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Article

# Research on the Optimization Path of Budget Performance Management and Final Account Control Methods of Universities Based on Regression Analysis Approach

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**Abstract:** The budget performance management of colleges and universities is still in the primary state, and the utilization efficiency of financial funds and input resources needs to be further improved. The study constructs a budget performance evaluation system for colleges and universities from two dimensions of input and output, takes the input data and output data of teaching funds of colleges and universities of A in 2022-2024 as samples, and analyzes the performance allocation of their teaching and research funds by using the DEA-Malmquist method. After that, a multiple regression model is constructed to judge the specific factors affecting the budget performance management and to propose the specific path to optimize the budget performance management.The performance appropriation of teaching and research funds in college A verifies that the current budget performance management of colleges and universities is not ideal, and there is a big difference in the funding of scientific research projects. And it is judged that the main factors affecting the budget performance management of colleges and universities are talent cultivation and manpower input. In this paper, in order to improve the efficiency of final account control, we start from 3 aspects of management mechanism, management process and evaluation system respectively to improve the effect of budget performance management in colleges and universities.

**Keywords:** performance evaluation system; DEA-Malmquist; multiple regression model; final accounts control

## 1. Introduction

Budget is not only a method and means, but also a management system, a system and a mechanism. A country must have a national budget and modernize national governance through a national budget management system, including the field of education. A college or university must also have a college or university budget, and realize the modernization of college or university governance by constructing a college or university budget management system and an institutional system matching it, and embedding the budget mechanism in this system [1-3]. In the modernization process of university governance, the governance role played by the budget is far from reaching the due degree, and the budget is more as a financial management method for balancing the income and expenditure of universities, or the state balances and controls the income and expenditure of universities through the budget [4-5]. In fact, the core concept of enterprise budget is "things follow the money", that is, all the business activities of the enterprise only must also realize the requirements of the budget value target, the business is useful and effective, so that the business can be accepted by the enterprise and unfolded, and only in this way the enterprise for the corresponding business allocation of resources [6-7]. In administrative institutions, including universities, the core concept of the budget is "money follows the matter", that is, all the budgetary expenditures of administrative institutions are based on the state to provide public goods and maintain public order and business needs [8-10].

The reality of the situation is that colleges and universities in the implementation of budget performance management, the various undertakings of the budget performance objectives, the allocation of budgetary resources, budgetary process control and results of the assessment has not yet been fully realized the effective integration of the school business and budget [11-13]. Strengthening the budget performance management of colleges and universities, improving the efficiency of the allocation and use of educational resources is essential to promote the deepening of reform and the realization of the connotative development of colleges and universities [14]. In the new era, the development of higher education is faced with new situations and new tasks and new requirements, and the traditional budget management and resource allocation model has been difficult to adapt to the needs of high-quality development of colleges and universities, and the in-depth promotion of budget performance management in colleges and universities is imminent [15-16]. How to promote budget performance management in colleges and universities to the deep development is an important proposition worthy of in-depth discussion.

Due to the existing performance evaluation indexes of university performance management system tends to be formalized, for similar scientific research achievements transformation and other indicators of the evaluation of the benefits of the missing, and the final accounts control in the mode of ex post facto audit lag is serious [17]. And regression analysis is a method of predicting future performance based on historical data. In regression analysis, it can be based on the trend of historical data to predict the trend of future business development and the degree of change that may occur, and it can effectively control confounding variables and make dynamic predictions, thus realizing the effective management of events [18-19]. This opens up a new path for budget performance management and final accounts control in colleges and universities.

In order to explore the current budget performance management of colleges and universities, this paper firstly constructs the budget performance evaluation index system of colleges and universities with human input, financial input and material input, talent cultivation, scientific research and international exchange and cooperation as the first-level indicators. Taking college A as an example, the input data and output data of teaching expenses of 15 colleges in 2022-2024 are analyzed by using DEA-Malmquist method. Then construct the multiple regression model to analyze the budget performance management, and use the investment income of colleges and universities to replace the budget performance of colleges and universities to re-regress and verify the regression results of the budget performance management model. Finally, the final account control method is proposed to improve the effect of budget performance management in colleges and universities.

## 2. Construction of Budget Performance Evaluation Index System for Higher Education Institutions

### *2.1. Preliminary Construction of Budget Performance Evaluation System for Higher Education Institutions*

(1) Resource input dimensions

First, human resource indicators. Human resources is to obtain the intangible labor capacity provided by the people themselves, and when measuring human input, the quantity and quality of human resources must be taken into account in order to reflect the overall level of human resources. This paper argues that labor quality is related to factors such as workers' education, title, age, etc., so the relevant labor quality is selected as a metric.

Secondly, financial resources indicators. Financial resources are the support of colleges and universities to obtain all kinds of funds, such as finance and society, in order to guarantee the daily operation of the school and produce relevant results. This indicator is the core element of the input indicators of colleges and universities, and the input of financial resources is not a stock but a service flow, so it can be measured from two aspects, namely, the source and the direction of the use of funds. One category is the amount of capital input, that is, all kinds of capital input of the school, mainly including the government's financial allocation, the university's own business activities, the community's donations and assistance, and the income contributed by the affiliated units. Another category is the special education funding, namely, education utility fee and education capital investment, of which the education utility fee expenditure mainly includes faculty and staff salaries and student awards and scholarships, etc., and the construction investment includes capital appropriation and self-financing capital expenditure, etc.

Finally, physical resources indicators. Physical resources refers to all the materials available for use, and the physical resources of colleges and universities are the material basis of college and university education, which is the direct physical manifestation of educational investment in colleges and universities. College teaching, organization, publicity and other activities all rely on material resources, the most direct indicators are fixed assets, materials and consumables.

(2) Performance output dimension

First, talent training indicators. Talent cultivation means that institutions of higher education cultivate various types of talents for the country and society. Talent cultivation is also the core function of all institutions of higher education, and the main purpose of talent cultivation in institutions of higher education is to improve students' knowledge reserve and practice their practical ability through teaching and practical activities, so the teaching level can be used as one of the metrics of talent cultivation.

Second, scientific research indicators. Institutions of higher education are not only educational institutions, but also scientific research institutions, undertaking the scientific research tasks of the state, local government and other departments, thus scientific research output is also one of the outputs of the budget performance of institutions of higher education. The output of scientific research, on the one hand, can be measured by obtaining various scientific research awards from the state, which can be expressed by awards such as the National Natural Science Award, the National Invention Award, the National Science and Technology Progress Award, and so on.

Third, international exchange and cooperation indicators. International exchanges and cooperation can absorb foreign management experience and technical means, attract foreign talents, and supplement technology and talents for China's economic and social development. Measured using the number of international academic conferences organized by institutions of higher education each year, the number of international exchanges among students and faculty, the number of international cooperative research projects, and the number of complementary international educational resources and assistance.

## *2.2. Budget Performance Evaluation System for Higher Education Institutions*

Based on the principles of science, wholeness, comparability, feasibility and dynamics, this paper screens the many indicators involved in the preliminary construction of the university budget performance evaluation system, takes into account the relevance of the indicators, selects the key indicators, and forms the final university budget performance evaluation system, and the university budget performance evaluation system is shown in Table 1. The university budget performance evaluation system is constructed from the two major dimensions of input and output respectively. In this paper, the input indicators are divided into three categories: human input, financial input and material input. The output indicators mainly include talent cultivation, scientific research and international exchange and cooperation.

***Table 1.*** University budget performance evaluation system.

| Input | Primary indicator | Secondary indicator | Output | Primary indicator | Secondary indicator |
|---|---|---|---|---|---|
| Resource input index | Human input (X1) | Positive number of teachers (X11) | Performance output index | Talent culture (Y1) | Graduate employment (Y11) |
| | | Special number of teachers (X12) | | | Pegatron graduates (Y12) |
| | | Number of technicians (X13) | | | Course number (Y13) |
| | Financial investment (X2) | Financial appropriation income (X21) | | Scientific research (Y2) | National science award (Y21) |
| | | Career income (X22) | | | Research project number (Y22) |
| | | Other income (X23) | | | Number of core journals (Y23) |

| | | | | | |
|---|---|---|---|---|---|
| | Material input (X3) | School area (X31) | | International exchanges and cooperation (Y3) | International academic meeting number (Y31) |
| | | Value of scientific equipment (X32) | | | International exchange number (Y32) |
| | | Classroom, administrative building, library area (X33) | | | Number of international cooperation (Y33) |

## 3. DEA-Malmquist-Based Budget Performance Evaluation of Higher Education Institutions

### *3.1 DEA-Malmquist*

#### 3.1.1. Basic Model of DEA

(1) CCR model based on constant returns to scale (CRS)

The CCR model assumes that the relative efficiency of the decision unit DMU is evaluated under the premise of constant returns to scale (CRS), and the resulting technical efficiency incorporates scale efficiency and is often referred to as the integrated technical efficiency.

a) Input-oriented CCR model

Suppose there are $n$ decision units $DMU_j(j=1,2,3,\cdots,n)$, each with $m$ inputs, denoted $x_i(i=1,2,\cdots,m)$, and the weights of the inputs denoted $v_i(i=1,2,\cdots,m)$. The $q$ outputs, denoted as $y_r(r=1,2,\cdots,q)$, and the weights of the outputs are denoted as $u_r(r=1,2,\cdots,q)$. Then the efficiency evaluation index of the decision-making unit $DMU_j$ to be measured can be expressed as $\theta_j=\frac{\sum_{r=1}^{q}u_r y_{rj}}{\sum_{i=1}^{m}v_i x_{ij}}(r\geq 0;u\geq 0)$, and at the same time, to qualify the efficiency evaluation index $\theta_j$ of all decision-making units $DMU_j$ to be in the interval of [0, 1], i.e., $\frac{\sum_{r=1}^{q}u_r y_{rj}}{\sum_{i=1}^{m}v_i x_{ij}}\leq 1$. The linear programming model based on the CCR model with constant returns to scale is expressed as:

$$\begin{cases}\max\frac{\sum_{r=1}^{q}u_r y_{rk}}{\sum_{i=1}^{m}v_i x_{ik}}\\ s.t.\ \frac{\sum_{r=1}^{q}u_r y_{rj}}{\sum_{i=1}^{m}v_i x_{ij}}\leq 1\\ v\geq 0;u\geq 0\\ i=1,2,\cdots,m;r=1,2,\cdots,q;j=1,2,\cdots,n\end{cases}\tag{1}$$

The CCR model in Eq. (1) is nonlinear programming with infinitely many optimal solutions, so further transformations are required.

Since $\sum_{i=1}^{m}v_k x_{ij}>0$, the constraints of model (1) are equivalent to:

$$s.t.\ \sum_{r=1}^{q} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0 \tag{2}$$

Let $t = \frac{1}{\sum_{i=1}^{m} v_i x_{ik}}$, the objective function of model (1) becomes:

$$\max t\sum_{r=1}^{q} u_r y_{rk} = \sum_{r=1}^{q} t u_r y_{rk} \tag{3}$$

Then let $\mu = tu$, $v = tv$, and the nonlinear model (1) transforms to an equivalent linear programming model:

$$\begin{cases} \max \sum_{r=1}^{q} \mu_r y_{rk} \\ s.t.\ \sum_{r=1}^{q} \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0 \\ \sum_{i=1}^{m} v_i x_{ij} = 1 \\ v \ge 0; \mu \ge 0 \\ i = 1,2,\cdots,m; r = 1,2,\cdots,q; j = 1,2,\cdots,n \end{cases} \tag{4}$$

The linear programming model is subjected to the pairwise programming process to obtain equation (5):

$$\begin{cases} \min \theta \\ s.t.\ \sum_{j=1}^{n} \lambda_j x_{ij} \le \theta x_{ik} \\ \sum_{j=1}^{n} \lambda_j y_{rj} \ge y_{rk} \\ \lambda \ge 0 \\ i = 1,2,\cdots,m; r = 1,2,\cdots,q; j = 1,2,\cdots,n \end{cases} \tag{5}$$

where $\lambda$ is the linear combination coefficient of the decision unit, $\left(x = \sum_{j=1}^{n} \lambda_j x_j, y = \sum_{j=1}^{n} \lambda_j y_j\right)$ as a virtual DMU with inputs no higher than those of $DMU_k$ and outputs no lower than those of $DMU_k$. If $DMU_k$ is in an inefficient state, the virtual $DMU\left(\hat{x} = \sum_{j=1}^{n} \lambda_j^* x_j, \hat{y} = \sum_{j=1}^{n} \lambda_j^* y_j\right)$ is the target value of the evaluated $DMU_k$. The optimal solution of the model $\theta^*$ represents the efficiency value, and $\theta^*$ ranges from $[0,1]$. $1-\theta^*$ denotes the maximum extent to which the inputs of the evaluated $DMU_k$ can be scaled down without lowering the level of outputs under the current level of technology, and the smaller the $\theta^*$, the greater the magnitude of the inputs that can be scaled down and the lower the efficiency. When $\theta^* = 1$, the evaluated DMU is on the frontier and in a technically efficient state. When $\theta^* < 1$, the evaluated DMU is in a technically inefficient state.

b) Output-oriented CCR model

The planning equation of the output-oriented CCR model is:

$$
\begin{cases}
\min \sum_{i=1}^{m} v_i x_{ik} \\
s.t.\ \sum_{r=1}^{q} \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0 \\
\sum_{r=1}^{q} \mu_r y_{rk} = 1 \\
v \ge 0; \mu \ge 0 \\
i = 1,2,\cdots,m; r = 1,2,\cdots,q; j = 1,2,\cdots,n
\end{cases}
\tag{6}
$$

Its dyadic model is:

$$
\begin{cases}
\max \varphi \\
s.t.\ \sum_{j=1}^{n} \lambda_j y_{rj} \le x_{ik} \\
\sum_{j=1}^{n} \lambda_j y_{rj} \ge \varphi y_{rk} \\
\lambda \ge 0 \\
i = 1,2,\cdots,m; r = 1,2,\cdots,q; j = 1,2,\cdots,n
\end{cases}
\tag{7}
$$

where the optimal solution of the model is $\varphi^*$. Under the current level of technology, the maximum proportion of output that can be increased by the evaluated $DMU_k$ without increasing inputs is $\varphi^* - 1$, and the larger $\varphi^*$, the greater the output can be increased, the less efficient it is.

(2) BCC model based on variable returns to scale

In the actual production activities, the production scale state of most enterprises is constantly changing, it is difficult to maintain the economic optimal scale, in order to make up for the shortcomings of the CCR model, the BCC model is proposed. BCC model assumes that the return to scale is variable (VRS), and the resulting technical efficiency excludes the impact of scale, known as the "pure technical efficiency.

(a) Input-oriented BCC model

The BCC model is based on the CCR dyadic model with the addition of the constraint $\sum_{j=1}^{n} \lambda_j = 1 (\lambda \ge 0)$, whose function is to make the scale of production at the projection point and the scale of production of the evaluated decision unit at the same level:

$$
\begin{cases}
\min \theta \\
s.t.\ \sum_{j=1}^{n} \lambda_j x_{ij} \le \theta x_{ik} \\
\sum_{j=1}^{n} \lambda_j y_{rj} \ge y_{rk} \\
\sum_{j=1}^{n} \lambda_j = 1 \\
\lambda \ge 0 \\
i = 1,2,\cdots,m; r = 1,2,\cdots,q; j = 1,2,\cdots,n
\end{cases}
\tag{7}
$$

BCC model of dyadic planning style:

$$
\begin{cases}
\max \sum_{r=1}^{q} \mu_r y_{rk} - \mu_0 \\
s.t. \ \sum_{r=1}^{q} \mu_r y_{rj} - \sum_{i=1}^{m} \nu_i x_{ij} - \mu_0 \le 0 \\
\sum_{i=1}^{m} \nu_i x_{ik} = 1 \\
\nu \ge 0; u \ge 0; u_0 \ free \\
i = 1, 2, \cdots, m; r = 1, 2, \cdots, q; j = 1, 2, \cdots, n
\end{cases}
\tag{9}
$$

b) Output-oriented BCC model

The planning equation for the output-oriented BCC model is:

$$
\begin{cases}
\min \varphi \\
s.t. \ \sum_{j=1}^{n} \lambda_j x_{ij} \le x_{ik} \\
\sum_{j=1}^{n} \lambda_j y_{rj} \ge \varphi y_{rk} \\
\sum_{j=1}^{n} \lambda_j = 1 \\
\lambda \ge 0 \\
i = 1, 2, \cdots, m; r = 1, 2, \cdots, q; j = 1, 2, \cdots, n
\end{cases}
\tag{10}
$$

The output-oriented BCC model is likewise constructed by adding constraint $\sum_{j=1}^{n} \lambda_j = 1 (\lambda \ge 0)$ to the output-oriented CCR model (7), whose pairwise planning equation is:

$$
\begin{cases}
\min \sum_{i=1}^{m} \nu_i x_{ik} + \nu_0 \\
s.t. \ \sum_{r=1}^{q} \mu_r y_{rj} - \sum_{i=1}^{m} \nu_i x_{ij} - \nu_0 \le 0 \\
\sum_{r=1}^{q} \mu_r y_{rk} = 1 \\
\nu \ge 0; \mu \ge 0; \nu_0 \ free \\
i = 1, 2, \cdots, m; r = 1, 2, \cdots, q; j = 1, 2, \cdots, n
\end{cases}
\tag{11}
$$

In the case of multiple inputs and multiple outputs, the decision-making units will not all be in the effective, both CCR model and BCC model will have the slack problem, for the problem can be analyzed by projection, calculate the slack variables, and improve the input and output indicators of the non-effective decision-making units in order to achieve the effectiveness of the efficiency. Therefore, it is necessary to add input and output slack variables $s^-$ and $s^+$ in the objective function of the model, and the planning equation after adding slack variables in the objective function is:

$$
\begin{cases}
\min \theta - \varepsilon (s^- + s^+) \\
s.t. \ \sum_{j=1}^{n} \lambda_j x_{ij} + s^- = \theta x_{ik} \\
\sum_{j=1}^{n} \lambda_j y_{rj} - s^+ = y_{rk} \\
\sum_{j=1}^{n} \lambda_j = 1 \\
\lambda \ge 0; s^- \ge 0; s^+ \ge 0; \\
i = 1, 2, \cdots, m; r = 1, 2, \cdots, q; j = 1, 2, \cdots, n
\end{cases}
\tag{12}
$$

where $\varepsilon$ is a constant, denoting non-Archimedean infinitesimals, and $s^-$, $s^+$ denote the slack variables of inputs and outputs, respectively. According to the size of the evaluation index $\theta$ of efficiency, it is judged whether the decision-making unit DMU is effective or not, and then it observes the slack variables of inputs and outputs, whether there are redundancies and deficiencies, and determines whether it needs to be adjusted in order to improve and perfect the production and operation of the enterprise.

The BCC model is more refined than the CCR model [20], so this paper chooses the BCC model for computational analysis.

### 3.1.2. Malmquist Exponential Modeling

The DEA model mainly focuses on the production technology situation at a certain time, but for the coal industry, production development is a long-term continuous process. The research period of this paper includes 2016-2021, and the DEA model can only analyze for a certain year, while the Malmquist total factor productivity (TFP) index is applicable to the data of the evaluated DMUs as panel data containing observations at multiple points in time, which can analyze the changes in productivity, the respective roles of technological efficiency and technological advancement on the changes in productivity[21]. The Malmquist index can be expressed as:

$$M_0 = (x^{t+1}, y^{t+1}; x^t, y^t) = \left[ \frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \times \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^t, y^t)} \right]^{\frac{1}{2}} \tag{13}$$

where $D_0^t(x^t, y^t)$ and $D_0^t(x^{t+1}, y^{t+1})$ denote the distance function, and $(x^t, y^t)$ and $(x^{t+1}, y^{t+1})$ denote the vectors of inputs and outputs in period $t$. $D_0^{t+1}(x^t, y^t)$ and $D_0^{t+1}(x^{t+1}, y^{t+1})$ denote the distance function from the input-output vectors in period $t+1$ for $(x^t, y^t)$ and $(x^{t+1}, y^{t+1})$ respectively. $M_0$ denotes the total factor productivity index from the input-output vector in period $t$ to the input-output vector in period $t+1$.

The quantitative relationship between the Malmquist index, efficiency change and technical change is $TFP = EC \times TC$, i.e., the Malmquist index can be decomposed into a composite technical efficiency change index and a technical progress index:

$$M_0 = (x^{t+1}, y^{t+1}; x^t, y^t) = \frac{D_0^{t+1}(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \times \left[ \frac{D_0^t(x^t, y^t)}{D_0^{t+1}(x^t, y^t)} \times \frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^{t+1}, y^{t+1})} \right]^{\frac{1}{2}} \tag{14}$$

With variable returns to scale, the combined technical efficiency is further decomposed into pure technical efficiency and scale efficiency, i.e. the Malmquist index can be decomposed into a pure technical efficiency index, a scale efficiency index and a technical progress index:

$$TFP = EC \times TC = PE \times SE \times TC \tag{15}$$

When $TFP > 0$, it means that the productivity of the firm is increasing. When $TFP = 0$, the firm's productivity is unchanged. When $TFP < 0$, the firm's productivity is in decline.

## *3.2. Sample Selection and Data Sources*

The study takes university A as an example, and selects 15 colleges as the sample of teaching and research budget performance evaluation (DMU), namely, College of Political Science and Economy, College of Materials Science and Engineering, College of Journalism and Communication, College of Chemistry and Chemical Engineering, College of Education, College of Mathematics and Information Science, College of Arts, College of Physics and Information Technology, College of History and Culture, College of Foreign Languages, College of Tourism and Environment, College of Food Engineering and Nutritional Science, College of Physical Education, College of Fine Arts, and College of Computer Science. The DEA method is utilized to evaluate the relative performance of the use of teaching and research funds in this university, and the input of teaching and research funds is used as the input index of the model, and the output of the colleges is used as the output index to evaluate the relative performance of the use of teaching and research funds among the colleges. In this paper, the input data and output data of teaching and learning expenses of the colleges of this university in 2022-2024 were selected.

## *3.3 Analysis of Budget Performance Evaluation of Higher Education Institutions*

### 3.3.1. Static Evaluation of the College's Budget Performance Management

This paper takes the input and output data of three time nodes in 2022, 2023 and 2024 as an example, and measures the relative efficiency of static teaching and research expenditures of 15 colleges in University A in the three years of 2022-2024 from the perspective of outputs by using the BBC model in the Data Envelopment Analysis Method, and the arithmetic process is realized through the DEAP2.1 software. When a college's comprehensive efficiency, pure technical efficiency and scale efficiency are all 1, this paper considers that this college's teaching and research expenditure DEA is effective. When a college's teaching and research expenditure scale efficiency and pure technical efficiency, one of which is 1 and the other is not 1, we call this situation for the weak DEA effective.

(1) Pure technical efficiency analysis

The results of pure technical efficiency of inputs and outputs of 15 colleges at three time points from 2022-2024 are shown in Table 2. From the average pure technical efficiency in 2022-2024, it can be seen that there are 9 colleges in college A with evaluation pure technical efficiency value of 1 for teaching and research expenditure in 2022-2024, accounting for 60% of all decision-making units, which indicates that these 9 colleges have strong resource allocation ability, and they can reasonably manage and effectively utilize teaching and research funds allocated by the university. The lowest average pure technical efficiency is DMU2, with an efficiency value of 0.791, which leads to the maximum amount of difference in the average pure technical efficiency value of teaching and research expenditures of the colleges of University A is 0.209.

***Table 2.*** The cost of teaching research is the result of pure technical efficiency.

| DMU | Pure technical efficiency | | | Mean |
|---|---|---|---|---|
| | 2022 | 2023 | 2024 | |
| DMU1 | 0.79 | 0.838 | 0.921 | 0.85 |
| DMU2 | 0.744 | 0.783 | 0.845 | 0.791 |
| DMU3 | 1 | 1 | 1 | 1 |
| DMU4 | 1 | 1 | 1 | 1 |
| DMU5 | 1 | 1 | 1 | 1 |
| DMU6 | 1 | 1 | 1 | 1 |
| DMU7 | 0.898 | 0.765 | 0.92 | 0.861 |
| DMU8 | 0.734 | 1 | 0.836 | 0.857 |
| DMU9 | 0.806 | 0.829 | 0.815 | 0.817 |
| DMU10 | 1 | 1 | 1 | 1 |
| DMU11 | 0.836 | 0.767 | 0.807 | 0.803 |
| DMU12 | 1 | 1 | 1 | 1 |
| DMU13 | 1 | 1 | 1 | 1 |
| DMU14 | 1 | 1 | 1 | 1 |
| DMU15 | 1 | 1 | 1 | 1 |

(2) Analysis of scale efficiency and returns to scale

The closer the scale efficiency value is to 1, the more suitable the scale of the decision-making unit is. Scale reward portrays the relationship between earnings and scale, irs indicates that with the increase of teaching and research funding, the earnings are increasing. drs indicates that the revenue can be increased only by downsizing the scale of expenditure on teaching and research funding. 15 colleges' scale efficiency and returns to scale status in 2022-2024 are shown in Table 3. In terms of average scale efficiency, there are three colleges with an average scale efficiency value of 1 for teaching and research expenditures of college A in 2022-2024, which are DMU6, DMU14 and DMU15, accounting for 20% of all colleges, and the rest of the colleges do not realize scale efficiency. Among them, the college with the lowest average scale efficiency is DMU2, with an efficiency value of 0.36, which can be derived from the fact that the maximum difference in the evaluated scale efficiency of teaching and research expenditures of colleges in University A is 0.64, which is larger than the difference in the average pure technical efficiency.The scale of teaching and research expenditures of the vast majority of colleges in University A is in the state of diminishing returns to scale in the period of 3 years, which indicates that the scale of teaching and research expenditures of the colleges is grew too fast. Among them, only DMU10 has been in the stage of increasing returns to scale from 2022 to 2024, and increasing the scale of teaching and research expenditures is conducive to improving its efficiency.

***Table 3.*** Scale efficiency and scale compensation.

| DMU | 2022 | | 2023 | | 2024 | | Mean |
|---|---|---|---|---|---|---|---|
| | Scale efficiency | Scale compensation | Scale efficiency | Scale compensation | Scale efficiency | Scale compensation | |
| DMU1 | 0.675 | drs | 0.589 | drs | 0.572 | drs | 0.612 |
| DMU2 | 0.349 | drs | 0.364 | drs | 0.367 | drs | 0.36 |
| DMU3 | 0.545 | drs | 0.387 | drs | 0.433 | drs | 0.455 |
| DMU4 | 0.333 | drs | 0.631 | drs | 0.692 | drs | 0.552 |
| DMU5 | 0.345 | drs | 0.318 | drs | 0.519 | drs | 0.394 |
| DMU6 | 1 | - | 1 | - | 1 | - | 1 |
| DMU7 | 0.308 | drs | 0.517 | drs | 0.51 | drs | 0.445 |
| DMU8 | 0.331 | drs | 0.314 | drs | 0.52 | drs | 0.388 |
| DMU9 | 0.511 | drs | 0.354 | drs | 0.457 | drs | 0.441 |
| DMU10 | 0.992 | irs | 0.936 | irs | 0.988 | irs | 0.972 |
| DMU11 | 0.372 | drs | 0.624 | drs | 0.353 | drs | 0.45 |
| DMU12 | 0.73 | drs | 0.682 | drs | 0.859 | drs | 0.757 |
| DMU13 | 0.993 | drs | 0.979 | drs | 0.985 | drs | 0.986 |
| DMU14 | 1 | - | 1 | - | 1 | - | 1 |
| DMU15 | 1 | - | 1 | - | 1 | - | 1 |

(3) Comprehensive efficiency analysis

Comprehensive efficiency consists of two parts: pure technical efficiency and scale efficiency, which is numerically derived from the multiplication of the two, and it is a comprehensive indicator for evaluating whether the teaching and research funding expenditures are effective or not.The results of the comprehensive efficiency of the use of teaching and research funding of 15 colleges in the three time points from 2022 to 2024 are shown in Table 4. The average comprehensive technical efficiency of teaching and research expenditure varies more significantly among colleges, and most of them do not realize the DEA efficient allocation of teaching and research funds. Out of the 15 colleges, three colleges realized DEA effective with an efficiency value of 1. They are DMU6, DMU14, and DMU15, which account for 20% of all decision-making units in college A. In addition, DMU2 has the lowest average combined technical efficiency with an efficiency value of 0.341, and the maximum amount of difference in the average combined technical efficiency value of teaching and research expenditures of all colleges in HEI A is 0.659.

***Table 4.*** Comprehensive efficiency of scientific funding.

| DMU | Integrated efficiency | | | Mean |
|---|---|---|---|---|
| | 2022 | 2023 | 2024 | |
| DMU1 | 0.688 | 0.585 | 0.572 | 0.615 |
| DMU2 | 0.333 | 0.337 | 0.353 | 0.341 |
| DMU3 | 0.541 | 0.384 | 0.447 | 0.457 |
| DMU4 | 0.356 | 0.645 | 0.685 | 0.562 |
| DMU5 | 0.353 | 0.31 | 0.51 | 0.391 |
| DMU6 | 1 | 1 | 1 | 1 |
| DMU7 | 0.315 | 0.493 | 0.51 | 0.439 |
| DMU8 | 0.332 | 0.314 | 0.52 | 0.389 |
| DMU9 | 0.527 | 0.343 | 0.473 | 0.448 |
| DMU10 | 1.006 | 0.934 | 0.983 | 0.974 |
| DMU11 | 0.373 | 0.612 | 0.341 | 0.442 |
| DMU12 | 0.728 | 0.687 | 0.877 | 0.764 |
| DMU13 | 0.999 | 1 | 0.973 | 0.991 |
| DMU14 | 1 | 1 | 1 | 1 |
| DMU15 | 1 | 1 | 1 | 1 |

### 3.3.2. Dynamic Evaluation of the College's Budget Performance Management

(1) Analysis of Malmquist productivity index of colleges of University A in 2022-2023

The Malmquist productivity index is used to analyze the inter-period dynamic efficiency situation from 2022-2023.The results of Malmquist productivity index are calculated by DEAP2.1 software, and the specific calculated efficiency data are shown in Table 5.The Malmquist productivity index is 0.771, which indicates that the total factor productivity index has declined as a whole, and the total factor productivity index has declined in two years by 22.9%. Among the 15 colleges in University A, three of them had an increase in the Malmquist productivity index, and the rest of them had a decrease, with the highest increase in DMU8, which amounted to 35.5%, and the highest decrease in DMU11, which amounted to 48.8%.

***Table 5.*** 2022-2023 college Malmquist productivity index analysis.

| DMU | Integrated technology efficiency index | Technical efficiency index | Pure technology efficiency index | Scale efficiency index | Malmquist productivity change index |
|---|---|---|---|---|---|
| DMU1 | 1.031 | 0.868 | 1.112 | 0.973 | 0.891 |
| DMU2 | 1.087 | 0.696 | 0.924 | 0.842 | 0.757 |
| DMU3 | 0.915 | 0.85 | 1 | 0.979 | 0.778 |
| DMU4 | 0.956 | 0.765 | 1 | 0.923 | 0.731 |
| DMU5 | 0.907 | 0.708 | 1 | 0.779 | 0.642 |
| DMU6 | 1 | 0.893 | 1 | 1 | 0.893 |

| | | | | | |
|---|---|---|---|---|---|
| DMU7 | 1.049 | 0.84 | 0.992 | 1.041 | 0.881 |
| DMU8 | 1.803 | 0.662 | 0.924 | 1.098 | 1.355 |
| DMU9 | 0.844 | 0.853 | 1.133 | 0.778 | 0.72 |
| DMU10 | 0.866 | 0.726 | 1 | 0.994 | 0.629 |
| DMU11 | 0.775 | 0.66 | 1.012 | 1.025 | 0.512 |
| DMU12 | 0.913 | 0.774 | 1 | 1.012 | 0.707 |
| DMU13 | 0.77 | 0.769 | 1 | 0.917 | 0.592 |
| DMU14 | 1 | 0.728 | 1 | 1 | 0.728 |
| DMU15 | 1 | 0.845 | 1 | 1 | 0.845 |
| Mean | 0.994 | 0.776 | 1.01 | 0.957 | 0.771 |

(2) Analysis of Malmquist productivity index of colleges of University A in 2023-2024

The Malmquist productivity index is used to analyze the inter-period dynamic efficiency situation from 2023-2024, and the Malmquist productivity index can be obtained by using the DEAP2.1 software, and the specific computational efficiency data are shown in Table 6.The Malmquist productivity index is 2.29, and the Malmquist productivity index is numerically equal to the product of the integrated technical efficiency change index and the product of the technical efficiency change index, due to the abnormal increase in the technical efficiency index, resulting in the Malmquist productivity index also increased. Therefore. But we can still see the increase in the faculties, and among the 15 faculties in University A, the Malmquist productivity index saw the largest increase in DMU13 and the least in DMU3.

***Table 6.*** 2023-2024 college Malmquist productivity index analysis.

| DMU | Integrated technology efficiency index | Technical efficiency index | Pure technology efficiency index | Scale efficiency index | Malmquist productivity change index |
|---|---|---|---|---|---|
| DMU1 | 1.012 | 1.949 | 1.139 | 0.791 | 1.972 |
| DMU2 | 1.019 | 2.2 | 1.087 | 0.867 | 2.242 |
| DMU3 | 0.938 | 1.939 | 1 | 0.765 | 1.819 |
| DMU4 | 0.921 | 1.999 | 1 | 0.943 | 1.841 |
| DMU5 | 0.76 | 2.705 | 1 | 1.059 | 2.056 |
| DMU6 | 1 | 2.308 | 1 | 1 | 2.308 |
| DMU7 | 1.084 | 2.371 | 1.109 | 1.099 | 2.57 |
| DMU8 | 0.785 | 2.408 | 1.136 | 0.73 | 1.89 |
| DMU9 | 0.791 | 2.484 | 0.912 | 0.797 | 1.965 |
| DMU10 | 0.911 | 2.778 | 1 | 0.78 | 2.531 |
| DMU11 | 0.893 | 2.798 | 0.763 | 0.988 | 2.499 |
| DMU12 | 1.073 | 2.437 | 1 | 0.964 | 2.615 |
| DMU13 | 1.196 | 2.591 | 1 | 1.041 | 3.099 |
| DMU14 | 1 | 2.69 | 1 | 1 | 2.69 |
| DMU15 | 1 | 2.17 | 1 | 1 | 2.17 |
| Mean | 0.959 | 2.388 | 1.01 | 0.922 | 2.29 |

(3) Analysis of Malmquist Productivity Index of Colleges of A in 2022-2024

The analysis of Malmquist productivity index of colleges in college A in 2022-2024 is shown in

Table 7.The average Malmquist productivity index of colleges in college A in 2022-2024 increased sharply from 0.771 to 2.29, and its fluctuation was mainly determined by the combination of the comprehensive technical efficiency change and the technical change, in which, the comprehensive technical efficiency change index showed a a small downward trend, while the index of technological change shows a large growth trend, so the Malmquist productivity index of colleges in University A increased mainly due to technological changes during the three years, but the innovative effect of this technology has not been fully reflected. Therefore, in the process of changing from high to low on the scale of teaching and research expenditures, the changes in different directions of the combined technical efficiency change index and technology change index made the total factor productivity rise.

***Table 7.*** 2022-2024 college Malmquist productivity index analysis.

| Year | Integrated technology efficiency index | Technical efficiency index | Pure technology efficiency index | Scale efficiency index | Malmquist productivity change index |
|---|---|---|---|---|---|
| 2022-2023 | 0.994 | 0.776 | 1.01 | 0.957 | 0.771 |
| 2023-2024 | 0.959 | 2.388 | 1.01 | 0.922 | 2.29 |
| Mean | 0.977 | 1.582 | 1.01 | 0.94 | 1.531 |

### 3.3.3. Indicators of the College's Outputs and Overall Budget Level

If the university preallocates 100 million yuan to these 15 colleges as the performance allocation for teaching and research funding, the performance allocation for teaching and research funding in college A is shown in Table 8.The total costs of the 15 colleges in the six areas of human resources input, financial resources input, material resources input, personnel training, scientific research and international exchange and cooperation are respectively 7635242 yuan, 25,263,3647 yuan, 66,366,654 yuan, 27352332 yuan, 16636523 yuan and 16475602 yuan.

***Table 8.*** The performance grant of teaching research funds of a university.

| DMU | X1 | X2 | X3 | Y1 | Y2 | Y3 |
|---|---|---|---|---|---|---|
| DMU1 | 7.05% | 0.31% | 8.86% | 7.11% | 7.33% | 7.33% |
| DMU2 | 7.65% | 2.54% | 8.00% | 8.21% | 7.14% | 8.27% |
| DMU3 | 8.76% | 4.27% | 1.04% | 7.17% | 8.96% | 7.01% |
| DMU4 | 7.47% | 7.51% | 9.37% | 8.87% | 8.16% | 7.60% |
| DMU5 | 4.14% | 9.15% | 3.25% | 8.17% | 7.16% | 7.01% |
| DMU6 | 2.20% | 7.77% | 6.56% | 8.25% | 7.55% | 7.63% |
| DMU7 | 0.38% | 7.85% | 5.83% | 7.89% | 7.04% | 7.76% |
| DMU8 | 3.08% | 5.97% | 7.71% | 7.93% | 7.11% | 8.50% |
| DMU9 | 9.39% | 7.36% | 7.70% | 7.73% | 7.11% | 7.40% |
| DMU10 | 8.32% | 5.58% | 7.46% | 8.04% | 5.71% | 7.04% |
| DMU11 | 9.52% | 8.98% | 8.32% | 7.39% | 8.40% | 8.73% |
| DMU12 | 8.63% | 7.95% | 7.06% | 1.58% | 2.21% | 4.90% |
| DMU13 | 8.81% | 8.59% | 6.90% | 3.24% | 7.89% | 7.02% |
| DMU14 | 8.16% | 7.78% | 8.19% | 5.59% | 2.69% | 0.83% |
| DMU15 | 6.44% | 8.39% | 3.75% | 2.83% | 5.54% | 2.97% |
| Total | 100% | 100% | 100% | 100% | 100% | 100% |
| Amount | 7635242 | 25263647 | 6636654 | 27352332 | 16636523 | 16475602 |

In summary, the current performance allocation of teaching and research funds in School A is not reasonable, and the difference between human and material inputs and other indicators is large, making it difficult to realize balanced development. In this regard, the following section will use regression analysis to determine the specific factors affecting budget performance management and propose specific paths to optimize budget performance management.

## 4. Study of Factors Affecting Budget Performance Management in Higher Education Institutions

### *4.1. Multiple Linear Regression Analysis*

Multiple regression analysis is a method of regression analysis in which a linear or nonlinear mathematical function model is built so that the output of the model is as close as possible to the dependent variable in the dataset when the function of the sample dataset consists of a single dependent variable and multiple independent variables separately [22]. Multiple multiple regression problems with multiple dependent variables and multiple independent variables have also been discussed, but that case is not discussed in this paper. By multiple regression modeling in this paper, we mean mathematical modeling between multiple independent variables and a dependent variable.

For a given data set $\{X_1, X_2, \cdots, X_k, Y\}$ there are multiple linear regression models:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k + \varepsilon \tag{16}$$

where $Y$ is the dependent variable and $X_i (i = 1, 2, \cdots, k)$ is the independent variable. $\beta_i (i = 0, 1, 2, \cdots, k)$ is the multivariate regression parameter and $\varepsilon$ is the random error term. For this model, the objectives of the multiple regression analysis are:

(1) To make estimates of the model parameters $\beta_i$ using the sample data.

(2) To predict the model output using the model parameters, i.e., to calculate the value of $Y$.

Also, to ensure the accuracy of the model's predictions, the following hypotheses are proposed:

Assumption 1: There is no complete covariance between variables $X_i$.

Assumption II: The random error term $\varepsilon$ has the properties of zero mean, i.e., $E(\varepsilon) = 0$ and certain variance, i.e., $D(\varepsilon) = \sigma^2$.

Assumption III: There is no autocorrelation in the random error term $\varepsilon$, i.e., $\mathrm{cov}(\varepsilon_i, \varepsilon_j) = 0$.

From Assumption II's $E(\varepsilon) = 0$, it follows that taking expectations on both sides of Eq. (16) yields:

$$E(Y| X_1, X_2, \cdots, X_k) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k \tag{17}$$

Equation (17) is the conditional mean of the model output $Y$ computed given the independent variables $X_i (i = 1, 2, \cdots, k)$, and equation (17) is also known as the overall regression function. The biggest goal of multiple linear regression is to find the estimate $\overline{\beta}_i (i = 0, 1, 2, \cdots, k)$ of $\beta_i (i = 0, 1, 2, \cdots, k)$ in this function makes:

$$\overline{Y} = \overline{\beta}_0 + \overline{\beta}_1 X_1 + \overline{\beta}_2 X_2 + \cdots + \overline{\beta}_k X_k \tag{18}$$

Equation (18) is also known as the sample regression function.

Given the data preconditions of the constructed model, the estimate $\overline{\beta}_i (i = 0, 1, 2, \cdots, k)$ of $\beta_i (i = 0, 1, 2, \cdots, k)$ can be calculated by least squares.

Let the error squared function $Q$ be satisfied:

$$Q = \sum (Y - \overline{Y})^2 \tag{19}$$

The required problem becomes to find $\min Q$, and from the knowledge of higher mathematics, the required problem can be reduced to solving the system of equations by finding the partial derivatives of $Q$ to zero for $\overline{\beta}_i (i = 0,1,2,\cdots,k)$, respectively:

$$\begin{cases} \dfrac{\partial Q}{\partial \overline{\beta}_0} = (-1)\sum_i \left( Y - \overline{\beta}_0 - \sum_{t=1}^{k} \overline{\beta}_t X_t \right) = 0 \\ \dfrac{\partial Q}{\partial \overline{\beta}_1} = (-X_1)\sum_i \left( Y - \overline{\beta}_0 - \sum_{t=1}^{k} \overline{\beta}_t X_t \right) = 0 \\ \vdots \\ \dfrac{\partial Q}{\partial \overline{\beta}_k} = (-X_k)\sum_i \left( Y - \overline{\beta}_0 - \sum_{t=1}^{k} \overline{\beta}_t X_t \right) = 0 \end{cases} \tag{20}$$

The estimate $\overline{\beta}_i (i = 0,1,2,\cdots,k)$ is obtained and then substituted into the sample regression function thus obtaining the sample estimate.

### *4.2. Design of Research Variables*

This paper collects a sample of 40 colleges and universities in Province S. The sample period is from 2022 to 2024. The performance allocation of university teaching and research funds is chosen to reflect the budget performance of universities, which is set as the dependent variable. Human resource input (X1), financial resource input (X2), material resource input (X3), talent cultivation (Y1), scientific research (Y2), and international exchanges and cooperation (Y3) are selected as independent variables. Multiple linear regression equations are constructed to explore the specific factors affecting budget performance management in universities.

### *4.3. Model Construction*

According to the research conception, a descriptive statistical analysis of the variables was done first to see the reasonableness of the overall data. Then the correlation analysis of each variable is conducted to determine whether there is a problem of covariance initially. Finally, multivariate linear regression is used to analyze the relationship between the respective variables and the dependent variable, and this paper also combines with the practical work experience, and proposes to establish the basic theoretical model of panel data as follows formula:

$$\begin{aligned} ROE_{i,t} &= \alpha + \beta_1 LEV_{i,t} + \beta_2 TURNOVER_{i,t} + \beta_3 CR1_{i,t} \\ &+ \beta_4 INVESTED_{i,t} + \beta_5 LnSIZE_{i,t} + \beta_6 GDP_t + \mu_t \end{aligned} \tag{21}$$

where $\alpha$ is the constant term, $\beta_1$ to $\beta_6$ denote the coefficients of each independent variable, and $\mu$ is the error term.

$i = 1,2,3,4\cdots40$, denoting different schools.

$t = 2022 - 2024$, denotes the year.

$ROE_{i,t}$ is the budget performance of $i$ colleges in year $t$.

$X1_{i,t}$ is the labor input of $i$ colleges in year $t$.

$X2_{i,t}$ is the financial input of $i$ colleges in year $t$.

$X3_{i,t}$ is the physical input of $i$ colleges in year $t$.

$Y1_{i,t}$ is the talent development of $i$ colleges in $t$ years.

$Y2_{i,t}$ is the scientific research of $i$ HEIs in $t$ years.

$Y3_{i,t}$ is the international exchange and cooperation of $i$ HEIs in $t$ years.

$\mu_t$ is the random error term.

### *4.4 Analysis of Factors Affecting Budget Performance Management in Higher*

### 4.4.1. Descriptive Statistics

The descriptive statistics of the variables after normalization are shown in Table 9.The Mean value of ROE is 0.863 and the gap between Max and Min values is large, indicating that the overall ROE gap in budgetary performance of the universities is slightly large and the sample is suitable for the study of influencing factors.

***Table 9.*** Performance evaluation index descriptive statistics.

| Var | Observed value | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| ROE | 120 | 0.863 | 0.132 | 0.5 | 1 |
| X1 | 120 | 0.236 | 0.053 | 0.114 | 0.253 |
| X2 | 120 | 0.225 | 0.096 | 0.132 | 0.246 |
| X3 | 120 | 0.249 | 0.065 | 0.136 | 0.269 |
| Y1 | 120 | 0.298 | 0.038 | 0.124 | 0.304 |
| Y2 | 120 | 0.166 | 0.072 | 0.063 | 0.197 |
| Y3 | 120 | 0.173 | 0.049 | 0.113 | 0.194 |

### 4.4.2. Correlation Analysis

Before regression analysis, correlation analysis is generally needed to confirm the relationship between the independent variables and the dependent variable as the basis of regression analysis. Since all of the above variables are fixed-distance variables, Pearson correlation coefficient is used to test the correlation between the six independent variables and the composite score of budget performance. The results of the variable correlation test are shown in Table 10. The Pearson correlation coefficient varies in the closed interval [-1, 1], the larger the absolute value, the higher the degree of correlation of the research variables, and the positive and negative values represent the consistency or not of the direction of correlation change among the variables. The budget performance composite score has a significant correlation with all six independent variables.

***Table 10.*** Variable correlation test results.

| | X1 | X2 | X3 | Y1 | Y2 | Y3 | ROE |
|---|---|---|---|---|---|---|---|
| X1 | 1 | | | | | | |
| X2 | 0.63 | 1 | | | | | |
| X3 | -0.03* | -0.06 | 1 | | | | |
| Y1 | -0.63 | 0.25 | 0.28 | 1 | | | |
| Y2 | -0.19 | -0.063* | -0.063 | 0.011 | 1 | | |
| Y3 | 0.24** | -0.28* | 0.011* | 0.027** | 0.135** | 1 | |
| ROE | 0.063** | 0.075** | 0.245** | 0.241** | 0.281** | 0.053** | 1 |

### 4.4.3. Diagnosis of Covariance

In the process of model construction and prediction, the problem of multiple covariance is often encountered, which will make the prediction of the whole model lose its significance, therefore, in order to avoid this problem, this paper applies the variance expansion factor method, through the covariance diagnosis to ensure that the model study is scientific. The covariance diagnosis results are shown in Table 11. The variance inflation factor (VIF) in general tolerance interval ∈ [0, 1], the closer the value is to 0, the more likely there is covariance between the explanatory variables in the model. Similarly, the larger the VIF is, then their multicollinearity will be more severe. This is shown by the fact that it does not exist in the interval VIF ∈ (0-10). stronger for VIF ∈ (10-100). Severe when VIF ≥ 100. As can be seen from the covariance diagnostic results table, the tolerance is between 0-1, VIF<10, and each test result is within the required range, indicating that the model variables constructed in this paper passed the covariance diagnostic.

***Table 11.*** Collinearity Diagnosis.

| Index | Tolerance | VIF | Index | Tolerance | VIF |
|---|---|---|---|---|---|
| X11 | 0.946 | 1.005 | Y11 | 0.942 | 1.057 |
| X12 | 0.944 | 1.03 | Y12 | 0.954 | 1.05 |
| X13 | 0.931 | 1.011 | Y13 | 0.959 | 1.006 |
| X21 | 0.951 | 1.084 | Y21 | 0.99 | 1.049 |
| X22 | 0.97 | 1.094 | Y22 | 0.973 | 1.03 |
| X23 | 0.938 | 1.083 | Y23 | 0.923 | 1.071 |
| X31 | 0.918 | 1.079 | Y31 | 0.989 | 1.048 |
| X32 | 0.9 | 1.029 | Y32 | 0.943 | 1.012 |
| X33 | 0.958 | 1.071 | Y33 | 0.98 | 1.025 |

### 4.4.4. Regression Analysis

By using the integrated budget performance, the sample data of human inputs, financial inputs, material inputs, talent cultivation, scientific research and international exchanges and cooperation of colleges and universities were brought into the established equations for regression analysis, and the results were shown in Table 12 after the regression of the panel data using the SPSS 22.0 software. Among the selected independent variables, the significant P-value of international exchange and cooperation (Y3) is greater than 0.05, which indicates that international exchange and cooperation does not have a significant impact relationship on budget performance. The standard regression coefficients show that each independent variable has a positive influence relationship on budget performance. Among them, the standard regression coefficients of talent cultivation and manpower input are 0.323 and 0.316 respectively, which are much higher than the standard regression coefficients of other indicators. This indicates that talent cultivation and manpower input have a greater impact on the budget performance of colleges and universities.

***Table 12.*** Regression results.

| | Unnormalized coefficient | SD | Normalization factor | T | Sig. |
|---|---|---|---|---|---|
| | B | | Beta | | |
| Constants | -0.409 | 0.014 | - | -28.059 | 0 |
| X1 | -0.002 | 0 | 0.316 | 1.429 | 0.001 |
| X2 | -0.00495 | 0 | 0.022 | 2.28 | 0.006 |
| X3 | -0.002 | 0 | 0.012 | 0.736 | 0.09 |
| Y1 | -0.003 | 0 | 0.323 | 28.051 | 0.001 |
| Y2 | 0.015 | 0 | 0.198 | 15.882 | 0 |
| Y3 | 0.078 | 0 | 0.087 | 7.808 | 0.052 |

### 4.4.5. Robustness Tests

In order to test the robustness of the above conclusions, this paper replaces the budget performance of universities with the indicator university investment income, then regresses again to derive the model regression results, and finally, combines the new regression results and analyzes them in a comparative manner. The robustness regression results are shown in Table 13. The significant p-value of international exchanges and cooperation (Y3) is greater than 0.05. Human resources investment (X1), financial resources investment (X2), material resources investment (X3), talent cultivation (Y1), and scientific research (Y2) have a significant influence relationship on the return on investment of colleges and universities, and the direction of the standard regression coefficients of each variable is the same as that of the regression model with the budget performance as the dependent variable. Therefore, it can be considered that the aforementioned research hypotheses and empirical analysis results are relatively robust.

***Table 13.*** Results of robustness tests.

| | Unnormalized coefficient | SD | Normalization factor | T | Sig. | Common linear statistics | |
|---|---|---|---|---|---|---|---|
| | B | | Beta | | | Tolerance | VIF |
| Constants | 6.411 | 0.019 | - | 28.057 | 0.014 | - | - |
| X1 | 0.008 | 0.001 | 0.322 | 1.417 | 0.016 | 0.967 | 1.059 |
| X2 | 0.01705 | 0.000 | 0.021 | 2.271 | 0.008 | 0.92 | 1.077 |
| X3 | 0.002 | 0.000 | 0.015 | 0.732 | 0.003 | 0.955 | 1.065 |
| Y1 | 0.013 | 0.000 | 0.316 | 28.033 | 0.000 | 0.916 | 1.073 |
| Y2 | 0.026 | 0.009 | 0.218 | 15.888 | 0.000 | 0.968 | 1.038 |
| Y3 | 0.072 | 0.000 | 0.089 | 7.821 | 0.041 | 0.905 | 1.034 |

## 5. Study on Methods of Finalization Control

### *5.1. Optimize the Budget Performance Target Management Process*

The school finance department, budget department and project fund application department shall organize and implement the performance target management according to their responsibilities, and establish a multi-level performance target management mechanism. Under the multi-level performance target management mechanism, each department shall review the performance target according to its authority, and if one of the review contents fails, the performance target shall not be passed. The management mechanism of budget performance objectives should review the following aspects of the objectives:

(1) Target necessity: colleges and universities have multiple functions such as scientific research, education and social influence, and the performance target should be set in line with the diversified development of the school after comprehensive analysis and research from multiple dimensions. The decision-making process of target setting is standardized and in line with the direction and focus of financial investment.

(2) Comprehensiveness of objectives: the establishment of performance objectives should be in line with the concept of comprehensive budget management, and the performance objectives should not be set only for part of the funding program, but should cover all the expenditures and incomes of the school.

(3) Implementation feasibility: the implementation of the project has the basic ability and conditions, and the risk is controllable.

(4) Target specificity: the performance targets set should be meticulously broken down into specifics, not generalized, but expressed in quantitative terms as much as possible, and responded to in terms of quantity, quality, and cost. For projects that cannot be described quantitatively, qualitative analysis, classification and other methods can be adopted.

(5) Reasonableness of objectives: the setting of performance objectives should be in line with the objective reality and compatible with the development of the school and the content of budget management. Feasibility studies need to be conducted through analysis and justification.

(6) Matchability of funds: whether the performance objectives and budget funds are matched, and the data are accessible.

### *5.2. Establishment of a Dual Supervision and Management Mechanism for Performance*

Operation monitoring is the key stage to ensure the effect of budget implementation, universities should build a dual supervision mechanism of financial and operational departments, carry out dual supervision of financial expenditures and performance indicators, and analyze the effect of the use of funds. On the basis of performance information, the finance department uses scientific and reasonable analysis methods to monitor and supervise the matching degree of the direction of budget fund expenditure and the direction of performance targets, as well as the progress of budget implementation and the efficiency of budget implementation, so as to timely find out the problems in the implementation process and take corresponding measures to solve them. The business department links performance evaluation with all aspects of budget preparation, adjustment and implementation, and carries out full-scale monitoring of capital operation, so as to be able to carry out comprehensive monitoring of project progress, completion and the economic benefits achieved.

### *5.3. Sound Budget Performance Evaluation System*

The budget performance evaluation system is the core of the budget management system, and the establishment of a reliable budget evaluation system is very important to ensure the normal operation of budget management. In the budget performance evaluation of colleges and universities, the budget performance should be reflected in a scientific and precise way, the budget performance objectives should be compared with the actual effects, and the budget performance of each department and the utilization efficiency of various resources should be reasonably assessed [23]. When assessing the performance of financial expenditures of institutions of higher education, firstly, attention should be paid to the degree of conformity between the allocation of funds and the real needs, and also to whether the allocation of funds has achieved the optimal effect. Secondly, when evaluating the utilization of various resources, it is necessary to consider both the effect of the utilization of various resources and the distribution of various resources in various projects. In addition to this, when evaluating the performance of colleges and universities, in addition to looking at the economic and social benefits brought about by each indicator, it is more important to look at the role of these indicators for the long-term development of the university. The methods of evaluating budget performance can be divided into two categories: one is common indicators, which can reflect the overall situation of an organization or project. They mainly include the decision-making, budgeting and implementation of each unit or project, the financial management status, the allocation, use, disposal of assets and the management of their proceeds, the soundness and implementation of the management system, as well as the outputs, benefits and satisfaction. The other category is individualized indicators, which refer to the evaluation indicators of the performance of each unit or project in a particular aspect of its work according to its own characteristics.

## 6. Conclusion

This paper measures the performance allocation of instructional funding for 15 colleges in University A based on the DEA-Malmquist method. The school is preallocated 100 million yuan in 2022-2024, but the total costs of human and material inputs are 7635242 yuan and 6636654 yuan, respectively, which is a large difference from other program indicators, and the performance allocation of teaching funds is not satisfactory. In this regard, the study adopts regression analysis to empirically analyze the teaching and research funding of 40 colleges and universities in S province from 2022 to 2024 as a sample to explore the main factors affecting the budget performance management of colleges and universities. Among the six independent variables affecting budget performance management of colleges and universities, the standardized regression coefficients of talent cultivation and manpower input are 0.323 and 0.316 respectively, which are much higher than other indicators. It shows that talent cultivation and manpower input have a greater impact on the budget performance of colleges and universities. The final account control is based on the management mechanism, management process and evaluation system to further improve the efficiency of budget performance management in colleges and universities.

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