

The Importance of Mathematical Modeling to the Study of Budget Performance Management in Colleges and Universities based on AHP Method

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Abstract

Firstly, this paper briefly summarizes the budget performance management of colleges and universities, and then expounds the defects of the current budget performance management of colleges and universities in China. It is considered that the current budget performance management of colleges and universities in China is lack of scientific analysis, and the budget management of colleges and universities in China should be planned combined with the method of mathematical modeling. Taking Colleges and universities a and B as examples, this paper analyzes the budget management of colleges and universities A and B respectively by AHP analysis and AHP combined with BSC analysis methods. Finally draws objective conclusions for colleges and universities A and B respectively. This paper studies and proves that the method based on mathematical model is of significant use to the performance budget management of colleges and universities.

Keywords

Budget Performance Management; University of China; AHP; BSC.

1. Introduction

The comprehensive implementation of budget performance management will be the focus of fiscal budget work in China at present and in the future. Financial departments have established a special financial review system in advance, too high a reduction rate will affect next year's budget arrangements; Double monitoring of budget implementation progress and performance target implementation process; Through the combination of self-evaluation and other evaluation, the annual budget amount will be deducted for units that fail to meet the chronological progress or have poor performance evaluation.[1-2] These measures put forward higher requirements for the resource allocation ability of colleges and universities, and the comprehensive promotion of budget performance management is urgent.

In recent stage, budget performance management has become one of the most important work contents in the budget management of colleges and universities, and it plays an increasingly significant role in the development of colleges and universities. [3-4]China's investment in education is very large, which gradually reveals that the low level of budget performance management in Chinese colleges and universities is not in line with the development and construction requirements of Chinese colleges and universities, mainly manifested in the imperfect budget mechanism, low execution strength, and lack of effective performance evaluation and other aspects. In order to control the performance management of university budget more effectively, it is very important to find a reliable method. However, in the budget management of colleges and universities, the method of mathematical model analysis is seldom used to evaluate the budget management content of colleges and universities. This paper will

take AHP as an example to focus on the importance of mathematical analysis to the budget management of Chinese colleges and universities.

2. Data Statistics and Feature Design Summary of Budget Performance Management in Colleges and Universities

The campus budget is different from the department budget. The department budget is the basis and direction of the campus budget. The campus budget is the refinement and decomposition of the department budget and the specific allocation of the existing resources. Based on the overall situation, the department budget makes a comprehensive plan for the overall income and expenditure of colleges and universities. The internal budget is a detailed arrangement made by the university according to the disposable income and the actual work needs. The disposable income here mainly refers to the total income of the school after deducting special funds, scientific research funds, non-equivalent fiscal allocation income and other funds for special purposes, including basic fiscal allocation income, education income and other self-raised income of the school. The budget of the university consists of personnel funds, daily operation and special operating expenses, which are divided into teaching, personnel training, discipline construction, scientific research, personnel training, laboratory, maintenance and construction funds. The budget on campus accounts for a large proportion of the budget of the department. Taking the budget expenditure on campus of Z University as an example, the budget expenditure on campus accounts for more than 63% of the total budget expenditure of the department in the past three years. [5-6] From the perspective of the amount of funds, the campus budget is very important for colleges and universities, and the performance management of the campus budget is particularly important.

At present, the basic expenditure of the department budget remains detailed according to the expenditure function classification and expenditure economic classification, and there is no mandatory requirement to evaluate its performance. The internal budget of the university is applied for by each functional department and college according to the work plan at the end of the year. After summarizing the fund demand at the school level, this part of the fund is decomposed and implemented to each functional department and college in the form of projects according to the overall fund situation and work priorities of the University. The process of decomposition and implementation is the process of school resource allocation. Therefore, Strengthening the budget management and budget performance management in colleges and universities can ensure the standardization, necessity, rationality and effectiveness of the expenditure of colleges and universities, so as to improve the efficiency of the use of funds in colleges and universities. [7-8]

3. Analytic Hierarchy Process

The Analytic Hierarchy Process is a systematic and hierarchical analysis method combining qualitative and quantitative analysis, which is suitable for the situation with relatively complex structure, multi-level and multi-objective.

At the end of each year, the decision-making of the next year's budget of colleges and universities includes the allocation of talent introduction budget, foreign affairs funds, capital construction funds and scientific research funds. The allocation of these expenses is a thorny problem, which can only be solved through repeated communication between various departments. This process is inefficient and cannot achieve information disclosure, which is not conducive to the formation of internal force of the organization. The analytic hierarchy process can design a set of index questionnaires containing key success areas and key success factors, and put them into the functional departments and experts participating in the decision-making. After the speech and report of each department applying for the budget in the school council

and other processes, the expert group will score on site and generate the budget preparation weight in real time. In the later stage, the school decision-making group will adjust the overall consideration according to the actual situation.

The basic steps of analytic hierarchy process are as follows:

Step1: Calculating consistency indicators $CI=(\gamma-n)/(n-1)$

Step2: Find the corresponding average random consistency index RI

Step3: Calculating consistency ratio $CR=CI/RI$

Step4: If $CR<0.1$, the consistency of judgment matrix can be considered acceptable. Otherwise, the judgment matrix needs to be modified.

Step5: Each element divided by the sum of its columns (column normalization)

Step6: Add the normalized columns (row by row)

Step7: Divide each element of the resulting vector by n to get the weight vector

Step8: Assume the judgment matrix A, and use the arithmetic average method to get the weight vector

Step9: The weights obtained are sorted and compared, and the one with the highest weight is the optimal scheme

4. Application of Analytic Hierarchy Process

4.1. University Budget Performance Management based on AHP

Through data collection, literature review, combined with the individual and other university A expert opinions, according to the evaluation index system analysis and sorting, and combined with the development of the school, the establishment of college budget performance evaluation index system. The system is mainly divided into personnel training, internal management, financial management and social development. The specific evaluation indicators are shown below:

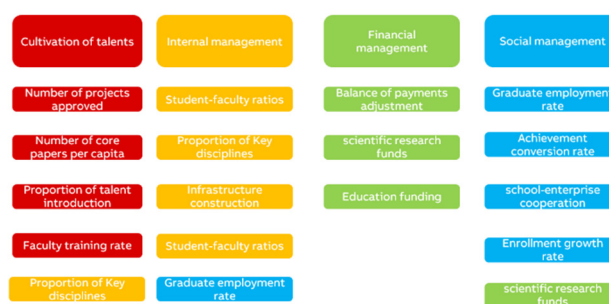


Fig 1. College budget performance management evaluation index system

The data in this case were obtained mainly through questionnaires, which were conducted by professionals with practical experience in the industry, and they evaluated the importance of indicators at all levels. According to the scoring value of each expert, arithmetical average method is adopted to statistically summarize the average value, which can ensure the integration of the opinions of each expert. Compare each criterion of each level in pairs and construct the judgment matrix. In this case, 1-9 scale method is used to express the judgment matrix. Finally, the hierarchy analysis software is used to check whether it is consistent. Besides, hierarchical analysis software is used to check whether it has consistency, as shown in the following table 1.

Table 1. Mean random consistency index

n	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.90	1.12	1.24	1.36	1.41	1.46

Table 2. Judgment matrix of relative importance of each indicator of talent cultivation

Cultivation of talents	Number of projects approved	Number of core papers per capita	Proportion of talent introduction	Faculty training rate	Proportion of Key disciplines	Wi
Number of projects approved	1	2	1	1	2	0.2565
Number of core papers per capita	0.5	1	3	1	3	0.2609
Proportion of talent introduction	1	0.3333	1	1	0.5	0.1394
Faculty training rate	1	1	1	1	2	0.2085
Proportion of Key disciplines	0.5	0.3333	2	0.5	1	0.1347

Through calculation, the consistency ratio of talent cultivation judgment matrix is 0.0987; The weight of "performance management of university budget": 0.2500; Lambda Max: 5.4420. (Table 2)

Table 3. Internal management of the relative importance of each indicator judgment matrix

Internal management	Student-faculty ratios	Proportion of Key disciplines	Teaching hardware and software equipment	Growth of various types of data	Graduate employment rate	Wi
Student-faculty ratios	1	2	3	3	0.3333	0.2238
Proportion of Key disciplines	0.5	1	0.3333	1	0.5	0.094
Teaching hardware and software equipment	0.3333	3	1	3	0.5	0.2359
Growth of various types of data	0.3333	1	0.3333	1	0.2	0.0685
Graduate employment rate	3	2	2	5	1	0.3778

Through calculation, the consistency ratio of internal management judgment matrix is 0.0895; The weight of "performance management of university budget": 0.2500; Lambda Max: 5.4009. (Table 3)

Table 4. Judgment matrix of relative importance of financial management indicators

Financial management	Balance of payments adjustment	Scientific research funds	Education funding	Wi
Balance of payments adjustment	1	1	0.3333	0.2098
Scientific research funds	1	1	0.5	0.2402
Education funding	3	2	1	0.5499

By calculation, consistency ratio of financial management judgment matrix: 0.0895; The weight of "performance management of university budget": 0.2500; Lambda Max: 5.4009. (Table 4)

Table 5. Judgment matrix of relative importance of social development indicators

Social development	Graduate employment rate	Growth rate of achievement transformation	Growth rate of school-enterprise cooperation	Enrollment growth rate	Scientific research	Wi
Graduate employment rate	1	4	0.5	2	0.5	0.2134
Growth rate of achievement transformation	0.25	1	0.5	0.5	0.5	0.0939
Growth rate of school-enterprise cooperation	2	2	1	3	1	0.296
Enrollment growth rate	0.5	2	0.3333	1	0.5	0.1244
Scientific research funds	2	2	1	2	1	0.2723

Through calculation, the consistency ratio of social development judgment matrix is 0.0754; The weight of "performance management of university budget": 0.2500; Lambda Max: 5.3378. (Table 5)

By calculation, the consistency ratio of budget performance management index matrix of colleges and universities is 0.0266; The weight of "university budget performance management": 1.0000; Lambda Max: 4.0710. (Table 6)

Table 6. University budget performance management index relative importance judgment matrix

Budget performance management in colleges and universities	Cultivation of talents	The financial management	The internal management	Social development	Wi
Cultivation of talents	1	4	0.5	2	0.4182
The financial management	0.25	1	0.5	0.5	0.1205
The internal management	2	2	1	3	0.1906
Social development	0.5	2	0.3333	1	0.2707

It can be seen from the test results that the analysis has passed the one-time test and sorted the importance of each subdivision index under the budget performance management of colleges and universities: through the analysis of the above method, the importance of each subdivision index under each element can be intuitively seen (see the table7 below) by sorting the indexes under each dimension according to their weight.

Table 7. Rank the importance of each subdivision index of budget performance management in colleges and universities

Alternative plan	Weight
Graduate employment rate	0.1458
Number of core papers per capita	0.1091
Number of projects approved	0.1072
Faculty training rate	0.0872
Enrollment growth rate	0.0801
Proportion of Key disciplines	0.0742
Education funding	0.0663
Scientific research funds	0.0626
Proportion of talent introduction	0.0583
Growth rate of achievement transformation	0.0578
Infrastructure construction	0.045
Student-faculty ratios	0.0427
Growth rate of school-enterprise cooperation	0.0254
Balance of payments adjustment	0.0253
Growth of various types of data	0.013

Through the index scoring analysis of university budget performance management of University A, this study finds that university a attaches great importance to the basic training of talents, attaches great importance to the number of core papers per capita, the number of project projects and the training rate of teaching staff, which shows that the university takes the improvement of student quality and the level of teaching staff as the basic goal in the process of its own development. Secondly, the University attaches great importance to the growth rate of enrollment and the proportion of key disciplines. At the same time, it also pays more attention to teaching funds and scientific research funds, which shows that in terms of budget performance management, the university still has high requirements for its own basic design and construction and financial management. Although the weight of talent introduction

and other indicators is not too high, the school still pays more attention to them without violating the basic development premise of the school.

4.2. Application of Combination of BSC and AHP

Balanced Score Card is a new type of performance management system. Different from the performance indicator system in the industrial era, which only focuses on the logic of financial indicators, Balanced Score Card designs assessment indicators from the four dimensions of finance, customer, internal process, learning and growth. It also combines lagging indicators and leading indicators, results and process factors, long-term strategies and short-term goals within the organization, especially applicable to large and medium-sized enterprises, non-profit organizations and national public departments. Therefore, the combination of BSC and university budget management system has natural fit genes.

In order to avoid the subjectivity of qualitative results, all factors are not compared together when determining the weight of each index, but compared with each other to improve accuracy. Finally, according to the importance of 1-9 points, sorting out the results to build a judgment matrix. (Table 8)

Table 8. Assume that B university budget items importance judgment expert questionnaire results

	B1 Talent introduction	B2 The teaching reform	B3 Foreign funds	B4 Discipline construction	B5 Service System construction	B6 Library funding	B7 Teaching equipment	B8 Infrastructure maintenance
A1 Talent introduction	1							
A2 The teaching reform	0.2	1						
A3 Foreign funds	0.1428	0.2	1					
A4 Discipline construction	0.3333	3	5	1				
A5 Service System construction	0.1111	0.3333	1	0.3333	1			
A6 Library funding	0.1111	0.3333	1	0.2	1	1		
A7 Teaching equipment	0.2	1	3	0.2	3	3	1	
A8 Infrastructure maintenance	3	5	7	3	9	9	7	1

Each row of the established judgment matrix is multiplied to get a set of numbers. After taking the n (order of the matrix) power of this set of numbers, n values are obtained for normalization processing, and the result is the weight of each index. Here, the SPSSAU management tool is used for model calculation. So, after the first round of expert voting, the weight of the eight indicators of budget allocation of colleges and universities are talent introduction 27.15%, teaching reform 8.07%, foreign affairs funds 2.92%, discipline construction 15.80%, service system construction 3.03%, library funds 3.52%, teaching equipment 9.21% and infrastructure maintenance 30.30% respectively. (Table 9 Fig2)

Table 9. AHP and BSC hierarchy analysis results

AHP analysis results				
Item	Feature vectors	Weight value	Maximum eigenvalue	CI
Index 1	2.172	27.15%	8.915	0.131
Index 2	0.646	8.07%		
Index 3	0.234	2.92%		
Index 4	1.264	15.80%		
Index 5	0.242	3.03%		
Index 6	0.281	3.52%		
Index 7	0.737	9.21%		
Index 8	2.424	30.30%		

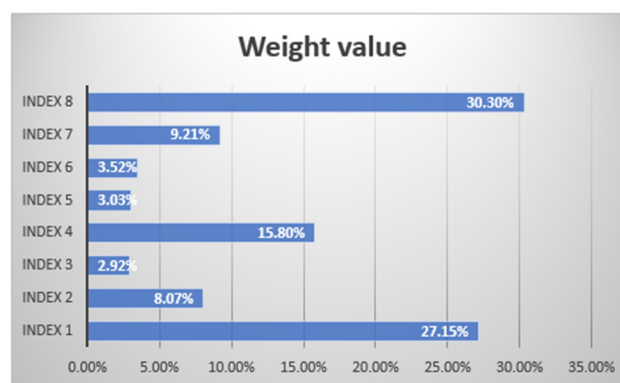


Fig 2. Weight value of budget appropriation

The construction matrix is an eight-order matrix, and the random consistency RI value is 1.410. Finally, CR=0.093<0.1, so the conclusion is valid after passing the consistency test.

5. Conclusion and Enlightenment

The contradiction between the finiteness of financial funds and the increasing of educational investment demands the higher education institutions to improve the efficiency of using funds. Budget in colleges and universities can not only consider the budget balance, more should focus on the effect of the budgetary expenditures and responsibility identification, spending result oriented, with industry fiscal integration as a starting point, based on the university's strategic development target, combined with the development of various teaching departments requirements and conditions, to establish a reasonable department budget performance management goal, Financial department should assist related departments to do the project expenditure budget implementation tracking control, after the project expenditure performance evaluation should be undertaken in a timely manner, according to the evaluation results of performance appraisal, and identify performance rewards and punishment, according to the results of the assessment at the same time introducing the assessment results next year's budgets, arouse the enthusiasm of participation and budget management, Thus establish a closed-loop budget performance management system with the whole process and full participation, improve the rationality of budget preparation and the timeliness and efficiency of budget execution, in order to promote the realization of budget management objectives.

The basic task of colleges and universities is to train corresponding talents for the development of the motherland. Although the budget performance evaluation cannot make a perfect evaluation on the performance and economy of the fund benefit of colleges and universities, it

can still provide some guidance for the development of colleges and universities. We issued questionnaires in B university to get the score of each indicator, combined with analytic hierarchy process to establish an evaluation system, more objective and fairer to get the focus of budget performance management of colleges and universities, make contributions to the development of budget performance management of colleges and universities, hope to promote the development of budget performance of colleges and universities. We can see the importance of mathematical modeling to the study of budget performance management in colleges and universities from two examples.

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