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Original Paper

Research on the Allocation Efficiency of Compulsory Education Resources in Chongqing from the Perspective of Space

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Abstract

This paper makes full use of the related research methods of spatial econometrics and envelope analysis to conduct in-depth analysis and research on the efficiency of the allocation of compulsory education resources in Chongqing. The influence of social and economic development, the scale of compulsory education and the distribution of urban and rural population on the allocation efficiency of compulsory education resources in Chongqing and its degree of influence. The analysis and research results show that: the overall level of the allocation efficiency of compulsory education resources in Chongqing is low, and it shows a gradual downward trend; the allocation of compulsory education resources in Chongqing is unbalanced within the region; the allocation efficiency of compulsory education resources in Chongqing has a significant positive spatial correlation; the districts (counties) of the same type of compulsory education resource allocation show obvious spatial aggregation characteristics, and the aggregation area is getting larger and larger; the spatial dependence and spatial spillover effect of the allocation efficiency of compulsory education resources in Chongqing is also very significant.

Keywords

Spatial measurement, Compulsory education, Resource allocation efficiency

1. Introduction

Since the implementation of the Compulsory Education Law in 1986, my country has always regarded compulsory education as a major strategy for promoting national development. Efforts to achieve the balanced development of compulsory education is also one of the important goals of my country's education development, because the balanced development of compulsory education is the starting point of actively realizing social fair development. With the development of the "basically balanced" supervision of compulsory education, statistics from relevant departments show that by 2108, my

country has basically achieved the basic balanced development of compulsory education in most regions. In recent years, the relevant documents of the Party Central Committee and the State Council on the development of compulsory education have also successively proposed that compulsory education should gradually change from basic balanced development to high-quality and balanced development direction. The so-called high-quality and balanced development of compulsory education refers to the gradual realization of a fair starting point for compulsory education and the continuous improvement of the allocation efficiency of compulsory education resources. At present, governments at all levels in my country are taking a series of policy measures to gradually narrow the urban-rural gap, inter-school gap, east-west gap, etc. in the stage of compulsory education, and are striving to achieve balanced development of compulsory education and efficient allocation of compulsory education resources.

Regarding the research on the allocation of educational resources, some foreign scholars have already formed certain research results in the 1960s. Relevant scholars believe that the efficient allocation of educational resources is helpful to actively solve a series of problems caused by insufficient educational funds. Chinese scholars have also conducted in-depth research on the allocation of educational resources, and in recent years, the research of Chinese scholars on the allocation of educational resources has gradually shifted from qualitative analysis to quantitative analysis. In the existing research, the improved data envelopment analysis (SBM-DEA) has become the main analysis method for evaluating the allocation of educational resources in recent years, and this method has been recognized by many scholars. This paper integrates SBM-DEA and spatial econometric analysis methods in the research, and conducts in-depth research and analysis on the input and output efficiency of the allocation of compulsory education resources in Chongqing in recent years. The spatial distribution characteristics and correlation of the allocation of compulsory education resources among (counties), and the main factors affecting the allocation of compulsory education resources in Chongqing from the perspective of space are analyzed by making full use of the econometric model. Provide reference for efficient allocation of educational resources.

2. Research Methods and Index System Design

2.1 Overview and Model of SBM-DEA Method

There are many efficiency evaluation methods in academia. DEA is the most commonly used method to measure relative efficiency in evaluating multi-input and multi-output multi-objective decision-making problems. The basic principle of Data Envelope Analysis (DEA) is to construct a non-parametric envelope frontier through the spatial data of the decision unit. Those on the frontier are valid points, while those outside the frontier are invalid points. The non-radial and non-angular SBM model proposed by Tone (2009) overcomes the traditional CCR and BCC models that do not consider the influence of input-output slack variables on the model estimation reliability, and adds slack

variables to the objective function, which can effectively solve the problem of including pollution variables efficiency measurement problem. The basic idea is as follows.

Assuming that the number of decision-making units in a system is n, each decision-making unit contains three variables: input (X), expected output (Yg) and undesired decision output (Yb). The matrices defining X, Yg, Yb are as follows:

$$X = [x_1, x_2, x_3, ..., x_n] \in R_{m \times n},$$
$$Y^g = [y_1^g, y_2^g, y_3^g, ..., y_n^g] \in R_{s1 \times n},$$
$$Y^b = [y_1^b, y_2^b, y_3^b, ..., y_n^b] \in R_{s2 \times n}$$

$X > 0, Y^g \geqslant 0, Y^b \geqslant 0$。Define the production possible set as：

$$p = \{(x, y^g, y^b) \mid x \geqslant X\lambda, y^g \leqslant Y^g \lambda, y^b \geqslant Y^b \lambda, \lambda \geqslant 0\}$$

The linear programming form of the SBM model is as follows:

$$\rho^* = \min \frac{1 - \frac{1}{m}\sum_{i=1}^{m} \frac{s_i^{-1}}{x_{i0}}}{1 + \frac{1}{s_1 + s_2}\left(\sum_{s2}^{s1} \frac{s_r^g}{y_{r0}^g} + \sum_{r=1}^{s2} \frac{s_r^b}{y_{r0}^b}\right)}$$

$$s.t. \begin{cases} x_0 = X\lambda + s^{-1} \\ y_0^g = Y^g \lambda - s^g \\ y_0^b = Y^b \lambda + s^b \\ \lambda, s^{-1}, s^g, s^b \geqslant 0 \end{cases}$$

In the above formula, $0 \leqslant \rho^* \leqslant 1$, and s^{-1}, s^g, s^b are strictly decreasing. s^{-1}, s^g, s^b are represents slack variables, λ representing excessive input, ρ^* insufficient expected output and excessive undesired output, respectively, representing the weight of each variable, and the numerator and denominator of the objective function respectively express the deviation of input and output from the optimal state, the decision-making unit is the most effective only when there is no redundancy or deficiency in the input and output.

2.2 Spatial Measurement Analysis

2.2.1 Exploratory Spatial Data Analysis

The Exploratory Spatial Data Analysis method uses global correlation and local correlation test analysis to explore the non-randomness and spatial correlation of spatial distribution. Among them, global correlation mainly studies the correlation of spatial economic data in the entire space-time system; local correlation is to explore the correlation of local regions, and the main observation

indicators are Moran index, Moran scatter plot and LISA statistics.

First, the Moran index. The global spatial correlation test mainly revolves around Moran's I index. The value range of the index is [-1, 1]. When the value is positive, it means that there is a positive spatial correlation between the research objects, and the closer the value is to 1, the more The more significant the positive correlation is, and vice versa. When the value is 0, it means that the research subjects are randomly distributed. The formula for calculating the index is as follows:

$$I = \frac{n\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\left(x_i - \bar{x}\right)}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}\left(x_i - \bar{x}\right)^2} = \frac{n\sum_{i=1}^{n}\sum_{j\neq 1}^{n} w_{ij}\left(x_i - \bar{x}\right)\left(x_j - \bar{x}\right)}{S^2\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}}$$

In the above formula, n represents the total number of cities and counties in Chongqing; x_i and x_j represents the observed values of district I and district J, which are spatial weight matrices.

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \quad ; \quad S^2 = \frac{1}{n}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2$$

The setting of the space matrix in this study adopts the binary first-order space adjacency matrix W, and the specific settings are as follows:

$$w_{ij} = \begin{cases} 1, \textit{ Region I and region J have a common boundary} \\ 0, \textit{ Region I and region J have not a common boundary} \end{cases}$$

The spatial weight matrix is mainly used to express the correlation degree between regions from the spatial perspective. At present, the spatial adjacency weight matrix is widely used in the research on the spatial effect of educational resource allocation. The allocation of educational resources will produce spatial autocorrelation due to the adjacency of geospatial. Therefore, the spatial adjacency matrix is used to reflect the mutual proximity relationship between regions. Its setting principle is that regions are adjacent, that is, if there is a common boundary, the weight is set to 1, if not adjacent, there is no common boundary, the weight is set to 0, and the diagonal elements of the matrix are all 0.

Second, Moran scatter plot and LISA index. The Moran's I index clarifies whether a phenomenon or attribute has spatial correlation and agglomeration, but it cannot reflect local spatial correlation and agglomeration. In order to further identify the correlation of the local space, this paper uses the Moran scatter plot and the local space association indicator (LISA) to conduct research. The Moran scatter plot can reflect the local spatial agglomeration characteristics through four quadrants, the first quadrant is "high-high type area (H-H)", the second quadrant is "low-high type area (L-H)", and the third quadrant is "Low-Low Zone (L-L)" and the fourth quadrant is "High-Low Zone (H-L)". At the same time, the

LISA index is used to test whether the correlation between regions has agglomeration effect, and its calculation formula is as follows:

$$I_i = \frac{\left(x_i - \bar{x}\right)}{S^2} \sum_{j \neq 1}^{n} w_{ij}\left(x_j - \bar{x}\right)$$

When I_i is a positive value, it means being surrounded by high values by high values, or by low values by low values. When I_i is negative, it means that high values are surrounded by low values or low values are surrounded by high values. That is, the type of aggregation.

2.2.2 Spatial Metering Panel Model

Moran's I index can show global spatial correlation. In fact, the spatial allocation of educational resources is significantly affected by the allocation of resources in surrounding districts and counties. Therefore, the use of OLS alone may lead to estimation bias, so it is necessary to incorporate spatial correlation factors into the empirical regression model. In order to verify, the Spatial Lag Model (SLM) and Spatial Error Model (SEM) proposed by Anselin are used to verify the impact of spatial correlation on the resource efficiency of resources.

The Spatial Lag Model (SLM) usually studies whether variables have obvious spillover effects among different regions. Combined with the research object of this paper, this model is mainly used to measure whether there are spillover effects of compulsory education resources among various districts and counties in Chongqing. The specific model is as follows:

$$y_{i,t} = \alpha W y_{i,t} + \beta X_{i,t} + \varepsilon_{i,t}$$

Among them, $y_{i,t}$ is the explained variable, that is, the allocation efficiency of compulsory education resources in various districts and counties in Chongqing. $Wy_{i,t}$ is the spatial lag variable, and W is the spatial crowd matrix. $X_{i,t}$ is a control factor that may affect the allocation efficiency of compulsory education resources in districts and counties.

The Spatial Error Model (SEM) measures the dependence between spatial elements through the perturbation change of the error term. The model is set as:

$$y_{i,t} = \beta X_{i,t} + \mu_{i,t} \quad , \quad \mu_{i,t} = \alpha W \mu_{i,t} + \varepsilon_{i,t}$$

The variables of the above formula are the same. In the above formula α is the autocorrelation coefficient of the spatial error term, which mainly measures the real influence of the adjacent area after the disturbance of the local error term.

2.3 Choice of Indicators

In a general sense, the analysis of efficiency always involves the selection of two dimensional indicators of "input and output". By considering the research on the efficiency of resource allocation of compulsory education and the availability of researchers' data, three dimensions of "human resources, material resources and financial resources" are selected as input indicators; for output indicators, this paper uses compulsory education respectively. The completion rate is used as a realistic indicator of basic education. The enrollment rate in the compulsory education stage reflects the "quality" of the development of compulsory education, and the data of compulsory education participation of people over 6 years old is used to construct the balance of compulsory education development. The specific indicators are shown in Table 1.

Table 1. The Input and Output Index System of the Allocation Efficiency of Compulsory Education Resources in Chongqing

Input indicator	Teacher-student ratio in compulsory education (percentage) X1
	Fixed assets per student in compulsory education (yuan) X2
	Education expenditure per student in the compulsory education stage (yuan) X3
Output indicator	Completion rate of compulsory education (percentage) Y1
	Progression rate in compulsory education stage (percentage) Y2
	Compulsory education accepts GINI coefficient Y3

Note. The relevant data in this article are all from the "Chongqing Statistical Yearbook", "China Education Statistical Yearbook" and the relevant data published on the website of the Chongqing Municipal Education Commission.

3. An Empirical Analysis of the Efficiency of the Allocation of Compulsory Education Resources in Chongqing

3.1 Analysis of the Differences in the Allocation Efficiency of Compulsory Education Resources among Districts and Counties in Chongqing

This paper uses Matlab software commonly used in mathematical statistics to analyze the relevant index data of compulsory education in various districts and counties in Chongqing from 2010 to 2020. The relative efficiency of resource allocation for compulsory education, and then the relative rate of resource allocation in each time period is sorted out to ensure that the relative efficiency of resource allocation in each time period is more objective and truer.

According to the calculation, the change trend of the allocation efficiency of compulsory education resources in various districts and counties in Chongqing from 2010 to 2020 and the differences in resource allocation among districts and counties are as follows: First, the overall allocation efficiency of compulsory education resources in Chongqing is low, and the allocation efficiency of compulsory education resources in various districts and counties in Chongqing is as follows: The resource allocation efficiency of compulsory education in Chongqing shows a downward trend; second, the districts and counties with relatively low economic development in Chongqing have relatively high resource allocation efficiency in their regions. In the relatively good areas of Chongqing, the allocation efficiency of compulsory education resources is relatively low. Obviously, there is no proportional relationship between the level of economic development and the allocation efficiency of compulsory education resources. Third, the overall allocation of compulsory education in Chongqing has shown a gradual upward trend, and the increase rate and scale are relatively small.

3.2 Spatial Distribution Characteristics of the Allocation Efficiency of Compulsory Education Resources in Chongqing

Based on the allocation efficiency of compulsory education resources in Chongqing, this paper further analyzes and researches whether there is a spatial correlation between the allocation efficiency of compulsory education resources in Chongqing, and makes full use of the existing spatial data analysis methods for the allocation efficiency of compulsory education resources in Chongqing. Association and regional clustering effects were analyzed and tested.

3.2.1 Spatial Correlation Test and Analysis Based on a Global Perspective

This paper mainly uses DeoDa software to calculate the global Moran's I index from 2010 to 2020, and test and analyze the calculated Moran's I index. Based on the global perspective, the spatial distribution characteristics of the allocation efficiency of compulsory education resources in Chongqing are analyzed and studied.

Table 3. Moran's I of Compulsory Education Resource Allocation Efficiency in Chongqing from 2010 to 2020

Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Moran's I	0.332	0.207	0.254	0.311	0.324	0.351	0.364	0.298	0.350	0.294	0.305
P-Value	0.001	0.020	0.003	0.004	0.002	0.001	0.003	0.002	0.001	0.002	0.001

According to the calculation results in Table 3 above, it can be seen that the Moran's I index of the allocation of compulsory education resources in Chongqing has obviously passed the 5% significance test, and the Moran's I index values are all greater than zero. This means that the allocation efficiency of compulsory education resources in Chongqing shows an obvious positive spatial autocorrelation in space. It can be seen that the allocation process of compulsory education resources in Chongqing shows obvious spatial aggregation in terms of geographical location, that is, the allocation process and results of compulsory education resources in Chongqing are not random, but come from spatial aggregation. Compulsory education Areas with abundant resource allocation have relatively rich allocation of compulsory education resources in their surrounding areas. Similarly, the surrounding areas of areas with relatively low allocation of compulsory education resources are also relatively lacking in resource allocation.

3.2.2 Spatial Correlation Test and Analysis from a Local Perspective

According to the above-mentioned Moran's I index analysis, it can be seen that the allocation efficiency of compulsory education resources in Chongqing has an obvious positive correlation in space. Moran and LISA scatter plot (due to limited space, this paper does not show the specific distribution of each quadrant of the scatter plot) analysis to represent the spatial aggregation characteristics of the allocation of compulsory education resources.

Through the analysis of Moran scatter plot distribution, it can be seen that in 2010, about 69% of the districts and counties in Chongqing had a positive spatial correlation between the allocation efficiency of compulsory education resources and the spatial distribution, while in 2020, about 57% of the districts and counties in Chongqing had a positive spatial correlation. The allocation efficiency of compulsory education resources has a positive spatial distribution correlation, and the rest of the years from 2010 to 2020 basically show the same phenomenon. This further confirms that from 2010 to 2020, the allocation efficiency of compulsory education resources in Chongqing showed a significant positive spatial correlation in the spatial distribution.

The Moran scatter plot distribution analysis above can only confirm that there is a positive spatial correlation in the spatial distribution of the overall compulsory education resource allocation efficiency in Chongqing, but it cannot explain its spatial agglomeration and whether there is a spatial

agglomeration effect. Here, according to the subdivision of LISA agglomeration areas, it can be seen that there is a significant spatial correlation in the allocation of compulsory education resources in the urban and county districts of Chongqing. Specifically, it shows that the districts and counties with higher allocation of compulsory education basically have obvious spatial aggregation characteristics, and the districts and counties with low allocation efficiency of compulsory education resources are also obviously clustered in a large area.

4. Analysis of the Factors Affecting the Allocation Efficiency of Compulsory Education Resources in Chongqing

The allocation efficiency of compulsory education resources is affected by a variety of macro and micro factors. This paper mainly analyzes six key factors, including the degree of government policy support, the level of scientific and technological development, the social and economic development environment, the degree of local opening to the outside world, and the scale and population structure of local compulsory education. Analyzed. Through analysis, this paper believes that the allocation efficiency of compulsory education resources in Chongqing first has obvious spatial dependence, that is, the allocation of compulsory education resources in each district and county will be directly affected by the allocation of compulsory education resources in adjacent districts and counties, not only by the district. The influence of factors such as county social economy, science and technology, culture and population structure.

Secondly, according to the above quantitative analysis results, it can be seen that the impact of the level of scientific and technological development on the allocation efficiency of compulsory education resources in Chongqing has a positive impact, but the degree of impact is weak, showing an insignificant positive correlation in statistics. The urban and rural population structure in the population structure has a greater impact on the allocation of compulsory education resources in Chongqing, and is the most influential among all influencing factors. This shows that there is an obvious positive relationship between the size of the rural population and the allocation efficiency of compulsory education resources. Correlation. The reason for this significant correlation may be that there are obvious differences in the allocation of urban and rural compulsory education resources. Under the influence of this difference, as long as the investment in rural compulsory education is increased, the input-output ratio of compulsory education assets will increase rapidly.

There is a significant negative correlation between the Chongqing municipal government's policy support, the degree of local social and economic development and the degree of local opening to the outside world, and the allocation efficiency of compulsory education resources. This further illustrates the imbalance in the allocation of compulsory education resources. For example, a main urban area with a high degree of social and economic development, strong government support, and a high degree of opening to the outside world has relatively more compulsory education resources invested, and may

even have excess, and its compulsory education resource allocation efficiency is relatively high.

Finally, there is a significant negative correlation between the size of compulsory education in Chongqing and its allocation efficiency. This shows that the larger the scale of compulsory education, the more complex the allocation of compulsory education resources in the region, and the effect of resource allocation is relatively lagging behind, resulting in the efficiency of compulsory education resource allocation will be inhibited by the scale of compulsory education.

5. Conclusion and Suggestion

The allocation of compulsory education resources in Chongqing has also become a hot issue of concern to the Chongqing Municipal Government in recent years. Under the guidance of the transformation of compulsory resource allocation from basic equilibrium to high-quality allocation, the efficiency of compulsory education resource allocation has attracted much attention. Based on the spatial perspective, this paper conducts a basic analysis on the allocation efficiency of compulsory education resources in Chongqing, and draws the following conclusions:

First, the overall allocation of compulsory education resources in Chongqing is currently in a basically balanced state, but in the process of transforming from overall equilibrium to high-quality allocation, there are obvious differences between districts and counties in Chongqing. The specific performance is that the districts and counties with a higher degree of economic development are significantly lower than the remote districts and counties. The main reason for this difference is that there has been an obvious gap in social and economic development between districts and counties for a long time, and there are significant differences in population size and local government financial investment. Due to the input of various resources from the government and the market in the main urban area, the compulsory education resources are piled up in a disorderly manner, and the allocation efficiency of compulsory education resources is relatively low.

Second, in terms of spatial distribution, there is an obvious positive spatial correlation in the allocation efficiency of compulsory education resources in Chongqing, and there is an obvious spatial agglomeration phenomenon in geographic spatial distribution. In addition to policy factors, the reasons for the existence of geographic agglomeration effect are also differences in regional socio-economic development.

Third, through the spatial econometric analysis of the allocation efficiency of compulsory education resources in Chongqing, it is found that the allocation of compulsory education resources in Chongqing has obvious spatial dependence and positive spatial spillover effect. The allocation efficiency of compulsory education resources in each district and county is directly affected by factors such as spatial dependence, social and economic development, population structure and the scale of compulsory education in the region.

In view of the above analysis results, this paper puts forward the following suggestions: First, vigorously improve the allocation capacity of compulsory education resources in districts and counties with less compulsory education allocation and low efficiency, so as to further improve the overall efficiency of compulsory education resource allocation in Chongqing. This can be achieved by increasing the investment in financial, material and human resources for compulsory education. Second, give full play to the positive spillover effect of the compulsory education resource space between districts and counties. Through the establishment of a compulsory education resource sharing platform among districts and counties, mutual assistance of teachers and other means, the leading role of the advantageous regions will be brought into full play, and the further improvement of the allocation of compulsory education resources in the surrounding districts and counties will be promoted. Third, attach importance to the common development of the quality and quantity of compulsory education.

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