Optimal investment strategy for funded school choice

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Abstract. With the development of charitable organizations, they have already become a special phenomenon promoting social education in a way. In this paper, we mainly discuss the optimal investment strategy for funded School choice in America. We first classify the affecting factors into economic status, teaching quality and future development after analyzing properties of 11 indicators. Then two evaluation models are built to ensure the final comprehensive result of determining the funded school. The first is a model of Principal Component Analysis (PCA), which is used to obtain the economic evaluation of each school. The second is a model of Gray Relational Analysis (GRA), which is to ensure the teaching quality and future development evaluation value respectively. Finally, according to the mean of three evaluation results, we determine the final top 200 funded schools.

1. Introduction

In recent years, with the rapid development of economy and society, an increasing number of charitable organizations have made significant contribution to science and technology. As a kind of unique social intermediate force, they play an important role in educational, which is worth studying. According to reports, some large grant organizations such as the Gates Foundation invest with an enormous amount of $7 million a year in education and press cooperation [1]. In order to produce a strong positive effect on student performance and get as much return as possible, how to establish an optimal investment strategy to select the funded schools becomes a primary problem. Only if completely considerate various factors of the funded schools, can charitable organizations get better investment return.

2. Classify Affecting Factors of Choosing Funded Schools

In order to produce a strong positive effect on student performance and get as much return, ensuring the appropriate schools to invest for charitable organizations is important. After we ran plenty of searches on colleges and universities in the United States, there are a large number of considered schools so that we need to fully consider the various affecting factors of investment [2].

We first combine several indexes of uniformly nature reasonably and then merge the information of collected data into 11 indicators after analyzing their properties. Then we classify the 11 indicators into three kinds of factors. They are economic status, teaching quality and future development.

All of the possible affecting indicators have different degree of impact on evaluation result, while we still classify most of important data into positive and negative indicators generally. In this context, the classification results of three factors are shown in Figure 1.

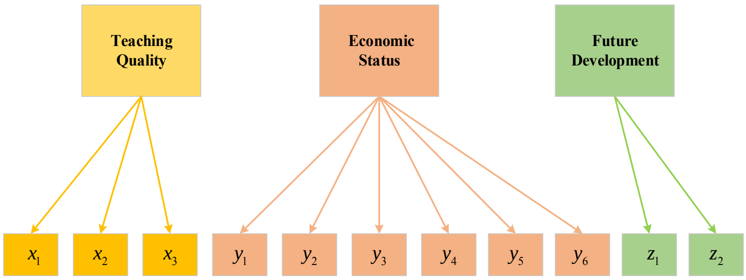

Figure 1. The classification results

In Figure 1, $x_1, x_2 \ldots z_2$ represent the eleven combined indicators which are positive or negative[3], and the concrete interpretation is as follows:

Positive indicators:

- ✧ x_1 means the normal graduation index.
- ✧ y_1 means the Share of undergraduate, degree-/certificate-seeking students who are part-time.
- ✧ y_3 means the weighting burden rate.
- ✧ y_5 means the percent of all federal undergraduate students receiving a federal student loan.
- ✧ y_6 means median debt of completers, suppressed for n=30.
- ✧ z_1 means median earnings of students working and not enrolled 10 years after entry.

Negative indicators:

- ✧ x_2 means the first-time, full-time student retention rate.
- ✧ x_3 means the first-time, part-time student retention rate.
- ✧ y_2 means 3-year repayment rate, suppressed for n=30.
- ✧ y_4 means the percentage of undergraduates who receive a Pell Grant.
- ✧ z_2 means median debt of completers expressed in 10-year monthly payments, suppressed for n=30.

3. Establish the Evaluation Model to Choose Funded Schools

3.1 Data pre-processing

In order to unify evaluation standard, we can make standard 0-1 transformation and it can make every indicators lies between 0 and 1.

For positive indicators, the standardization formula is:

$$b_{ij} = \frac{a_{ij} - a_j^{\min}}{a_j^{\max} - a_j^{\min}} \tag{1}$$

For negative indicators, the standardization formula is:

$$b_{ij} = \frac{a_j^{\max} - a_{ij}}{a_j^{\max} - a_j^{\min}} \tag{2}$$

Where a_{ij} is the data that need to be standardized, $a_j^{\min}$ is the minimum data of the indicators in group j, and $a_j^{\max}$ is the maximum data of the indicators in group j. The standardization result is b_{ij}.

3.2 Establish the Economic Evaluation Model Based on PCA

There are six economic status indicators of every school. To use less variables to represent the most change in the data, we build the model of principal component analysis[4].

● Step1: Calculate the data after standardization and obtain the coefficient of correlation matrix R. The formula is:

$$r_{ij} = \frac{\sum_{k=1}^{n} b_{ki} \cdot b_{kj}}{t-1} \tag{3}$$

Where r_{ij} is the coefficient of correlation of indicator i and indicator j. b_{ki} and b_{kj} is the data after standardization. t is the total amount of schools.

- Step2: Calculate the eigenvalues and the eigenvectors. λ_i is the eigenvalue of the coefficient of correlation matrix R and $\lambda_1 \ge \lambda_2 \ge \cdots\cdots \ge \lambda_n \ge 0$. The eigenvectors of the matrix are $u_1, u_2 \cdots u_n$, where $u_j = \left[u_{1j}, u_{2j}, \cdots, u_{nj}\right]^{\mathrm{T}}$.

According to that, we can get new values consisted of the eigenvectors as the following formula.

$$\begin{aligned} y_1 &= u_{11} \cdot b_1 + u_{21} \cdot b_2 + \cdots + u_{n1} \cdot b_n \\ y_2 &= u_{12} \cdot b_1 + u_{22} \cdot b_2 + \cdots + u_{n2} \cdot b_n \\ &\cdots \\ y_n &= u_{1n} \cdot b_1 + u_{2n} \cdot b_2 + \cdots + u_{nn} \cdot b_n \end{aligned} \tag{4}$$

Where y_1 is the number 1 principal component, y_2 is the number 2 principal component $\cdots$ n is the number of principal components.

- Step3: Select m principal components, and calculate the rate of contribution of each principal components. The concrete way is as follows.

$$p_i = \frac{\lambda_i}{\sum_{k=1}^{m} \lambda_k} \tag{5}$$

Where p_i is the rate of contribution of each principal component.

$$\alpha_m = \frac{\sum_{k=1}^{m} \lambda_k}{\sum_{k=1}^{n} \lambda_k} \tag{6}$$

Where α_m is the accumulated rate of contribution. We select m principal components instead of n previous principal components when α_m=0.85.

- Step4: Calculate the comprehensive evaluation value of each school.

$$X_t = \sum_{i=1}^{m} p_i y_i \tag{7}$$

Where X_t is the comprehensive evaluation value of each school. p_i is the rate of contribution of each principal components, y_i is the principal component.

Through above calculation, we obtain the comprehensive economic evaluation of each school.

3.3 Establish Teaching and Development Model by GRA

Considering the amount indicators of the teaching quality and future development factors are relatively less than economic status, we set a model based on Gray Relational Analysis as follows[5].

- *Ensure the reference sequence*

We select the optimal data of different factors as the reference sequence.

- *Ensure the weight of each indicator*

Since there are little indicators to be utilized, we can use the average value of them as the weight respectively.

- *Calculate the grey relational coefficient*

$$\zeta_i(k)=\frac{\Delta_{\min}+\rho\Delta_{\max}}{\Delta^{(0)}{}_{ik}+\rho\Delta_{\max}}(i=1,2,...t,k=1,2,...,m) \tag{8}$$

When the formula is used to calculate the teaching quality, $m=3$ while the future development, $m=2$.

Where :

- $\Delta^{(0)}{}_{ik}=\left|x_0(k)-x_i(k)\right|$ is absolute difference.
- $\Delta_{\min}=\min_s\min_t\left|x_0(t)-x_s(t)\right|$ is minimum difference of all indexes data.
- $\Delta_{\max}=\max_s\max_t\left|x_0(t)-x_s(t)\right|$ is maximum difference of all indexes data.
- ρ is resolution ration, $x_0(k)$ is the reference sequence, $x_i(k)$ is the compare sequence, $x_s(k)$ is the compare sequence.

- *Calculate the grey correlation degree of each school*

$$s_i=\sum_{k=1}^{n}w_i\zeta_i(k) \tag{9}$$

Where w_i is the weight of every coefficient, s_i is the grey correlation degree[6].

We finally get the correlation degree of each school s_i. According to the order of s_i from high to low, we can observe the teaching quality and future development evaluation value of each school respectively.

4. Analysis of the Results for Evaluation Model

Through the models based on Principal Component Analysis and Gray Relational Analysis, we can get three different evaluation results about the factors of economic status, teaching quality and future development. To determine the founded schools, we can use the mean of three evaluation results to calculate the final comprehensive evaluation result[7]. By doing this, we determine two hundred schools in the United States according to the magnitude of the final result and the top-ten schools are listed in Table 1 by their unit ID.

Table 1. The final comprehensive evaluation result of the top-ten schools

UNITID	Economic status	Teaching quality	Future development	Final result
173984	0.629	0.675	0.503	0.602
419457	0.600	0.683	0.503	0.595
139074	0.534	0.801	0.442	0.592
459994	0.648	0.728	0.382	0.586
137148	0.574	0.678	0.503	0.585
439057	0.532	0.717	0.503	0.584
105172	0.516	0.805	0.428	0.583
480091	0.526	0.796	0.417	0.580
134149	0.472	0.715	0.546	0.578
443766	0.670	0.661	0.382	0.571

Summary

In this paper, we mainly study the optimal investment strategy for funded School choice in America. We classify the affecting factors into economic status, teaching quality and future development after analyzing the properties of 11 indicators. Through establishing two evaluation models based on PCA and GRA, we get the evaluation results of three factors of all considered schools respectively. Furthermore, according to the mean of three evaluation results, the final top 200 funded schools can be determined.

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