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Evaluation and Comparative Study of the Equalization Level of Basic Public Services of Preschool Education in Chinese Provinces

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Abstract:

An evaluation index system is constructed in the present study to evaluate the equalization level of basic public services of provincial preschool education. This index is based on the defined connotation and constituent elements of equalization of basic public services in preschool education, combined with empirical preliminary screening and optimized screening methods. AHP method, entropy method, and critical method are used to determine the index weight and obtain the equalization level of basic public services of preschool education in 31 provinces (cities) in China at different periods. This paper conducts an in-depth comparative analysis of the overall level and main indicators of equalization of basic public services in preschool education in different provinces. The analysis is based on the above mentioned methods combined with the global and local spatial correlation analysis method, factor contribution analysis, and index dispersion coefficient analysis. Results showed that, from 2010 to 2018, the overall trend of the equalization level coefficient of basic public services of preschool education in all provinces (cities) in China was relatively stable. This result is depicted an obvious decreasing ladder distribution in the east, middle, and west, which suggests a stable aggregation and discrete distribution pattern in spatial distribution. The core-periphery spatial distribution pattern of the comprehensive score of equalization level of preschool education services in Chinese provinces was initially formed and was relatively stable. The analysis results of factor contribution and index dispersion coefficient can provide reference for local governments in formulating relevant regulatory policies to improve the equalization of basic public services in regional preschool education.

Keywords*: Basic public services of preschool education, Equalization, Evaluation index system, Combination empowerment, ESDA*

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I. INTRODUCTION

Building a wide coverage for basic, quality, and inclusive basic public service system of preschool education highlights the social value demands of "fairness and justice." Integrating political, economic, and social development ideals into the policy goal of "equalization of basic public services of preschool education" has become the basic point and value orientation of a new policy framework for public education. In 2010, the Chinese government promulgated the "National Medium and Long-term Education Reform and Development Plan (2010–2020)", which had the following mandate: "a basic public education service system covering urban and rural areas should be established; basic public education services should be gradually equalized, and regional gaps should be narrowed"; "preschool education should be basically popularized"; "the development of preschool education should be brought into the urban and new socialist rural construction plan"; "strive to improve the popularization of rural preschool education"; and "support the development of preschool education in poor areas". In 2012, the Notice of the Twelfth Five-Year Plan for the National Basic Public Service System included inclusive preschool education, nine-year compulsory education, and high school education into the scope of basic public education services. The Twelfth Five-Year Plan also proposed to build a public service system of preschool education covering urban and rural areas with a reasonable layout.

According to the "Statistical Bulletin of National Education Development in 2020" issued by the Ministry of Education of China, there are 291,700 kindergartens in China, 48.182 million children in kindergarten, and a gross enrollment rate of preschool education at 85.2%. "Preschool education" has been fully popularized and maintains a trend of rapid and stable development. In 2020, in the face of the COVID-19 pandemic, China extensively implemented online teaching and achieved full resumption of in-school classes in the fall semester, allowing the country to win the fight against poverty in education and achieve comprehensive reforms in education. However, the pandemic is like a magnifying glass that highlights many existing developmental bottlenecks in China's basic public services in preschool education. Among these bottlenecks are unreasonable educational structure and layout and unbalanced educational capacity and teaching development in urban and rural areas and inter schools among regions. This imbalance has become an important issue that must be addressed by the Chinese government. Therefore, a set of scientific evaluation index systems and programs should be designed to evaluate the current status and development trend of the equalization level of basic public services of preschool education in various provinces (municipalities) in China. Improving the effectiveness of policy implementation has strong practical significance as well.

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II. BRIEF REVIEW OF EXISTING RESEARCH

Research on the evaluation of basic public services of preschool education mainly focuses on two aspects. First is the evaluation of the equalization level of basic public services for individual preschool education. At present, domestic and foreign scholars use absolute difference values, such as standard deviation and range, and relative difference values, such as coefficient of variation, education Gini coefficient, and education Theil index, to measure the equalization level of preschool education. For example, from the perspective of government transfer payment, Qingsong Hong used the coefficient of variation index to measure the degree of preschool education equalization among Chinese provinces (cities)[1]. Ling Zhang et al. comprehensively calculated and evaluated the balance degree of development in urban and rural preschool education during the Twelfth Five-Year Plan using the Gini coefficient[2]. Ailing Zhuang et al. analyzed the degree of equalization of preschool education services nationwide and the four regions of the East, West, Central and Northeast by calculating the Theil index of education funds in the public financial budget weighted by the number of children in kindergartens and the GDP and by comparing the differential contribution rate[3]. Second is research on the level of equalization of basic public services of comprehensive preschool education. Scholars analyzed the equal development of preschool education among regions, between urban and rural areas, among schools, and among classes or groups from a macro and meso perspective. They started from the dimensions of equal starting point or equal opportunity, equal allocation of educational resources or conditions, equal quality of educational process, and equal educational results. For example, Minyi Li et al. combined the CIPP model to divide the preschool education indicator system into five dimensions, namely, preschool education background, investment, participation, institution and organization services, and output[4]. Fangfang Cui et al. analyzed the development of preschool education in China through cluster analysis based on the development data of preschool education in 31 provinces (cities) in 2008; their analysis used the following variables: gross enrollment rate, ratio of students to teachers, proportion of teachers with college degree or above, and average education expenditure[5]. Zhanlan Liu et al. constructed an index system for the comprehensive development level of preschool education in China, which includes four primary indicators, namely, preschool education opportunity, preschool education investment, preschool education quality, and preschool education equity, and six secondary indicators, namely, enrollment rate, proportion of financial investment in preschool education, proportion of public parks, teacher-to-child ratio, teacher education, and urban-rural differences[6]. Relevant studies of the Organization for Economic Co-operation and Development also show that the service quality of early childhood education and care (ECEC) is the core content of the overall quality of preschool education, which is mainly affected by factors, such as teacher-to-child ratio, project sustainability, and public funds per child.

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Relevant studies by domestic and foreign scholars have great reference significance for the present paper, but with certain limitations. First, existing research mainly focuses on the necessity and unequal performance of equalization of public services for preschool education. Second, no unified requirements and standards have been set for the specific indicators of equalization, and the measurement tools and contents lack of consistency, which may be related to the lack of basic public service standards for preschool education. Most of the processes of implementing comprehensive evaluation focus on simple weighted processing of single indicator. They lack a measurement system of multiple indicator linkage, and rarely carry out comprehensive evaluation research that uses certain evaluation methods. Third, most studies selected preschool education equalization in a certain area, which prefers one aspect of horizontal equality or vertical equality and ignores the organic combination of the two.

III. CONSTRUCTION OF THE EVALUATION INDEX SYSTEM OF THE EQUALIZATION LEVEL OF BASIC PUBLIC SERVICES OF PRESCHOOL EDUCATION

3.1 Connotation of Equalization of Basic Public Services of Preschool Education

The equalization of basic public services for preschool education means that all preschool children should enjoy roughly the same quality of preschool education services regardless of region, social class, or inter-school differences, which are closely related to the level of regional economic and social development. The provision of basic public services of preschool education differs in terms of content due to the different stages of economic and social development in each region. However, the policy orientation is consistent, that is, to realize the relative balance of the starting point, process, and result of education among regions, urban and rural areas, and groups by ensuring the rights and opportunities of preschool education through policy and institutional arrangements, and by allocating educational resources fairly and reasonably.

3.2 Empirical Preliminary Screening of Evaluation Indicators

Based on the viewpoints of scholars, such as Ailing Zhuang[7] and Jiangying Feng[8], and according to the typical representativeness and availability of the data, unavailable audition indicators were excluded to obtain a preliminary screening index system that covers four first-level indicators, namely, education expenditure, school conditions, faculty strength, and popularization degree. The quantifiability of the indicators were also fully guaranteed, as shown in TABLE I.

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Educational expenditures. Kindergarten education expenditure is categorized into personal expenditure, public expenditure, and capital construction expenditure. The degree of equalization can be measured by four indicators, namely, education expenditure per student, public expenditure per student (public part), wage and welfare expenditure, and subsidies to individuals and families. Per-student indicators were used to reflect the degree of education expenditures invested in children. Per-student indicators were also used to measure educational expenditures from the perspective of children, including per-student education expenditures and per-student institutional expenditures (public part). Teacher indicators were used to reflect the extent to which education funds (mainly institutional expenses) are invested in teachers, and to measure educational and institutional expenses from the perspective of teachers, including wages and welfare expenditures and subsidies to individuals and families.

Conditions for running a school. The indicators of the conditions for running kindergartens can be evaluated from the three main subjects, namely, children, teachers, and kindergartens. The indicators for children include the area of teaching and auxiliary rooms per student (the area of teaching and auxiliary rooms/the number of people in the kindergarten) and the number of books per student (the number of books/the number of people in the kindergarten). Children are the most direct beneficiaries of improvement in the area of teaching and auxiliary rooms, the number of books, and other factors. Therefore, the average student indicator is a realistic choice for evaluating the above aspects. The indicators for teacher include administrative office space per teacher (administrative office space/number of faculty and staff total) and office area per teacher (teacher office area/number of full-time teachers). The administrative office space is shared by faculty and staff, whereas the teacher's office is mainly used by full-time teachers. Therefore, the latter is considered differently when calculating the indicators. Kindergarten indicators use the area of new school buildings to reflect the improvement of school buildings in the running conditions of kindergartens in an incremental way.

Faculty strength. The strength of kindergarten teachers can be evaluated in terms of scale and structure. Scale indicators include teacher-to-child ratio (number of full-time teachers/number of students in the kindergarten) and number of faculty. Teacher-to-child ratio is used to reflect how much full-time teacher guidance each child can enjoy. This indicator is key to evaluating the strength of kindergarten teachers. The structure indicator selects "the number of full-time teachers with college degree or above" to reflect the level of kindergarten teachers.

Popularity. The popularity of preschool education is reflected by two indicators: the number of children in kindergartens and the number of kindergartens. The number of children

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in kindergartens reflects the scale of children's preschool education, and the number of kindergartens reflects the conditions for popularization of preschool education.

TABLE I. Set of evaluation indicators for the equalization level of basic public services of preschool education (2010–2018)

FIRST-LEVEL INDICATORS	SECOND-LEVEL INDICATORS	INDICATOR PROPERTIES	INDICATOR TYPE	INTERNAL CONSISTENCY COEFFICIENT					FILTER RESULTS
				2010	2012	2014	2016	2018	
Educational expenditures Y_a	Education expenditure per student X_{a1}	Per student indicator	Positive	1.260	1.553	1.301	1.481	1.452	Reservation
	Institutional expenditure per student (Common part) X_{a2}	Per student indicator	Positive	1.185	1.658	1.355	1.528	1.440	Reservation
	Wages and welfare expenditure X_{a3}	Indicators for teachers	Positive	1.057	1.187	1.193	1.261	1.267	Reservation
	Subsidies to individuals or families X_{a4}	Indicators for teachers	Positive	1.334	1.525	1.476	1.523	0.918	Reservation
School conditions Y_b	Area of teaching and auxiliary rooms per student X_{b1}	Indicators for children	Positive	3.365	4.063	5.163	6.342	7.063	Reservation
	Number of books per student X_{b2}	Indicators for children	Positive	2.304	2.550	2.784	3.027	3.223	Reservation
	Area of administrative office buildings per teacher X_{b3}	Indicators for teachers	Positive	3.852	2.637	2.803	2.393	2.347	Reservation
	Teaching office area per teacher X_{b4}	Indicators for teachers	Positive	4.019	2.844	2.984	2.565	2.837	Reservation
	New school building area X_{b5}	Kindergarten indicators	Positive	0.945	1.285	1.405	0.912	1.240	Reservation
Faculty strength Y_c	Teacher-to-child ratio X_{c1}	Scale indicator	Positive	3.279	3.542	4.101	4.879	5.263	Reservation
	Number of faculty members X_{c2}	Scale indicator	Positive	1.210	1.246	1.237	1.274	1.294	Reservation
	Number of full-time teachers with college	Structural indicators	Positive	1.364	1.362	1.346	1.339	1.338	Reservation

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	degree or above X_{c3}								
Popularity degree Y_d	Number of children in kindergartens X_{d1}	Scale indicator	Positive	1.348	1.335	1.321	1.347	1.314	Reservation
	Number of kindergartens X_{d2}	Scale indicator	Positive	1.305	1.389	1.440	1.506	1.454	Reservation

3.3 Optimization and Screening of Evaluation Indicators

The internal consistency coefficient was used in the present paper to measure the discriminative ability of indicators. The calculation formula is given as: $I_i = \bar{Y}_i / S_i$, where $\bar{Y}_i$ represents the average value of the evaluation target index X_i, and S_i is the standard deviation of X_i. The critical value of consistency coefficient is set as 7. The indicator will be retained if $I_i < 7$; otherwise it will be deleted. The specific screening results are shown in column 10 of TABLE I. In 2018, the indicator consistency coefficient "teaching and auxiliary room area per student" was 7.063, which is close to the critical value. The consistency coefficients of this indicator were not deleted because they meet the requirements in other years.

IV. EVALUATION OF THE STATUS QUO OF EQUALIZATION LEVEL OF BASIC PUBLIC SERVICES OF PRESCHOOL EDUCATION IN THE PROVINCE

4.1 Determination of Indicator Weight

The present paper combined MATLAB and SPSS and used the analytic hierarchy process and the judgment information on the "micro" level of experts to determine the weight distribution of the indicator system by comparing the relative importance of two indicators. The combined weighting method that reflects weight preference was also used in combination with entropy and critical methods to further improve the scientificity of index weighting.

4.1.1 Subjective determination of weight using Analytic Hierarchy Process (AHP)

AHP is a systematic analysis method that combines qualitative analysis and quantitative analysis. The main calculation steps of AHP are as follows[9]. First, expert Sk based on the grading ratio scale is introduced to the first and second level index set {Y1, Y2,...Ym}, {X1, X2, …Xn} to make pairwise comparison and judgment and construct an index judgment matrix. Second, the product square root method is combined to solve the weight of each index. For example, m-level judgment matrix (Formula 1) is obtained from the first-level index set.

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Each element is multiplied by rows and the m root is extracted to obtain the geometric mean of each row element. B_i is normalized to obtain the weight coefficient W_j of index X_j. C.I (Consistency Index) is introduced to test the consistency of the judgment matrix. The CR (Consistency Ratio) of the contrast matrix is calculated, which can be expressed as: CR=C.I/R.I, where R.I (Random Index) is the average random consistency index. C.R<0.1 means that the judgment matrix meets the consistency requirements; otherwise, further communication with experts on the judgment matrix should be conducted, and the matrix should be continuously adjusted to pass the consistency test. Finally, the degree of authority among the experts is assumed to be consistent. The final weight of the indicator is obtained by the simple arithmetic average of the weighting results of each expert, as shown in Formulas 2–4.

$$\mathrm{Y}=\begin{bmatrix} 1 & \mathrm{y}_{12} & \cdots & \mathrm{y}_{1\mathrm{m}} \\ 1/\mathrm{y}_{12} & 1 & \cdots & \mathrm{y}_{2\mathrm{m}} \\ \cdots & \cdots & \cdots & \cdots \\ 1/\mathrm{y}_{1\mathrm{m}} & 1/\mathrm{y}_{2\mathrm{m}} & \cdots & 1 \end{bmatrix} \tag{1}$$

$$B_i=(\prod_{j=1}^{m} y_{ij})^{1/m},\quad \mathrm{i}=1,2,\ldots,m \tag{2}$$

$$\mathrm{W_j}=\mathrm{B_j}/(\sum_{\mathrm{k}=1}^{\mathrm{m}}\mathrm{B_k}),\quad \mathrm{j}=1,2,\ldots,\mathrm{m} \tag{3}$$

$$C.I=(\lambda_{\max(\mathrm{Y})}-m)/(m-1)=\frac{1}{m}\sum_{i=1}^{m}\frac{\sum_{j=1}^{m} y_{ij}W_j}{W_i} \tag{4}$$

4.1.2 Objective determination of weight using entropy method

The entropy method is a multi-index comprehensive evaluation method that objectively assigns weights based on the information entropy reflected by the degree of variation between the original values of the indicators of the observation object[10]. This method can effectively avoid the risk factors caused by subjective experience weighting. The specific steps are as follows. First, the 0-1 standardization method was used to normalize the original data to obtain a normalized matrix. Second, weighting transformation was performed on the normalized index data. The entropy E_i of the X_i th i indicator was then calculated. Finally, the entropy, namely, the weight of the evaluation indicator x_i was calculated W_i. This method is shown in Formulas 5–8.

$$X^{'}=(X_{ij}^{'})_{m\times n}(\mathrm{i}=1,2,\ldots,m;\ j=1,2,\ldots,n) \tag{5}$$

$$P_{ij}=\frac{X_{ij}^{'}}{\sum_{j=1}^{n}X_{ij}^{'}} \tag{6}$$

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$$E_i = -\frac{1}{\ln n}\sum_{j=1}^{n} P_{ij} \ln P_{ij} \tag{7}$$

$$W_i = \frac{1 - E_i}{m - \sum_{j=1}^{m} E_i} \tag{8}$$

4.1.3 Objective determination of weights using CRITIC method

The CRITIC method is an objective weighting method that comprehensively measures indicators based on the contrast strength of evaluation indicators and the conflict between indicators. The specific steps are given as follows. First, the dispersion standardization method was adopted to normalize the original data. The specific method was consistent with the entropy weight method. Second, the standard deviation of the j th evaluation index S_j was calculated to reflect index fluctuation. The larger the value, the greater the difference of the index value, and the greater the evaluation intensity. Third, conflict index R_j was calculated to measure the degree of conflict between the indicators. The correlation coefficient between evaluation indicators i and j is denoted as r_{ij}. The greater the R_j value, the greater the conflict between the evaluation indicator j and other indicators, which reflects less similar information and greater evaluation strength. The amount of evaluation information of the j th evaluation index M_j was then calculated. The larger the value, the greater the role of the j th evaluation index in the whole evaluation index system. Finally, the objective weight C_j of the j th evaluation index was calculated. This method is shown in Formulas 9–11.

$$\mathrm{R_j} = \sum_{i=1}^{p} (1 - r_{ij}) \tag{9}$$

$$\mathrm{M}_j = \mathrm{S_j} \cdot R_j = \mathrm{S_j} \cdot \sum_{i=1}^{n} \mathrm{1\text{-}r_{ij}} \tag{10}$$

$$C_j = M_j \,/\, \sum_{i=1}^{n} M_j \tag{11}$$

4.1.4 Subjective and objective determination of weights using combination weighting method

By drawing on the concept of correlation coefficient, the present paper used the absolute value of the weight deviation of each corresponding attribute under each subjective and objective weighting method to obtain the weight coefficient of each weighting method. The final combined weight W_z was obtained to avoid the limitations of subjective judgment and

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emphasize objective methods. The specific steps are given as follows. First, the combined weight vector matrix W is obtained from the q weighting results. Correlation coefficient r_{mk} is introduced, which describes the deviation between the m weighting method and the k weighting method to measure the difference between q kinds of empowerment results. Second, the degree of correlation between the weighting method j and other weighting methods is calculated. The weight coefficient of each weighting method is normalized in the combination weighting m_j. Finally, the combined weight of each indicator w'_i was obtained. This method is shown in Formulas 12-16.

$$W = \begin{bmatrix} w_1 & w_2 & w_3 & \dots & w_q \end{bmatrix}^T \tag{12}$$

$$r_{mk} = 1 - \frac{\sum_{i=1}^{n} \left| w_{ki} - w_{mi} \right|}{n} \tag{13}$$

$$r_j = \frac{1}{q-1} \sum_{k=1, k \neq m}^{q} r_{jk} \tag{14}$$

$$m_j = r_j / \sum_{j=1}^{q} r_j \tag{15}$$

$$w'_i = \sum_{j=1}^{q} m_j \cdot w_{ij} \tag{16}$$

4.2 Combination Weighting Results

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The corresponding weighting results are obtained by combining the above subjective and objective weighting methods. Details are shown in TABLE II to TABLE IV.

TABLE II. . Results of subjective empowerment of experts based on AHP

FIRST-LEVEL INDICATORS	SECOND-LEVEL INDICATORS	S_1	S_2	S_3	S_4	MEAN
Y_a（0.125）	X_{a1}	0.100	0.091	0.473	0.424	0.034
	X_{a2}	0.300	0.364	0.211	0.122	0.031
	X_{a3}	0.300	0.182	0.211	0.227	0.029
	X_{a4}	0.300	0.364	0.105	0.227	0.031
Y_b（0.226）	X_{b1}	0.100	0.089	0.400	0.234	0.046
	X_{b2}	0.400	0.390	0.200	0.395	0.078
	X_{b3}	0.200	0.089	0.200	0.124	0.035
	X_{b4}	0.100	0.264	0.100	0.124	0.033
	X_{b5}	0.200	0.169	0.100	0.124	0.033
Y_c（0.408）	X_{c1}	0.400	0.163	0.117	0.387	0.109
	X_{c2}	0.400	0.297	0.268	0.169	0.116
	X_{c3}	0.200	0.540	0.614	0.443	0.184
Y_d（0.241）	X_{d1}	0.500	0.750	0.500	0.667	0.146
	X_{d2}	0.500	0.250	0.500	0.333	0.095

TABLE III. . Objective weighting results based on entropy method and CRITIC method (2010–2018)

SECOND-LEVEL INDICATORS	ENTROPY METHOD					CRITIC				
	2010	2012	2014	2016	2018	2010	2012	2014	2016	2018
X_{a1}	0.119	0.112	0.118	0.091	0.100	0.081	0.084	0.081	0.083	0.077

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X_{a2}	0.125	0.080	0.107	0.092	0.106	0.065	0.088	0.074	0.085	0.078
X_{a3}	0.092	0.077	0.073	0.078	0.071	0.051	0.054	0.050	0.054	0.052
X_{a4}	0.064	0.064	0.060	0.063	0.122	0.065	0.063	0.052	0.056	0.070
X_{b1}	0.041	0.058	0.051	0.044	0.027	0.052	0.067	0.073	0.078	0.076
X_{b2}	0.057	0.047	0.062	0.028	0.023	0.056	0.059	0.070	0.064	0.064
X_{b3}	0.048	0.075	0.070	0.086	0.084	0.106	0.077	0.076	0.069	0.066
X_{b4}	0.049	0.083	0.070	0.076	0.070	0.119	0.086	0.085	0.073	0.070
X_{b5}	0.101	0.069	0.066	0.122	0.087	0.063	0.069	0.084	0.071	0.082
X_{c1}	0.042	0.065	0.055	0.054	0.051	0.059	0.068	0.071	0.080	0.089
X_{c2}	0.070	0.068	0.067	0.064	0.060	0.059	0.058	0.056	0.058	0.057
X_{c3}	0.059	0.061	0.062	0.063	0.062	0.067	0.064	0.062	0.060	0.060
X_{d1}	0.066	0.069	0.069	0.069	0.070	0.082	0.080	0.078	0.077	0.073
X_{d2}	0.067	0.071	0.068	0.070	0.068	0.074	0.083	0.089	0.092	0.086

Note: All index data are obtained from the "China Education Statistics Yearbook" and "China Education Funding Statistics Yearbook".

TABLE IV. . Subjective and objective weighting results based on the combination weighting method (2010–2018)

SECOND-LEVEL INDICATORS	COMBINATION WEIGHTING				
	2010	2012	2014	2016	2018
X_{a1}	0.078	0.077	0.078	0.070	0.070
X_{a2}	0.074	0.067	0.071	0.070	0.072
X_{a3}	0.057	0.053	0.051	0.054	0.051
X_{a4}	0.053	0.053	0.048	0.050	0.074
X_{b1}	0.046	0.057	0.057	0.056	0.050
X_{b2}	0.064	0.061	0.070	0.057	0.055
X_{b3}	0.063	0.063	0.060	0.063	0.062
X_{b4}	0.067	0.068	0.063	0.061	0.058

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X_{b5}	0.066	0.057	0.061	0.076	0.068
X_{c1}	0.070	0.080	0.078	0.081	0.083
X_{c2}	0.082	0.080	0.079	0.079	0.077
X_{c3}	0.103	0.102	0.102	0.102	0.102
X_{d1}	0.098	0.098	0.097	0.097	0.096
X_{d2}	0.079	0.083	0.084	0.086	0.083

4.3 Evaluation Results and Analysis

The comprehensive evaluation value of the equalization level of basic public services of preschool education in each province (city) in 2010, 2012, 2014, 2016, and 2018 was obtained based on the 0-1 standardized value of the original data in combination with the indicator weights determined by the combination weighting method. The results are shown in TABLE V. The coefficient of equalization of basic public services for preschool education in China's provinces (municipalities) fluctuated slightly from 2010–2018. The overall evolution trend was stable.

TABLE V. Comprehensive evaluation value of equalization level of basic public services of preschool education (2010–2018)

PROVINCES	2010	2012	2014	2016	2018	MEAN
Beijing	0.464	0.448	0.440	0.402	0.371	0.425
Tianjin	0.238	0.234	0.229	0.201	0.241	0.229
Hebei	0.361	0.311	0.342	0.305	0.339	0.332
Shanxi	0.303	0.220	0.211	0.193	0.183	0.222
Neimenggu	0.276	0.252	0.268	0.267	0.266	0.266
Liaoning	0.283	0.279	0.265	0.257	0.242	0.265
Jilin	0.159	0.181	0.175	0.174	0.161	0.170
Heilongjiang	0.174	0.220	0.196	0.192	0.180	0.192
Shanghai	0.487	0.368	0.347	0.347	0.313	0.372
Jiangsu	0.533	0.510	0.479	0.433	0.399	0.471
Zhejiang	0.514	0.478	0.462	0.417	0.398	0.454
Anhui	0.213	0.222	0.207	0.207	0.221	0.214
Fujian	0.274	0.257	0.251	0.228	0.240	0.250
Jiangxi	0.242	0.256	0.262	0.296	0.344	0.280
Shandong	0.500	0.512	0.475	0.454	0.461	0.480
Henan	0.411	0.410	0.423	0.399	0.395	0.408
Hubei	0.239	0.258	0.243	0.243	0.260	0.249

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Hunan	0.359	0.343	0.327	0.309	0.300	0.328
Guangdong	0.581	0.571	0.604	0.587	0.613	0.591
Guangxi	0.174	0.193	0.194	0.195	0.205	0.192
Hainan	0.110	0.181	0.156	0.190	0.173	0.162
Chongqing	0.158	0.153	0.142	0.152	0.160	0.153
Sichuan	0.355	0.354	0.339	0.333	0.338	0.344
Guizhou	0.143	0.150	0.205	0.252	0.285	0.207
Yunnan	0.219	0.192	0.207	0.209	0.240	0.213
Xizang	0.197	0.218	0.246	0.246	0.251	0.232
Shanxxi	0.313	0.343	0.380	0.344	0.333	0.343
Gansu	0.233	0.198	0.191	0.213	0.206	0.208
Qinghai	0.175	0.125	0.115	0.128	0.115	0.132
Ningxia	0.145	0.117	0.141	0.144	0.119	0.133
Xinjiang	0.398	0.203	0.187	0.294	0.236	0.264

V. COMPARISON OF THE OVERALL LEVEL OF EQUALIZATION OF BASIC PUBLIC SERVICES OF PRESCHOOL EDUCATION IN THE PROVINCES

5.1 Comparative Analysis of the Overall Level of Equalization in Different Provinces

Based on the average score of the comprehensive evaluation value of equalization level in five years, the present paper used the centroid clustering method and selected the squared Euclidean distance as the metric to perform Q-type clustering. Thirty-one provinces (cities) were divided into five regional levels to compare and analyze the differences between the comprehensive scores of different categories of provinces. TABLE VI shows the corresponding average comprehensive scores within the group, the range within the group, and the development gap between different categories of provinces and the first category of provinces.

Guangdong obtained the highest overall score, and demonstrated the best effect of equalization of basic public services for preschool education. Guangdong belonged to the first category of regions.

4 Eastern provinces, including Beijing, Shandong, Jiangsu, and Zhejiang, and the central province of Henan had high comprehensive scores and good levels of effectiveness of equalization of basic public services for preschool education. They belong to the second type of regions, and their development gap with the first type of region was 24.2%.

Five provinces, including Shanghai, Hebei, Hunan, Sichuan, and Shaanxi, had medium comprehensive scores, with acceptable levels of effectiveness of equalization of basic public

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services for preschool education. They belong to the third type of regions. Their development gap with the first type of region was 41.8%.

Fifteen provinces, including Niaoning, Fujian, and Tianjin had low comprehensive scores with poor levels of effectiveness of equalization of basic public services for preschool education. They belong to the fourth type of regions, which are mostly central and western regions. Their development gap with the first type of region was 60.7%.

Five provinces, including Jilin, Hainan, Chongqing, Ningxia, and Qinghai, had the lowest comprehensive scores. The effectiveness of equalization of basic public services for preschool education for this group was not optimistic. They belong to the fifth type of regions. Their development gap with the first type of region was 74.6%.

The eastern part occupied the vast majority of areas with high level of equalization (including regional levels I, II, and III). Two provinces in the central and western regions belong to this group. An increasing number of central and western provinces were concentrated in regional levels IV and V, which is a relatively backward position. This result shows that the level of equalization of basic public services for preschool education in Chinese provinces is experiencing a declining distribution in the east, middle, and west.

TABLE VI. . Comparative analysis of the average value of the comprehensive scores of different provinces

REGIONAL LEVEL	HIERARCHICAL CHARACTERISTICS	INCLUDING THE AREA	AVERAGE VALUE OF PROVINCIAL COMPREHENSIVE SCORES IN THE SAME CATEGORY	EXTREMELY POOR COMPREHENSIVE SCORES IN THE SAME CATEGORY	THE DEVELOPMENT GAP BETWEEN DIFFERENT TYPES OF PROVINCES AND THE FIRST TYPE OF PROVINCES
Grade I	Equalization Highest level	Eastern region: Guangdong	0.591	0.591	-
Grade II	Equalization Higher level	Eastern region: Beijing, Shandong, Jiangsu, Zhejiang Central	0.448	0.072	24.2%

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		region:Henan			
Grade III	Equalization Medium level	Eastern region: Shanghai, Hebei Central region: Hunan Western region: Sichuan, Shaanxi	0.344	0.044	41.8%
Grade IV	Equalization Lower level	Eastern region: Niaoning, Fujian, Tianjin Central region: Jiangxi , Hubei , Shanxi , Anhui , Heilongjiang Western region: Inner Mongolia, Xinjiang, Tibet, Yunnan, Gansu, Guizhou, Guangxi	0.232	0.088	60.7%
Grade V	Equalization Lowest level	Eastern region: Hainan Central region: Jilin Western region: Chongqing, Ningxia, Qinghai	0.150	0.038	74.6%

5.2 Comparative Analysis of the Spatial Evolution of Evaluation Results

5.2.1 Comparative analysis of global spatial autocorrelation based on Moran's I statistics

The global spatial autocorrelation indicator reflects the overall spatial correlation degree of each region through comprehensive statistical values. This indicator also detects the overall

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aggregation and dispersion degree of attribute values in space. The present paper used Moran's I to measure global spatial autocorrelation, which can be expressed by Formula 17:

$$I = \frac{\sum_{i=1}^{n}(x_i - \bar{x})\sum_{j=1}^{n} W_{ij}(x_j - \bar{x})}{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}\sum_{j=1}^{n} W_{ij}} \quad (17)$$

where n is the number of spatial samples in the study area, x_i and x_j represent the corresponding attribute values of the spatial sample unit, W_{ij} is a standardized spatial weight matrix. The present paper used a first-order Queen weight matrix based on a common boundary to reflect the neighboring relationship of spatial units. The value range of Moran's I is [-1.1] [11]. If each region is spatially positively correlated. The value should be relatively large. The negative correlation is small, which is close to or equal to 0, and indicates an uncorrelated distribution between spatial unit attributes.

The present paper used GEODA software to calculate and plot the global spatial autocorrelation index in Moran's I value and scatter points of the equalization level of basic public services of preschool education in China in 2010, 2014, and 2018. The values were 0.238, 0.212, and 0.178. The Z-score test in the three years reached a confidence level of 95% or higher, which indicates a spatial positive correlation between the equalization level of basic public services of provincial preschool education in China and shows obvious spatial agglomeration. From 2010–2018, the value of Moran's I gradually decreased, the spatial difference expanded, and the degree of spatial agglomeration decreased slightly. In addition, the Moran's I scatter plots in 2010, 2014, and 2018 showed similar characteristics, and a relatively stable pattern of clustering and discrete distribution. The “High-High” (HH) significant area represents high-value areas. Compared with that in 2010, the number of provinces in this area increased in 2018, which indicates that provinces with high level of equalization are in close proximity to each other. These provinces were mainly distributed in the coastal and central areas of East and North China. The “Low-Low” (LL) significant area represents the low-value area, which means that provinces with relatively low levels of equalization are adjacent to each other. These provinces are mainly distributed in the northwest, southwest, and northeast regions. The “Low-High” (LH) significant correlation area is a type of local low-value outliers, which means that the equalization level of provinces in this quadrant was low. However, the surrounding provinces had high ecological efficiency that are mainly distributed in some provinces in the middle and lower reaches of the Yangtze River and coastal parts. Compared with that in 2010, the overall number of "Low-Low" (LL) significant areas and "Low-High" (LH) significant areas remained unchanged in 2018. This result indicates that the spatial radiation effect of its surrounding advantageous areas was not obvious. The “High-

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Low" (HL) significant correlation area was a type of local high-value outliers, which means that the provinces in this quadrant had high eco-efficiency, but the surrounding provinces had low eco-efficiency. These provinces were mainly distributed in some coastal areas of the southwest and south. In addition, there are more provinces located in the HH and LL quadrants than in the HL and LH quadrants. This distribution indicates that the development of equalization level of preschool education services in the province had obvious spatial agglomeration characteristics and certain spatial dependencies, that is, high value areas were formed in the east and low value areas in the central and western regions. Figure 1 provides the details.

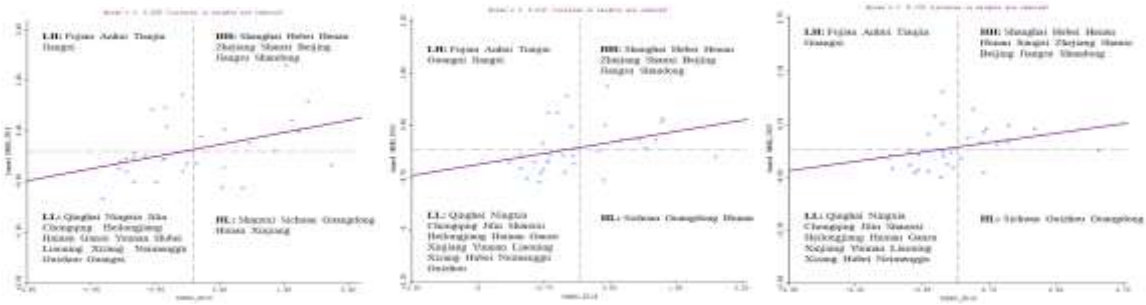

Figure 1. Moran's I scatter diagram of the comprehensive scores of the equalization level of basic public services of preschool education in China (2010, 2014, 2018)

5.2.2 Comprehensive comparison based on LISA analysis of spatial correlation local index

The global spatial autocorrelation phenomenon test based on Moran's I statistic shows that the LISA level maps of 2010, 2014, and 2018 are largely similar. Shanghai, Beijing, and other 10 provinces were located in the first quadrant, which shows a positive spatial autocorrelation and cluster effect (HH) with adjacent provinces. However, the central areas of cluster effect were identified as Jiangsu (2010), Hebei, and Shanghai (2014). No province effectively entered this central area in 2018. Fourteen provinces, such as Qinghai and Ningxia, were located in the third quadrant, but they showed negative spatial autocorrelation and cluster effect (LL) with adjacent provinces. The central area of cluster effect only included three provinces: Gansu, Ningxia (2014, 2018), and Inner Mongolia (2018). Other provinces failed to effectively enter this central area. The spatial differentiation of the above-mentioned cluster provinces with high and low equalization level of preschool education service showed that the core-periphery spatial distribution pattern of the comprehensive score of China's provincial preschool education service equalization level has been preliminarily formed and is stable. The coastal areas in the east and north regions represented by Jiangsu, Hebei, and Shanghai have become the core areas. The western areas represented by Gansu, Ningxia and Inner Mongolia have become the marginal areas [12][13].

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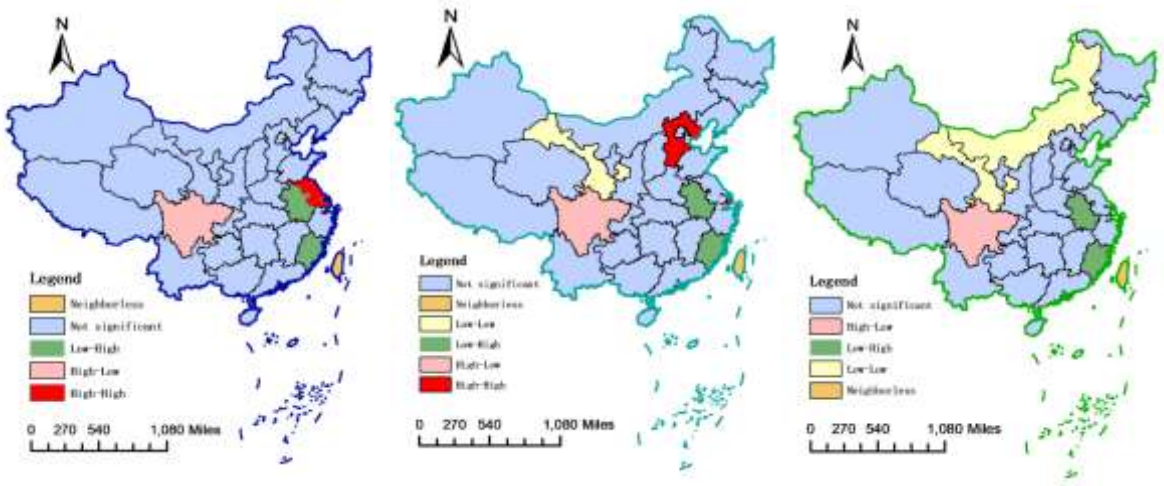

Figure 2. Spatial agglomeration pattern of equalization level of basic public services for preschool education in China (2010, 2014, 2018)

In addition, the two provinces of Fujian and Anhui had always been in the local low value area at the 0.05 significance level. The spatial spillover effect of the adjacent east China coastal regions was not significant. Sichuan had been in a local high-value region at the significance level of 0.05. Strengthening the demonstration effect on the surrounding provinces is an important issue that should be explored to promote the equalization of public services for preschool education in this region. Figure 2 provides the details.

5.3 Comparative Analysis of the Main Indicators Involved in the Evaluation

5.3.1 Analysis based on the index weight perspective

The realistic evaluation of the equalization level of provincial preschool education service should not only clarify the overall pattern of provincial preschool education service equalization transformation, but also identify the decisive influencing factors and transformation process of each influencing factor. These factors are important basis for local education authorities when formulating strategies to promote the equalization process.

Based on the overall evaluation, the present paper diagnosed the influencing factors that affect the level of equalization of preschool education services in the provinces, in combination with the degree of factor contribution U_r. The factor contribution of the four criterion levels in the index system was calculated according to Formula 18, where F_i represents the weight of the ith index factor to the overall goal; W_{zi} represents the weight of the ith index; W_r is the

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sum of the weights of all indicators at the r th criterion level; I_i represents the index membership degree of the i th indicator, that is, the proportion of the product of the standardized value of the i th index of the evaluation unit and the index weight W_{zi} in the equalization level coefficient V_i; C_i represents the contribution of the i th index factor to the provincial equalization level coefficient; and U_r is the contribution of the r th criterion layer to the regional equalization level coefficient[14].

$$U_r = \sum C_i = \sum \frac{F_i \bullet I_i}{\sum_{i=1}^{14} F_i \bullet I_i} = \sum \frac{W_r \bullet W_{zi} \bullet \frac{x_{ij} \times W_{zi}}{V_i}}{\sum_{i=1}^{14} W_r \bullet W_{zi} \bullet \frac{x_{ij} \times W_{zi}}{V_i}} \tag{18}$$

Based on the value of factor contribution of the four criterion levels over the years, the factor contribution of the equalization criterion level of preschool education public service of each province (city) tended to be non-flat. According to the standard of contribution $U_r \geq 20\%$, the "school conditions" and "faculty strength" in the standard layer were the main public contributing factors for the equalization of preschool education public services in all provinces (cities). The total contribution of both factors reached more than 60%. All provinces (cities) mainly rely on improving school conditions and teachers to improve the equalization level. Based on the annual change rate of indicator contribution of each standard level, the average contribution of "education expenditures", "faculty strength", and "preschool education popularity" at the standard level in 2018 gradually increased by 3.44%, 11.93%, and 5.63% compared with the rates in 2010. However, the average contribution of the "school conditions" decreased by 18.70%. Provinces (cities) have achieved certain results in promoting investment in education funds, teacher training, and popularization of preschool education by continuously improving the equalization level of public services for preschool education in the provinces. However, achieving breakthrough in the standard level of "school conditions" was difficult. This challenge will become an important focus for all provinces (cities) in their attempt to break through the bottleneck of equalization level.

5.3.2 Analysis based on the perspective of index discrete coefficient

The dispersion coefficient CV_i is used in the present paper to measure the degree of dispersion of the 14 indicators involved in the previous evaluation and further understand the development imbalances of various provinces (cities) in some indicators. This coefficient is also used to improve the interpretation and comparison of the unbalanced situation of basic public services of preschool education among provinces. The calculation formula is:

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$CV_i = \sigma_i / \overline{Y_i}$, where σ_i is the standard deviation of the evaluation target index X_i. $\overline{Y_i}$ means the average value of X_i. The larger the value of CV_i, the greater the relative difference in this indicator between provinces, the more obvious the unbalanced situation of basic public services for preschool education. The changes in index dispersion coefficients in 2018 compared with those in 2010 showed that the dispersion coefficients of nine in the 14 indicators were decreasing. This result indicates improvement in the spatial differences in most indicators of the equalization of basic public services of preschool education in different provinces. However, combined with the average value of index dispersion coefficient in five years, in addition to the "area of teaching and auxiliary rooms per student", "number of books per student", "area of administrative office rooms per teacher", "area of office of teachers per teacher", and "teacher-to-children ratio", the dispersion coefficient of the remaining indicators remained higher than 50%. This result indicates that the spatial differences in some indicators among provinces remain prominent, and the growth of these indicators will become a breakthrough for backward provinces (cities) in promoting the process of equalization.

VI. CONCLUSION

An evaluation index system was constructed in the present paper to evaluate the equalization level of basic public service for provincial preschool education. This matrix was constructed by defining the connotation of equalization of basic public services in preschool education, combined with empirical preliminary screening and optimized screening. The comprehensive evaluation value of the equalization level of basic public services of preschool education in 31 provinces (cities) in China in 2010, 2012, 2014, 2016, and 2018 was calculated using an evaluation method based on AHP, entropy method, and CRITIC method. The equalization level and main indicators of different provinces were compared and analyzed in depth. The main conclusions are as follows.

1. The overall evolution of the coefficient of equalization of basic public services for preschool education in various provinces (municipalities) in China was stable from 2010–2018. The coefficient demonstrated a decreasing ladder distribution in the east, middle and west. In terms of spatial distribution, a stable aggregation and discrete distribution patterns were observed. Most provinces failed to break away from their original cluster category at the beginning of the period. Improving the equalization level had serious path dependence.

2. The core-periphery spatial distribution pattern of the comprehensive score of equalization level of preschool education services in Chinese provinces was initially formed. The temporal and spatial evolution is relatively stable.

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3. "School conditions" and "faculty strength" are the main public contributing factors for the improvement of equalization level of public services for preschool education in various provinces (municipalities). In 2018, the average contribution of "education expenditures", "faculty strength", and "preschool education popularity" at the standard level gradually increased compared with those in 2010. The average contribution of the "school conditions" showed a downward trend. This result indicates an important point for all provinces (municipalities) as they aim to break through the bottleneck of equalization development.

4. The spatial differences in most indicators of equalization of basic public services for preschool education in different provinces have changed, but a large proportion of indicators had dispersion coefficients higher than 50%. The growth of these indicators will also become a major breakthrough in the reform process of equalization of public education services for preschool education in backward provinces (municipalities).

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