50 & 0.30 & 0 \\ 0.20 & 0.45 & 0.35 & 0 \\ 0.55 & 0.20 & 0.20 & 0.05 \end{bmatrix}$$

$$R_5 = \begin{bmatrix} 0.20 & 0.35 & 0.35 & 0.10 \\ 0.20 & 0.40 & 0.30 & 0.10 \\ 0.25 & 0.45 & 0.35 & 0.05 \end{bmatrix}$$

According to formula $B_i = W_i R_i = \sum (w_{ij} \times r_{ijk}) = (b_{i1}, b_{i2}, ..., b_{ik})$, we get:

$$B_1 = W_1 R_1 = (0.16, 0.19, 0.19, 0.05, 0.12, 0.29) \begin{bmatrix} 0.15 & 0.35 & 0.40 & 0.10 \\ 0.30 & 0.40 & 0.25 & 0.05 \\ 0.15 & 0.20 & 0.55 & 0.10 \\ 0.25 & 0.50 & 0.20 & 0.05 \\ 0.25 & 0.35 & 0.25 & 0.15 \\ 0.20 & 0.35 & 0.45 & 0 \end{bmatrix}$$

$$= (0.2100 \quad 0.3385 \quad 0.3865 \quad 0.0650)$$

Similarly, we can find:

$B_2 = (0.2385 \quad 0.3310 \quad 0.3380 \quad 0.0925)$,

$B_3 = (0.2015 \quad 0.3165 \quad 0.3750 \quad 0.1070)$,

$B_4 = (0.2525 \quad 0.3680 \quad 0.3200 \quad 0.0465)$,

$B_5 = (0.2145 \quad 0.3960 \quad 0.3630 \quad 0.0825)$

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The comprehensive evaluation of the target layer is:

$$B = W * R = (w_1, w_2, ..., w_5) * (B_1, B_2, ..., B_5)^T$$

$$= (0.11\ 0.21\ 0.29\ 0.17\ 0.22) \begin{bmatrix} 0.2100 & 0.3385 & 0.3865 & 0.0650 \\ 0.2385 & 0.3310 & 0.3380 & 0.0925 \\ 0.2015 & 0.3165 & 0.3750 & 0.1070 \\ 0.2525 & 0.3680 & 0.3200 & 0.0465 \\ 0.2145 & 0.3960 & 0.3630 & 0.0825 \end{bmatrix}$$

$$= (0.2217 \quad 0.3482 \quad 0.3565 \quad 0.0837)$$

According to the principle of maximum membership:

$$\max\{b_1, b_2, b_3, b_4\} = (0.2217 \quad 0.3482 \quad 0.3565 \quad 0.0837) = b_3 = 0.3565$$

It shows that the degree of membership of P_3 is the largest, so the evaluation result is that the level of development of productive service industry in Hebei Province is medium.

4.3 Evaluation of Results

By querying the data of each indicator, in view of the operability and representativeness of the indicator data, nine of them were selected for comparison, and the data of Hebei Province were used to compare with Beijing (representative of more productive areas) and Qinghai (representative of less developed areas) And the national average level is compared to get the following figure.

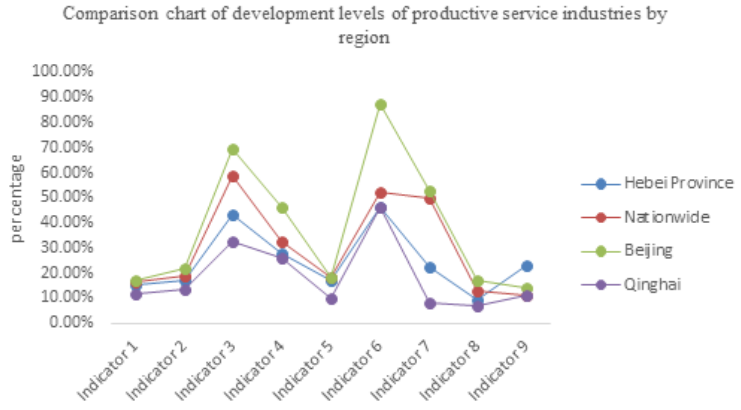

Figure.2 Comparison of Some Indicators of Productive Service Industries by Region

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From the picture above:

First, with regard to the growth rate of GDP per capita (indicator 1), the share of education expenditure in fiscal expenditure (indicator 2), the proportion of productive services in the value added of the tertiary industry (indicator 3), and the proportion of employees in productive services The proportion of all personnel (indicator 4), the four indicators, Hebei Province is lower than the national average and developed areas such as Beijing, but higher than less developed areas such as Qinghai Province, the overall level of development is still relatively low;

Secondly, for the four indicators of growth rate of the tertiary industry (indicator 5), urbanization rate (indicator 6), degree of openness (indicator 7), and the proportion of value added in the financial industry (indicator 8), Hebei Province is lower than Beijing, etc. Developed areas have a small gap with the national average, and are much higher than less developed areas such as Qinghai Province. The overall level of development is medium, and they have a strong upside potential;

For the value-added index of transportation, warehousing, and postal services (indicator 9), Hebei Province is much higher than the national average. Developed areas such as Beijing and less developed areas such as Qinghai have a better overall development level, indicating that their traditional service industries have Obvious advantages can create favorable conditions for further development.

5. Conclusion

As far as the productive service industry in Hebei Province is concerned, first of all, the proportion is relatively small. Although the modern service industry is generally on the rise, the overall proportion of the productive service industry is low, and the development energy level is not high. There is a gap compared with the service industry's advantageous regions. Secondly, the hierarchical structure is not reasonable, and the productive service industry is still dominated by traditional industries such as transportation, warehousing, and postal services. Production services, it is still difficult to meet the needs of the upgrading of the manufacturing industry; in addition, the market is not open enough, some high-tech, communications and other monopoly industries are not sufficiently open, lack of competition mechanisms, and the degree of openness of the productive service industry In addition, the competitiveness is not strong, the development of modern logistics, R&D design, information services, and business services is lagging, the scale is small, and the competitiveness is insufficient. Emerging service industries such as cultural creativity, animation industry, and service outsourcing start late and develop slowly. , Has not yet formed a competitive advantage.

On the other hand, although the overall level of productive service industry in Hebei Province is not very strong, it has a good development environment and favorable geographical advantages, and can provide a sufficient external environment guarantee for the further development of productive service industry; Furthermore, it can rely on the industrial advantages of developed areas such as Beijing and Tianjin to drive the development of its industrial foundation and

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enhance its development momentum; moreover, it can strengthen the expansion and development of industrial scale through industrial structural adjustment and internal upgrades.

In short, the construction and study of the indicator system of the productive service industry can obtain various factors that affect the development of the productive service industry, and provide a strong and favorable guarantee for the development of the regional economy.

In summary of the above aspects, the development level of productive service industry in Hebei Province is just at the development stage, and there are still many imperfections, which are consistent with the results obtained by using the AHP-fuzzy comprehensive evaluation above, thereby verifying the feasibility of the above method with correctness.

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