Research on the Supply and Demand Pattern of Inter-provincial Compulsory Educational Resources in China Based on Hierarchical Clustering Analysis

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Abstract. One of the main development goals of education in China is to promote the high-quality and balanced development of compulsory education. This paper constructs a general supply and demand analysis framework for educational resources. By integrating the current situation and trend indexes of the number of students, the number of teachers and the quality of teachers, this paper proposes an index system to comprehensively evaluate the supply and demand of education. This paper, using the hierarchical clustering analysis (HCA), a common unsupervised learning algorithm in data analysis, clusters the supply and demand indexes of compulsory education in 31 provincial-level administrative regions in China. The results show that these provinces can be clustered into six patterns. Through a comprehensive analysis of the educational supply and demand pattern and the population and economy characteristics in each region, this paper puts forward policy recommendations for educational improvement and development applicable to each region.

Keywords: compulsory education · high-quality and balanced development · supply and demand analysis framework · hierarchical clustering analysis · inter-provincial differences

1 Introduction

Compulsory education is the foundation of the entire national education and is an important part of the country's talents training, which has attracted wide attention from all walks of life. *China's Education Modernization 2035* proposes that achieving high-quality and balanced compulsory education is a major goal of China's education development. However, affected by factors such as regional education foundation and economic level, the inter-provincial differences in the development level of compulsory education in China exist, which poses a serious challenge to the realization of high-quality and balanced education nationwide. Research by OECD (Organization for Economic Cooperation and Development) and UNESCO (United Nations Educational Scientific and Cultural Organization) pointed out that regional education development is the result of the interaction

V. Balakrishnan et al. (Eds.): ICMEIM 2022, AHSSEH 6, pp. 335–347, 2022.
https://doi.org/10.2991/978-94-6463-044-2_44

of many factors such as population, economy, policy, teacher resources, and education funding, and the evolution of the entire education system is driven by demand and supply [1]. Therefore, paying attention to the differences in educational development in various regions and conducting a scientific review of the current situation of supply and demand of educational resources can help us better rationally allocate educational resources and promote the high-quality and balanced development in education.

There have been a lot of studies on education supply and demand, and the results show that education demand and population structure are highly coupled [2, 3]. In particular, under the background of China's urbanization and the adjustment of fertility policies, the impact of population flow and resource distribution on the spatial distribution pattern of the school-age population is still deepening [4]. This requires comprehensive consideration of various influencing factors, so as to more accurately estimate regional education needs. In addition, education supply is objectively expressed as an educational condition, which maintains various human resources, material resources and financial resources occupied and consumed in the process of education [5], and it is also constrained by regional population structure, economic development, and educational policies [6]. These elements are integrated and influence each other, so the relationship between education supply and demand presents dynamic and complex characteristics.

Based on this background, this paper constructs a supply and demand analysis framework for regional educational resources, integrates the corresponding evaluation indexes, and conducts a comprehensive evaluation of the development status and trends of interprovincial compulsory education in China. This paper uses the hierarchical clustering analysis to classify the supply and demand of educational resources in China's 31 provincial-level administrative regions (hereinafter referred to as provinces, Hong Kong, Macao and Taiwan are not counted due to data reasons), and further explores the characteristics and differences of each category. This paper also summarizes the typical supply and demand pattern of educational resources in China, and puts forward policy recommendations for educational improvement and development applicable to various regions.

2 Framework Construction and Index Selection

2.1 Construction of Supply and Demand Analysis Framework for Regional Educational Resources

The interaction relationship between supply and demand of educational resources is shown in Fig. 1.

From the perspective of educational demand, the main body of educational demand is students at school. The number of students in a region determines the local educational demand, and, as a component of the population, the number of students is closely related to the birth, death, and migration of regional population, and will be greatly affected by regional population structure (including natural structures such as age and gender, and social structures such as class, culture, and ethnicity) [7].

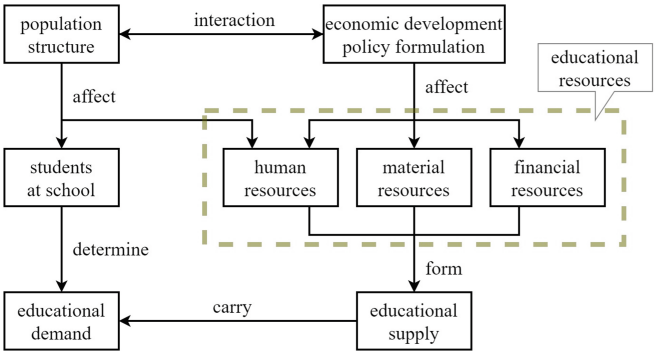

Fig. 1. Supply and Demand Analysis Framework for Educational Resources [Owner Draw]

From the perspective of education supply, regional human resources, material resources and financial resources are the most important forms of education supply, carrying local education needs. The educational resources a region can provide is clearly influenced by economic development and policymaking in that region. In addition, human resources engaged in education, as a component of the population, are also directly affected by the demographic structure.

Therefore, the carrying capacity of regional educational resources supply to educational demand is actually the result of the interaction between the regional population structure and economic development and policy formulation: On the one hand, specific population structure, besides directly determining educational needs and human resources, also indirectly affects the supply of various educational resources by acting on economic development and policy formulation; On the other hand, economic development and policy formulation not only directly affect the supply of various educational resources, but also indirectly affect educational demand through inter-regional population flow and migration.

2.2 Index Selection

China's compulsory education includes primary education and junior high school education, among which primary education is the foundational project for the formation of population quality and is an important part of compulsory education. Considering that the dropout rate in China's compulsory education is relatively low, and the development level of primary education and junior high school education is roughly the same, therefore, this paper uses primary education data to evaluate the allocation of compulsory education resources in China. This paper will select indexes under the guidance of analytical framework shown in Fig. 1 to evaluate the current situation and trend of educational resources supply and demand in 31 provinces in China. The selection principles of indexes are as follows: the correlation of education supply and demand balance, the relative independence between indexes, and the comparability between provinces.

The educational needs of the district are measured by the number of students enrolled. Due to the large differences in the population size of each province, the absolute number of students in each province differs greatly. For inter-provincial comparison, this paper

selects "the number of primary school students per 100,000 population" to measure the current situation of educational needs in a region, denoted as S. The influencing factors of index S mainly include the original population structure, population migration, birth and death in a region, which are closely related to the regional economy and policies. Therefore, the index S not only reflects the educational needs of a region, but also contains social information such as population, economy, and policies. In addition, to measure the changing trend of regional education demand, this paper also selects the "growth rate of primary school students" as an index, denoted as R_S.

The regional education supply is measured by teacher resources. Although education supply includes human resources, material resources and financial resources, due to the poor availability and comparability of data on material resources and financial resources, this paper does not select these two indexes for the time being, and only selects the core of educational resources --- human resources represented by full-time teachers. First, this paper considers the quantitative indexes of teacher resources. The student-teacher ratio is the ratio of the number of students in the school to the number of teachers, which reflects whether the allocation of teacher resources in a region is sufficient and efficient to the needs of students. Therefore, the "student-teacher ratio of full-time teachers in primary schools" is selected to measure the supply of teacher resources in a region in terms of quantity, denoted as (S/T)[1]. If the index S/T is high, it means that each teacher bears more students, indicating that the supply of teacher resources in the region is relatively short. On the contrary, if the index S/T is low, it means that each teacher bears less students, indicating that the supply of teacher resources in the region is relatively excessive. In order to measure the changing trend of the number of teachers, the "growth rate of the number of full-time teachers in primary schools" is selected as an index, denoted as R_T[2]. Then this paper considers the quality indexes of teacher resources. Since the professional titles of teachers are not comparable among provinces, this paper measures the quality of teacher resources through the academic qualifications of full-time teachers. At present, in primary schools, the proportion of full-time teachers with a junior college degree or above has exceeded 90% and there is a significant difference in the proportion of bachelor's degree and above. Therefore, this paper selects the "proportion of full-time primary school teachers with bachelor's degree or above" to measure the quality of educational resources in the region, and denote it as the index Q. Similarly, in order to measure the changing trend of the quality of educational resources, the "growth rate of the proportion of full-time primary school teachers with a bachelor's degree or above" is selected as an index, denoted as R_Q.

[1] The "student-teacher ratio S/T of full-time teachers" can not only directly measure the relative balance of the supply and demand of teacher resources, but also derive the "number of full-time teachers per 100,000 population" by dividing the index S by the index S/T. Although it seems more reasonable to express the quantitative index of teacher resource supply as "the number of full-time teachers per 100,000 population", this derivative variable is not included following the principle of mutual independence of index selection.

[2] The "growth rate of the number of full-time teachers in primary schools" can not only directly measure the changing trend of the number of teacher resources, but also derive the "growth rate of student-teacher ratio of full-time teacher" by subtracting the index R_T from the index R_S. Following the principle of mutual independence in the selection of indexes, this derived variable was not included.

Table 1. Basic Information of Evaluation Indexes [data sources: see Sect. 2.3]

Index	Maximum	Minimum	Median	National Overall Level[3]	Standard Deviation
The number of primary school students per 100,000 population (S)	10,786 Guizhou	3,389 Heilongjiang	7,351 Shandong	7,569	2,115
Growth rate of primary school students (R_S)	20.7% Xinjiang	-11.2% Heilongjiang	6.8% Shandong	6.5%	6.6%
Student-teacher ratio of full-time teachers in primary schools (S/T)	18.8 Fujian	11.3 Jilin	16.7 Shandong	16.8	2.1
Growth rate of the number of full-time teachers in primary schools (R_T)	14.9% Guangxi	-10.3% Heilongjiang	7.8% Guizhou	8.3%	6.1%
Proportion of full-time primary school teachers with bachelor's degree or above (Q)	94.0% Beijing	38.1% Hainan	61.1% Chongqing	62.5%	12.8%
Growth rate of the proportion of full-time primary school teachers with a bachelor's degree or above (R_Q)	48.8% Hainan	3.8% Beijing	23.2% Liaoning	24%	9.9%

[3]This statistic is the overall average of all students at the national scale, not the average of the index.

To sum up, this paper selects a total of six indexes to comprehensively evaluate the balance of education supply and demand. Among them, S and R_S measure the demand for educational resources; S/T and R_T measure the supply quantity of educational resources; Q and R_Q measure the supply quality of educational resources (Table 1).

2.3 Data Sources

The data in this paper are all derived from the educational statistics released by the Development Planning Department of the Ministry of Education of the People's Republic of China. Among them, the absolute numerical indexes S, S/T, and Q come from the Education Statistics 2019; The growth rate indexes R_S, R_T and R_Q are the total growth rates from 2016 to 2019, which are calculated from Education Statistics 2016 and Education Statistics 2019.

3 Hierarchical Clustering Analysis

There are significant differences between provinces in the balance of supply and demand of educational resources (as shown in Table 1), revealing the characteristics of the allocation of primary education resources in each province. In order to extract typical supply and demand pattern of educational resources based on these evaluation indexes, this paper uses the hierarchical clustering analysis to cluster 31 provinces in China.

3.1 Data Standardization

To eliminate the influence of different units of measurements on the clustering results, the six selected indexes were firstly standardized, and the absolute values of the data were converted into relative values. The normalization process is as follows: for an index, its original value in province i is denoted as x_i; its overall value (rather than average) at the national scale is denoted as u; the standard deviation of the original value in all provinces is denoted as s; the standardization index is defined as:

$$x_i' = \frac{x_i - u}{s}$$

The above standardization process is slightly different from the traditional Z standardization method. Although the variance of the standardized index is 1, its mean is not zero. Through this method, the positive and negative status of the standardization index can directly reflect the relative value of the value in a province to the overall national level.

3.2 Clustering Process

This paper conducts hierarchical clustering of six standardization indexes in 31 provinces. The distance in the clustering analysis adopts the Euclidean distance, and the inter-cluster distance adopts the cluster average distance. The clustering results are shown in Fig. 2.

Setting the merging distance of clusters to 3.5, the supply and demand pattern of educational resources in all provinces across the country can be divided into three distinct clusters. The first cluster includes {Heilongjiang, Jilin, Gansu, Inner Mongolia, Liaoning, Shanxi}, denoted as Cluster A; The second cluster includes {Zhejiang, Jiangsu, Tianjin, Shanghai, Beijing}, denoted as Cluster B; Other provinces are divided into a third cluster, denoted as Cluster C.

Due to the large number of Cluster C members, in order to analyze the supply and demand pattern of educational resources of this cluster of members in more detail, this paper classifies the third cluster again. For all members of Cluster C, setting the merging distance of cluster to 2, then most provinces are classified into three sub-clusters: The first sub-cluster includes {Sichuan, Yunnan, Chongqing, Ningxia, Jiangxi}, denoted as Cluster C1; The second sub-cluster includes {Guangdong, Hunan, Guangxi, Henan, Hebei}, denoted as Cluster C2; The third sub-cluster includes {Shaanxi, Qinghai, Shandong, Fujian, Hubei, Anhui}, denoted as Cluster C3. Due to the unique index

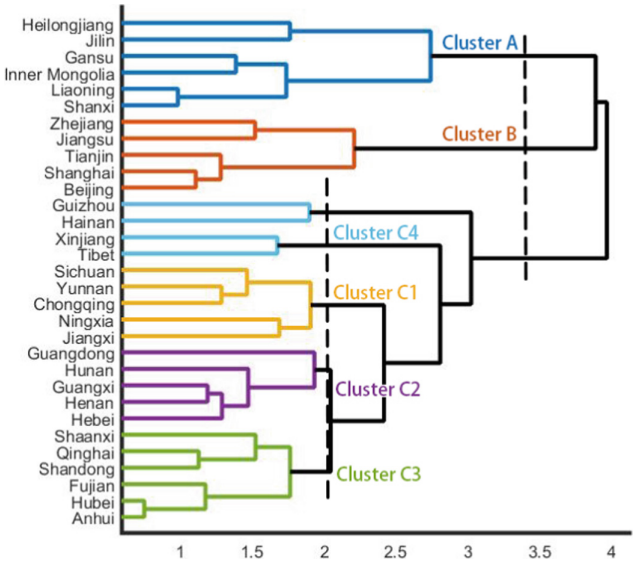

Fig. 2. Clustering Genealogy Diagram [Owner Draw]

characteristics of each province, {Guizhou, Hainan, Xinjiang, Tibet} are divided into two sub-clusters and for simplicity, this paper grouped them into one cluster and denoted as Cluster C4.

3.3 Description of Cluster Characteristics

Based on the characteristics of the evaluation indexes of the educational resources allocation, this paper uses the hierarchical clustering analysis to classify 31 provinces into six clusters: A, B, C1, C2, C3, and C4. For each cluster, calculate the original value of the corresponding index of its cluster center, and obtain a parallel coordinate graph based on the center of each cluster (Fig. 3). To more clearly show the specific characteristics of the evaluation indexes of the provinces included in each cluster, Table 2 also gives the provinces corresponding to the ranking of the evaluation indexes and the cluster to which the province belongs.

Provinces in Cluster A have remarkable characteristics and have the lowest student-teacher ratio (S/T), indicating that the allocation of teacher resources is oversupplied in quantity. The proportion of students in school to the total population (S) is the lowest, with an average of only about 5,000 primary school students per 100,000 population. This value is only half of that of Cluster C4, indicating that the direct cause of excess teacher resources is the serious shortage of demand due to the small number of students at school. From a trend point of view, the growth rate of students (R_S) and the growth rate of full-time teachers (R_T) are both the last and negative, indicating that both the demand and supply of educational resources are shrinking further.

The most notable feature of Cluster B is that the proportion of full-time teachers with a bachelor's degree or above (Q) is the highest in China, reaching 83%, ranking

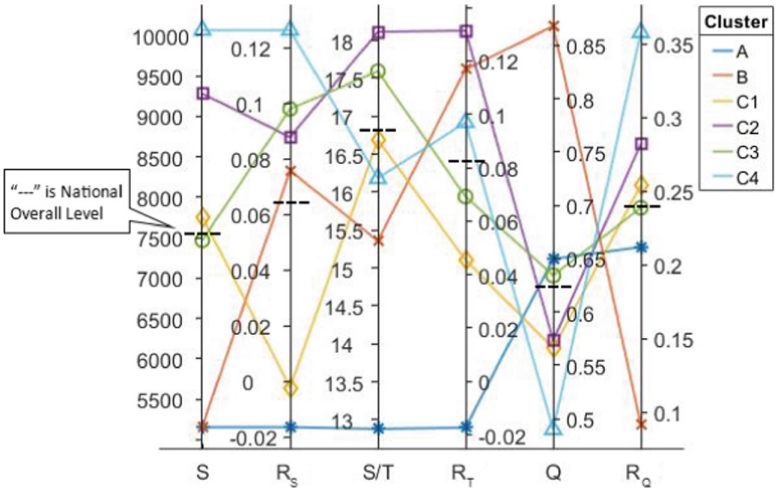

Fig. 3. Parallel Coordinate Graph of Cluster Center [Owner Draw]

among the top 5 of all 31 provinces (Table 1), indicating that the quality of teachers in this cluster of provinces is leading in China. The student-teacher ratio (S/T) of Cluster B is slightly lower than the national overall level, and the allocation of teacher resources is basically balanced in quantity, although the proportion of students in school to the total population (S) is very low. Looking at the trend, the growth rate of students (RS) is comparable to the national overall level, while the growth rate of full-time teachers (RT) is significantly higher than the growth rate of students (RS), which means that the supply of teachers in these provinces is growing faster than the demand.

Generally speaking, the student-teacher ratio (S/T) of the Cluster C is higher than the national overall level, indicating that the allocation of teacher resources in these provinces is in a state of shortage in quantity.

The student-teacher ratio (S/T) of Cluster C1 is slightly higher than the national overall level. However, the proportion of full-time teachers with a bachelor's degree or above (Q) is significantly lower than the overall national level, indicating that although the allocation of teachers' resources is basically balanced in quantity, the quality still needs to be improved. From a trend point of view, the growth rate of students (R_S) is close to zero. Although the growth rate of full-time teachers (R_T) is lower than the national overall level, it is positive, which means that the scarcity of teacher resources has improved in recent years.

Cluster C2 have the highest student-teacher ratio (S/T) in the country (ranked 2, 3, 4, 8, and 12, respectively). The proportion of students in school to the total population is much higher than the national overall level, which shows that the teacher resources in these provinces are seriously in short supply. This consequence is directly due to the large number of students on the demand side. Although the current teacher resources in these provinces are difficult to fully meet the demand, the growth rate of full-time teachers (R_T) is the highest in the country (ranked 1, 4, 5, 6, and 9 respectively), which is higher than the growth rate of students (R_S). This shows that the growth rate of the

Table 2. Sorting table of evaluation indexes [data sources: see Sect. 2.3]

Rank	S	R_S	S/T	R_T	Q	R_Q
1	Guizhou(C4)	Xinjiang(C4)	Fujian(C3)	Guangxi(C2)	Beijing(B)	Hainan(C4)
2	Henan(C2)	Shaanxi(C3)	Guangdong(C2)	Jiangsu(B)	Jiangsu(B)	Guizhou(C4)
3	Xinjiang(C4)	Guangdong(C2)	Guangxi(C2)	Xinjiang(C4)	Shanghai(B)	Sichuan(C1)
4	Guangxi(C2)	Tibet(C4)	Hunan(C2)	Guangdong(C2)	Zhejiang(B)	Guangdong(C2)
5	Tibet(C4)	Fujian(C3)	Guizhou(C4)	Hunan(C2)	Tianjin(B)	Hunan(C2)
6	Hainan(C4)	Tianjin(B)	Anhui(C3)	Hebei(C2)	Shaanxi(C3)	Yunnan(C1)
7	Guangdong(C2)	Guizhou(C4)	Hubei(C3)	Beijing(B)	Inner Mongolia(A)	Tibet(C4)
8	Hebei(C2)	Guangxi(C2)	Henan(C2)	Tianjin(B)	Shandong(C3)	Hubei(C3)
9	Jiangxi(C1)	Jiangsu(B)	Qinghai(C3)	Henan(C2)	Jilin(A)	Henan(C2)
10	Ningxia(C1)	Hebei(C2)	Jiangxi(C1)	Shanghai(B)	Guangdong(C2)	Anhui(C3)
11	Fujian(C3)	Qinghai(C3)	Jiangsu(B)	Tibet(C4)	Gansu(A)	Fujian(C3)
12	Qinghai(C3)	Hubei(C3)	Hebei(C2)	Shaanxi(C3)	Ningxia(C1)	Guangxi(C2)
13	Yunnan(C1)	Beijing(B)	Ningxia(C1)	Jiangxi(C1)	Liaoning(A)	Shanxi(A)
14	Hunan(C2)	Hainan(C4)	Zhejiang(B)	Shandong(C3)	Qinghai(C3)	Chongqing(C1)
15	Gansu(A)	Anhui(C3)	Yunnan(C1)	Zhejiang(B)	Shanxi(A)	Shaanxi(C3)
16	Shandong(C3)	Shandong(C3)	Shandong(C3)	Guizhou(C4)	Chongqing(C1)	Liaoning(A)
17	Anhui(C3)	Gansu(A)	Sichuan(C1)	Sichuan(C1)	Fujian(C3)	Gansu(A)
18	Shaanxi(C3)	Hunan(C2)	Shaanxi(C3)	Fujian(C3)	Anhui(C3)	Xinjiang(C4)
19	Jiangsu(B)	Henan(C2)	Hainan(C4)	Qinghai(C3)	Hebei(C2)	Hebei(C2)
20	Sichuan(C1)	Shanghai(B)	Chongqing(C1)	Hainan(C4)	Heilongjiang(A)	Heilongjiang(A)
21	Chongqing(C1)	Zhejiang(B)	Xinjiang(C4)	Anhui(C3)	Henan(C2)	Shandong(C3)
22	Zhejiang(B)	Yunnan(C1)	Tianjin(B)	Gansu(A)	Hunan(C2)	Jiangxi(C1)
23	Hubei(C3)	Inner Mongolia(A)	Tibet(C4)	Chongqing(C1)	Hubei(C3)	Inner Mongolia(A)
24	Shanxi(A)	Sichuan(C1)	Liaoning(A)	Inner Mongolia(A)	Guizhou(C4)	Ningxia(C1)
25	Inner Mongolia(A)	Shanxi(A)	Shanghai(B)	Hubei(C3)	Yunnan(C1)	Jilin(A)
26	Tianjin(B)	Ningxia(C1)	Shanxi(A)	Yunnan(C1)	Tibet(C4)	Qinghai(C3)
27	Liaoning(A)	Chongqing(C1)	Beijing(B)	Ningxia(C1)	Jiangxi(C1)	Zhejiang(B)
28	Jilin(A)	Liaoning(A)	Inner Mongolia(A)	Liaoning(A)	Sichuan(C1)	Jiangsu(B)
29	Beijing(B)	Jiangxi(C1)	Gansu(A)	Shanxi(A)	Xinjiang(C4)	Tianjin(B)
30	Shanghai(B)	Jilin(A)	Heilongjiang(A)	Jilin(A)	Guangxi(C2)	Shanghai(B)
31	Heilongjiang(A)	Heilongjiang(A)	Jilin(A)	Heilongjiang(A)	Hainan(C4)	Beijing(B)

supply of teaching resources exceeds the growth rate of demand, and the student-teacher ratio is developing in a positive direction.

Although Cluster C3 also have a high student-teacher ratio (S/T), the proportion of students (S) is comparable to the overall national level. This shows that the shortage of teacher resources in these provinces does not come from excessive demand, but from

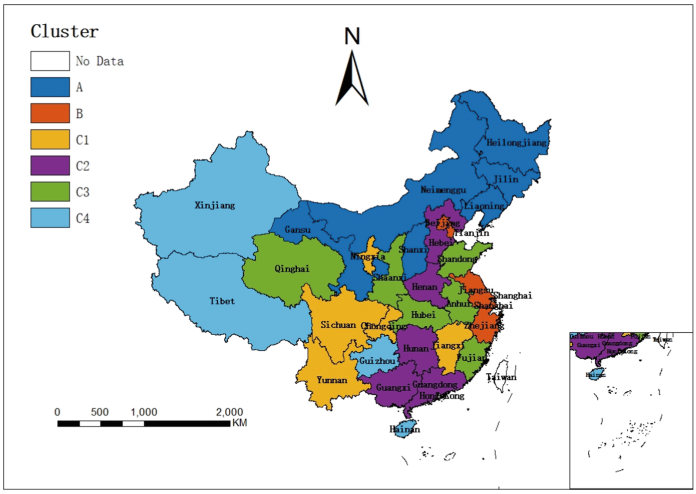

Fig. 4. Cluster map [Owner Draw]

insufficient supply on the supply side. From a trend point of view, the growth rate of full-time teachers (R_T) is comparable to the national overall level, but the growth rate of students (R_S) is higher than the growth rate of full-time teachers (R_T), which shows that the severe situation of the student-teacher ratio in these provinces is still worsening.

Cluster C4 is an artificially merged cluster in the clustering process, and there are large differences among cluster members. Nonetheless, this cluster still has some notable features: The proportion of students (S) is the highest in the country (ranked 1, 3, 5, and 6, respectively) and the growth rate of students (R_S) is also very high (ranked as 1, 4, 7, and 14, respectively), indicating that the teaching resources in these provinces are in great demand and are still growing at a high rate. In terms of educational resources supply, the proportion of full-time teachers with a bachelor's degree or above (Q) in these provinces is the lowest in the country (24, 26, 29, 31) and the growth rate (R_Q) leads the country (ranked 1, 2, 7, 18 respectively), indicating that the absolute level of teaching resource quality is very low, but it is rapidly improving.

4 Conclusions and Policy Recommendations

As pointed out in the analysis framework of supply and demand for educational resources, the carrying capacity of regional educational resources supply to educational demand is the result of the interaction between population structure and economic development and policy formulation. Next, this paper expounds the characteristics of population and economic policies reflected by the above-mentioned six categories of educational resources supply and demand pattern, and puts forward corresponding policy suggestions accordingly.

There is insufficient demand for educational resources in Cluster A. As can be seen from Fig. 4, provinces in Cluster A are mainly distributed in the northern and northeastern regions of China. The main feature of these regions is that the population shows a state of

net outflow. Taking the three eastern provinces as an example, the number of registered households has been decreasing continuously since 2009, especially since 2016. There has been a large number of household registration population moving out [8]. Moreover, the outflow population in this area is mainly young and middle-aged [9], which will further exacerbate the current situation of the continuous reduction of the school-age population, which will lead to insufficient demand for educational resources. Based on these characteristics, the supply and demand pattern of educational resources in this cluster of area is summarized as the "the pattern of net outflow of school-age population". For this region, China, in accordance with changes in the school-age population, should make a scientific layout, rationally allocate educational resources, improve resource utilization efficiency, and avoid irrationally building or retaining schools. At the same time, it is also necessary to consider the basic needs of students, analyze the specific situation in a specific way, not to make a one-size-fits-all approach, and avoid educational reforms such as unreasonable withdrawal or merger of schools.

The supply and demand of educational resources in Cluster B are basically balanced, and the quality of teachers is leading in China. Provinces in Cluster B are mainly distributed in the developed areas of eastern China, including the three municipalities of Beijing, Shanghai and Tianjin and the two economically powerful provinces of Jiangsu and Zhejiang. The main characteristics of these areas are that they are economically developed and attractive. In 2018, the average of the "per capita GDP" of the five provinces was 1.9 times that of the "per capita GDP"[3], and the quality of teachers was far ahead of China's other regions. According to these characteristics, the supply and demand pattern of educational resources in such areas is summarized as "the pattern of high-quality educational resources". Although the area still maintains a reasonable student-teacher ratio, in recent years, the area has seen a continuous influx of school-aged population. Therefore, China should continue to pay attention to the impact on the local education system of the continuous influx of school-aged people caused by the attractiveness of the region.

The allocation of teacher resources in Cluster C1 is basically balanced in quantity, but the quality needs to be improved. Provinces in Cluster C1 are mainly distributed in the underdeveloped areas of southwest China. The main characteristics of these areas are that the regional education level is lagging behind, the development of compulsory education is relatively weak, and there is a gap between the quality of teachers in this region and those in the eastern. According to these characteristics, the supply and demand pattern of educational resources in this cluster of area is summarized as "the pattern of teacher quality to be improved". The region's top priority is to improve the quality of local teachers and strengthen long-term cooperation with other educationally developed regions, so as to narrow the gap and meet the growing demand for high-quality education.

There is a strong demand for teacher resources in Cluster C2. Provinces in Cluster C2 are mainly distributed in the central and southern regions of China. The main feature of these regions is that, except for Guangdong, the economic foundation of other regions is poor. At the same time, these regions have a large population base, the school-age population accounts for a high proportion of the total population, and the demand for

[3] The gross regional product, gross national product and birth rate are all calculated according to *the 2019 China Statistical Yearbook*.

education is much higher than that of other regions. Therefore, the carrying capacity of regional educational resources faces severe challenges. According to these characteristics, the supply and demand pattern of educational resources in such areas is classified as a "the pattern of high density of school-age population". The proportion of students and teachers in the region is already at the forefront. Compared with other regions, this region should establish a more flexible and reasonable teacher admission and exit mechanism. Meanwhile, further decline in the quality of teachers caused by the expansion of teacher enrollment should be avoided.

The supply of teacher resources in Cluster C3 is insufficient. Provinces in Cluster C3 are mainly distributed in the central and eastern regions of China. The main characteristics of these areas are that the economic foundation is still well developed, and the educational foundation is relatively good. But the regional birth rate is high: the average birth rate of the six provinces in this cluster in 2018 was 12.6%, which was much higher than the national average birth rate of 10.9%. This has led to the rapid growth of the school-age population in the region and the insufficient supply of educational resources. Based on these characteristics, the supply and demand pattern of educational resources in such areas are classified as "the pattern of school-age population growth". The region should objectively estimate the future trends of the school-age population, thus expand teacher recruitment as needed, and avoid a structural teacher shortage.

The quality of teachers in Cluster C4 is the lowest in China. These provinces are all areas inhabited by ethnic minorities. These areas are characterized by poor economic development, deep poverty and weak educational foundation, and the quality of teachers lags far behind other areas. But at the same time, these regions have distinctive national traditional culture. Based on these characteristics, the supply and demand pattern of educational resources in such areas is classified as "the pattern of weak educational foundation". Compared with other regions, due to its objective conditions, it is more difficult to attract talents. This requires unified national deployment, precise alignment with educational development needs, and the introduction of high-quality schools. Meanwhile, China should focus on cultivating schools with local characteristics [10], thus promoting the inheritance and development of traditional culture, and promoting the development and progress of comprehensive educational level in the region.

Promoting the high-quality and balanced development of compulsory education reflects the new requirements for education after China has entered a new era of socialism with Chinese characteristics. In this paper, through the cluster analysis of the supply and demand pattern of educational resources in 31 provinces, the current situation of supply and demand of educational resources in various regions can be more comprehensively and clearly presented. This paper provides more sufficient theoretical supports for the realization of the goals put forward by *China's Education Modernization 2035*.

Acknowledgements. We are grateful to the Big Data Center of School of Systems Science, Beijing Normal University (https://sssdata.bnu.edu.cn) for their support.

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