An Empirical Analysis of the Service Efficiency of Basic Public Education Based on the BCC-DEA Model of Neural Network Computing Principles

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Abstract. Aiming at the problem that the performance ranking analysis method in the traditional BCC-DEA model will produce infeasible solutions under the assumption of variable returns to scale, this paper proposes to apply the neural network calculation principle to the DEA performance ranking analysis, thereby establishing a BCC based on the neural network calculation principle -DEA model, and then use this model to analyze the efficiency of basic public education service investment in Jilin Province during the "Twelfth Five-Year Plan" period, and studied the details of the nine-year compulsory education service. The implementation measures and implementation rules examine the relationship between the government's interactions between educational resources and economic benefits. The layer is facing empirical research in Jilin Province as a whole. The study found that the overall high speed of basic public education services in Jilin Province is insufficient, and the education system, management level, and pure technical efficiency of resource allocation are the main factors affecting overall efficiency. Various investments made by the government during the 12th Five-Year Plan period, the efficiency changes in the whole period: the overall comprehensive efficiency changes in Jilin Province decreased during the five years, and the direct influencing factors were insufficient progress in education and through a variety of training, and a variety of multimedia education and new technology application. To this end, the paper puts forward the following suggestions: explore the public policy of sufficiency education, improve the performance of resource allocation; build a public policy of responsive education, improve the financial security mechanism; establish a public policy of binding education, improve the system management; promote learning education Public policy to improve the development of capabilities.

Keywords: Neural Network Computing, BCC-DEA model, Jilin Province, Basic public education services, Efficiency

1. Introduction
Education is the foundation of a century-long plan. Basic public education service, The government has primary management responsibilities for public services. This is the key to the transformation of
service-oriented government functions, These things have a prominent role in improving the country's economic strength and developing people's lives[1].

In July 2012, the Ministry of Education proposed a development plan for building a well-off society in an all-round way, and also established a development idea to revitalize the country by building teaching, promote priority development of education and scientific development, and make education more in line with the needs of building socialism with Chinese characteristics for personnel training[2]. It meets the ardent expectations of the broad masses of the people for education. In the 12th Five-Year Plan of the Ministry of Education, it is also proposed to improve the efficiency of investment in education [3]. Through scientific planning, we can improve the macro-benefit of education investment, arrange increments scientifically, optimize the structure of education investment, and avoid duplication of construction and waste[4].

Based on the implementation of educational public policy and the current situation and trend of investment efficiency of human, financial and material resources, this paper evaluates the efficiency of basic public education services in Jilin Province by BCC-DEA model, thus revealing the intrinsic influencing factors of static and dynamic efficiency changes of basic public education services in Jilin Province, and trying to analyze and summarize the optimization of educational public policy performance[5]. The countermeasures and suggestions will provide some reference for the construction and development of service-oriented government and scientific demonstration of public education policy in Jilin Province during the 13th Five-Year Plan period of building a well-off society in an all-round way[6].

![Figure 1. How SaaS is developed by application (adapted from Anderson, Britz, & Bell, 2012[2])](image)

**2. Basic Public Education Service Concept**

The essence of education is to provide citizens with more comprehensive services and improve the quality and level of the overall citizenship, so as to ultimately play a positive role in promoting the
development of the entire nation [7]. The main characteristics of basic public education services include: publicity, inclusiveness, basicity, and developmental characteristics [8].

3. Analysis Of Bcc-Dea Model Of Basic Public Education Service Efficiency In Jilin Province

3.1. Research methods and model description

In this paper, the BCC-DEA model proposed by Banker is used to analyze the basic public education service efficiency in Jilin Province. We can use DEA to analyze, and use the BCC model to improve the original CCR model, and set different VRS variables to observe the changing characteristics of DMU technology [9]. Suppose there are n decision-making units in the model. Each decision-making unit has m types of output and output of s types, which respectively represent the unit's "full utilization of basic public education investment" and "investment idle" [10].

$$x_{ij} \left( 1 \leq i \leq m \right)$$ represents the input of the jth decision unit for the ith type input, and  

$$y_{ir} \left( 1 \leq r \leq s \right)$$ represents the output of the jth decision unit for the rth type output. ...
the \( j \)th decision unit for the \( r \)-th type output [2]. After introducing the Archimedes infinitesimal \( \varepsilon \) and the relaxation variable \( s^- \) to produce the relaxation variable \( s^+ \), finally the model is:

\[
\begin{align*}
\min & \quad \theta - \varepsilon \left( \sum_{j=1}^{n} c_{j}\lambda_{j} + s^- \right) \\
\text{s.t.} & \quad \sum_{j=1}^{n} A_{j}x_{j} + s^- = \theta x_0 \\
& \quad \sum_{j=1}^{n} B_{j}y_{j} - s^+ = y_0 \\
& \quad \lambda_{j} \geq 0, \quad j=1,2,\ldots,n \\
& \quad s^+ \geq 0, s^- \geq 0
\end{align*}
\]

among them,

\[
x_j = (x_{j1}, x_{j2}, \ldots, x_{jm})^T, \quad y_j = (y_{j1}, y_{j2}, \ldots, y_{j1})^T,
\]

\[
\hat{\theta} \in \mathbb{E}^m, \quad \hat{e} = (1,1,\ldots,1)^T \in \mathbb{E}^m,
\]

\[
x_0 = x_{j0}, y_0 = y_{j0}, \text{ the input slack variable is } s^- = (s^1, s^2, \ldots, s^m)^T \text{ and the output slack variable is } s^+ = (s^1, s^2, \ldots, s^m)^T.
\]

\[\text{Figure 3. Input-oriented DEA model}\]

3.2. DEA effective target value

Using projection analysis, the following formula can be used to calculate the effective target value of DEA for the basic public education service efficiency in Jilin Province during the ”Twelfth Five-Year Plan” period, that is, the relatively optimized basic public education service investment and scale. The specific operation process is as follows:

Let \( \lambda_0, s_0, s_0^+, \theta_0 \) be the optimal solution for linear programming, with expressions:

\[
\hat{x}_0 = \theta_0 x_0 - s_0 = \sum_{j=1}^{n} \lambda_0^j x_j
\]

\[
\hat{y}_0 = y_0 + s_0^+ = \sum_{j=1}^{n} \lambda_0^j x_j
\]

Among them, \( s_0^+, s_0^- \) is the secondary vocational education funding input and the corresponding slack variable of the \( j_0 \) decision-making unit, and \((\hat{x}_0, \hat{y}_0)\) is the projection of the evaluation unit
DMU on the corresponding \((x_0, y_0)\) DEA relative effective surface. A valid target value can be found by projecting the value of the slack variable and the amount of basic public education service input. The specific indicators are as follows: the variables are the number of basic public education services; the cost of education is on the individual, mainly on the salaries and benefits of teachers, and the subsidies for students; the cost of education is public, mainly refers to public education services[11]. Expenditure on public expenditure and special expenses; capital construction fee, mainly used for the establishment of school buildings; observation indicators are original values, that is, the expenditure and education scale of basic public education services in Jilin Province under actual conditions[12]; The value, that is, the input redundant value, indicates the degree of idleness of the basic public education service input; the value of the slack variable of the output indicator indicates the unreasonable degree of the basic public service education scale[13].

4. Status Quo Of Basic Public Education Services In Jilin Province

Over the years, Jilin Province has made great progress in promoting the equalization of basic public services. Especially with the continuous strengthening of the economic strength of Jilin Province, the financial support capacity of basic public services has been significantly improved. He has made remarkable achievements in actively promoting reforms in social undertakings such as education, health, and culture, and has accumulated rich experience. In particular, great achievements have been made in free and compulsory education in urban and rural areas, the renovation of rural primary and secondary schools, the basic medical security for urban and rural residents, the improvement of the living standards of low-income households, and the construction of low-rent housing[14]. With the full realization of rural free compulsory education, the expansion of employment scale, the further strengthening of the social security system, the continuous improvement of the public health system and the basic medical service system, especially the realization of the comprehensive coverage of the new rural cooperative medical care, Jilin Province's people's living standards and health standards have been continuously improved, and happiness has been continuously enhanced. In recent years, Jilin Province has made clear arrangements and plans for accelerating the process of equalization of basic public services, and has adopted a series of measures and achieved remarkable results [15].

The Jilin Provincial Government is committed to the transformation of government functions and strengthening the concept of a service-oriented government. The public's satisfaction with the government's provision of basic public services has also increased. Taking basic medical and basic education as an example, basic medical and health services are the most basic medical care needs of the masses and a basic public service that the masses are most concerned about. Compared with 2010, the number of beds per 10,000 people in Jilin Province in 2017 was 25.54%, and the growth rate of doctors was 7.96%[16]. In 2018, the growth rate of beds per 10,000 population in 2017 was 5.13%, and the growth rate of doctors was 4.51%[17]. In 2018, the growth rate of doctors reached 56.66% during the entire 12th Five-Year Plan period. This is not only the achievement of simple capital investment, but also the effectiveness of the government's supply-side structural reform, efforts to adapt to the needs of the masses, and efforts to increase the level of medical and health services[18]. Basic education is also a basic public service with strong demand from the masses. The level of basic education has shown outstanding results under the macro-control of local governments in Jilin Province. At the end of 2018, Jilin Province's public finance education funds reached about 47.046 billion yuan, an increase of 16.62% over the same period of 2017, about 40.343 billion yuan [19]. By the end of 2018, the ratio of ordinary primary school students in Jilin Province was 11.53, junior high school was 9.34, and ordinary high school was 13.81. The school is 8.93. Compared with 2017, it has seen further adjustments and declines[20]. It can be seen that the governments at all levels in Jilin Province have made great efforts to provide more adequate, balanced and better public services for the basic educational needs of the people.
5. Empirical Research

Before using the indicator system for model analysis, it is necessary to analyze the correlation between selected input and output indicators. The purpose is to test whether the indicators are stuck. If the correlation between the indicators is strong, the principal component analysis method should be used for data dimensionality reduction to ensure the independence between the indicators. In this paper, the SPSS software is used to test the input and output values of the research objects during the "Twelfth Five-Year Plan" period, and the KMO sample test and Bartlett's spherical test are carried out. The judgment criteria are as follows.

| KMO       | >0.9   | 0.8-0.9 | 0.7-0.8 | 0.6-0.7 | 0.5-0.6 | <0.5      |
|-----------|--------|---------|---------|---------|---------|-----------|
|           | Very relevant | Relatively strong correlation | Strong correlation | General relevance | Not relevant | Very weak correlation |
| Bartlett's | When the P value is the significance probability ≤ α, the correlation is strong. |

The KMO-BTS test for the primary school junior high school input indicator data in the basic public education services of 8 prefecture-level cities in Jilin Province and one autonomous prefecture in 2018 is shown below.

Table 3. KMO and Bartlett's test of the input indicators for the junior high school in 2018

| Sampling a sufficient Kaiser-Meyer-Olkin metric | 0.641 |
|-----------------------------------------------|-------|
| Bartlett's sphericity test                     |       |
| Approximate chi-square distribution            | 15.600|
| Df                                             | 3     |
| sig                                            | 0.001 |

This study uses the macro analysis of the efficiency of basic public education services in Jilin Province. According to the new public management theory and public policy performance theory, follow the index screening principle, draw on the statistical analysis of existing literature indicators, combined with DEA research methods, the index system of this paper will consist of two categories: input indicators and output indicators.

Table 4. Evaluation Index System of Basic Public Education Service Efficiency in Jilin Province

| Indicator category | Primary indicator | Secondary indicators | unit      |
|--------------------|-------------------|----------------------|-----------|
| Input indicator    | Faculty           | Number of faculty and staff | people    |
|                    | Education funding | Average educational budget within the budget | yuan      |
|                    | School conditions | Average fixed asset value | yuan      |
| Output indicator   | Output quantity   | Number of students in school | people    |
|                    | Output quality    | Number of graduates | people    |
|                    |                   | Progression rate | Percentage (%) |
In 2015, the ending year of the "Twelfth Five-Year Plan". Therefore, this paper selects the statistics of the basic public education service input and output indicators for the year, and adopts the variable-oriented compensation (BCC) input-oriented DEA model. Deap2.1 statistical software for basic public education services in 8 cities and 1 autonomous prefecture of Jilin Province (Changchun City, Jilin City, Siping City, Liaoyuan City, Tonghua City, Songyuan City, Baicheng City, Baishan City and Yanbian Korean Autonomous Prefecture) Efficiency for cross-sectional analysis. The adoption of the BCC model is based on the practical fit of the non-optimal scale operations that may be caused by various cities due to historical basis and resource availability [6].

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|c|c|}
\hline
Prefecture-level city & crste & vrste & scale & Scale remuneration & Avg (crste) & Avg (vrste) & Avg (scale) \\
\hline
SiPing & 0.8 & 0.804 & 0.955 & drs & 0.882 & 0.891 & 0.983 \\
JiLin & 1 & 1 & 1 & drs & & & \\
ChangChun & 0.989 & 0.989 & 1 & - & & & \\
LiaoYuan & 0.998 & 0.998 & 1 & - & & & \\
Tonghua & 0.792 & 0.792 & 1 & - & & & \\
SongYuan & 0.921 & 0.921 & 0.995 & - & & & \\
BaiCheng & 0.83 & 0.834 & 1 & - & & & \\
BaiShan & 0.858 & 0.858 & 1 & - & & & \\
YanBian & 0.751 & 0.821 & 0.897 & - & & & \\
\hline
\end{tabular}
\caption{School efficiency of nine-year compulsory education school in basic public education service in Jilin Province in 2015}
\end{table}

At the same time, due to the special factors such as fixed and mandatory objects in the basic public education service, the DEA effective input-oriented model is realized by optimizing the investment without reducing the output conditions. Taking the efficiency of running a nine-year compulsory education school as an example, the efficiency of DEA investment is analyzed.
The main indicators of basic public service education efficiency include the number of secondary schools per capita and the number of teachers, and the proportion of education funds to local fiscal expenditure. The higher level of education infrastructure determines the highest score for education civilization factors in Jilin City. In 2015, the number of secondary schools per 10,000 people in Jilin City was 0.731, which was 0.137 higher than that of Changchun City, which was the second highest in the last two places, 0.373 and 0.383 in Yanbian and Tonghua. The number of faculty members per 100 people in Changchun City reached 8.646, only slightly lower than the first place in Jilin City, 0.311 people.

![Efficiency of ordinary primary and junior high schools in basic public education services in Jilin Province in 2018](image)

**Figure 5.** Efficiency of ordinary primary and junior high schools in basic public education services in Jilin Province in 2018

6. Recommendations

6.1. Exploring the sufficiency education public policy and improving the performance of resource allocation

Exploring the fixed cost-variable benefits of existing resource benefits maximization, variable costs-changing benefits, minimum investment, maximum output, education public policy, narrowing the horizontal gap between regions, and constructing a new pattern of coordinated development in Jilin Province. The economic bases of 8 cities and 1 autonomous prefecture in Jilin Province are different. To achieve the high quality and efficiency of the basic public education services in Jilin Province, we can explore the horizontal transfer payment model of 8 cities and 1 autonomous prefecture. The government has improved the quality of education services by continuously improving the field of educational resources and services and adopting practical methods.

6.2. Building a public policy for responsive education and improving the financial security mechanism

Focusing on the needs of "customers" such as "quality education", "comprehensive thinning" and "comprehensive two-child", we will build a responsive public education policy with increased financial input. Facing the continuous improvement of the demand for public education services with the improvement of living standards from the protection type to the development type; the demand for urban diversified quality education; the development trend of urbanization and social mobility brought...
about by the development of individual urban advantages and The reality of “full two children” needs to give full play to the leading role of government finance, continuously increase the investment in education finance, respond positively to the public's value preferences on different levels of basic public education services, and form a service area of 8 cities and 1 autonomous prefecture. The strategy matches the educational landscape.

6.3. Establish public policies for binding education and improve system management

Improve the performance evaluation and accountability system of basic public education services and improve the efficiency of resource allocation. The performance appraisal system not only has the function of diagnosis and information feedback, but also has the functions of policy orientation and incentive enhancement. Therefore, the efficiency of basic public education services should be regarded as an important dimension in the evaluation of government officials' performance. At the same time, it explores the introduction of third-party performance evaluation mechanism to ensure the authenticity and scientific of the assessment. Implement the accountably system, ensure the right to be responsible, and the responsibility to the people, and urge the grassroots government to improve the efficiency of basic public education services and the effective allocation of resources under the incentive of policy performance.

6.4. Promote the public policy of learning education and improve the development of ability

With the "smart campus" of "Internet + education" as the technical carrier, based on the "platform + application + service" design concept, we will promote the frontier of education services. The technological changes in basic public education services in the past five years have been "wave" but the trend of ineffectiveness has developed, indicating that the efficiency of educational technology has not kept pace with the development of network information. Accelerating the construction of the "cloud-net-end" basic public education service information system is an urgent task. Improve the system of online education resource quality standards, intellectual property protection, safety supervision and market social access audit. Promote education model innovation and teaching technology advancement, promote the quality and efficiency of basic public education services; explore educational big data to assist scientific decision-making and policy formulation, and improve basic public education service level and governance capacity.

7. Conflict of Interest

We all declare that we have no conflict of interest in this paper.

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