

Research on the Assessment of Vocational College Educational Efficiency based on Data Envelopment Analysis

Chao Bu

Automobile NCO School Army Military Transportation University Bengbu, China

buchao6667@sina.com

Abstract. This paper first probes into the application of Data Envelopment Analysis in educational efficiency assessment. Based on this, it establishes the assessment index system of vocational college educational efficiency. It makes a case evaluation of certain colleges' efficiency using Data Envelopment Analysis and ranks the effectively-running vocational colleges with the C²R model and C²GS² model.

Keywords: Vocational College, Efficiency, Assessment, Input.

1. Introduction

The Vocational College Educational Efficiency refers to the comparison between the education's achievements, which are acquired by the college to meet the society's needs, and the education resources consumption and occupation. Its realization involves various aspects of the vocational college's running and greatly connects with the personnel system and the application of scientific research achievements.

2. The Application of Data Envelopment Analysis in Educational Efficiency Assessment

2.1 Brief Introduction to Data Envelopment Analysis

In the mid of 1990, Data Envelopment Analysis is used to education analysis and assessment and gets better effects. Due to education its own specialty and relevant mathematic technology, however, we do not pay due attention to it.

In DEA model, we name each unit that is to be assessed as decision making unit (DMU). The C²R model to evaluate Num. j_0 DMU's relative effectiveness is as following formula (1).

$$\left\{ \begin{array}{l} \min \theta_{j_0} \\ s.t. \sum_{j=1}^n X_j \lambda_j + S^- = \theta_{j_0} X_0 \\ \sum_{j=1}^n Y_j \lambda_j - S^+ = Y_0 \\ \lambda_j \geq 0 (j=1, \dots, n); S^- \geq 0, S^+ \geq 0 \end{array} \right. \quad (1)$$

C²R model cannot simply evaluate technology validity of decision-making units. On the basis of C²R model, putting in the constraint=1, we can get C2GS2 model.

In terms of certain DMU_j which is ineffective for DEA, it has a relatively large input. In order to increase its effectiveness, we should decrease its input.

Suppose the optimal solution to certain DMU_j which is ineffective for DEA is θ^{j*} , and if there exists certain $S_i^- > 0$, it suggests that the index of Num. i input is relatively larger; if there exists certain $S_r^+ > 0$, it suggests the index of Num. r output is relatively less. According to the following two formulas, we can figure out the projection of DEA's relatively effective range that is corresponding to DMU_j.

2.2 The Advantage of Assessing Educational Efficiency by DEA

- Encourage quality education. The assessment DEA provides a relative assessment. DEA model can take colleges themselves as reference frame to make historical analysis of their own courses of pursuing value, and can also take the congener as reference frame analyze their own existing problems.
- With the optimization defined by relative assessment, we can provide strategies for vocational colleges to realize optimization in their running, which has great significance for colleges to improve their level.
- DEA uses relative effectiveness as bases for assessing and ranking, which can more correctly reflect colleges' running effectiveness than the assessing methods that simply rank colleges according to their output achievements and running conditions.
- DEA is suitable for comprehensive effectiveness assessment under the condition of much input and output, and of index with no integrated dimensions. Vocational education is a kind of complicated activity with much input and output, and its various input and output indexes have different dimensions.

With all the above analyses, we can see DEA is a comparatively suitable method.

3. Design of Index System

With the analysis of higher education's input and output, we establish the following index system of input and output, and make expert consultation with Delphi method and analytic hierarchy process to carry out index system's weight assignment.

3.1 Input Index System

The input index system is as table 1, in which the second level index' weight, compared to that of the first level index, is put into its following parenthesis.

Table 1. Input index

The first level index	The second level index
P ₁ Human resources input	P ₁₁ total number of faculty and staff(0.62)
	P ₁₂ teachers' skill level structure(0.38)
P ₂ Financial resources input	P ₂₁ superior appropriation(0.45)
	P ₂₂ self-raised funds(0.55)
P ₃ Material resources input	P ₃₁ dormitory area(0.35)
	P ₃₂ teaching buildings area(0.42)
	P ₃₃ total number of books(0.23)

Teachers' skill level structure refers to the number of teachers with the title of senior technician. Teaching buildings area refers to the total teaching area of classrooms, training workshops, specialized classrooms, computer rooms, language labs, and training fields in and out of colleges.

3.2 Output Index System

Table 2. Output index

The first level index	The second level index
Q ₁ Graduates	Q ₁₁ the number of graduates(0.55)
	Q ₁₂ occupation skill appraisal passing rate(0.45)
Q ₂ Awards	Q ₂₁ total number of teaching achievement award(0.58)
	Q ₂₂ total number of skills competition(0.42)

The index of graduates includes graduates' quantity and quality. It is very complicated of the specific assessing contents and methods to assess graduates' various qualities. Due to the relatively

identical cultivating and assessing standards for every college's undergraduates, the graduates grossly have a similar ideology, body and mind, and cultural quality.

Therefore, we can think about assessing their various qualities with occupation skill appraisal passing rate. Though this index cannot exactly reflect graduates' quality, it has a unified standard and it is easier to collect data, which is more feasible to carry out assessing.

4. Case Analyses

In the following we will make case analyses of college-running effectiveness with the method of DEA. The data we use is certain year's real data of our country's 10 vocational colleges which is converted into the relative value of the first level index.

4.1 Preliminary Analyses

Put data into C2R model, that is, formula (1), we can make every college's C2R model. With DEA arithmetic software "efficiency measurement system", we can figure out analytical result.

4.2 To Analyze with C2GS2 Model

C2GS2 model may be used to assess relative technology efficiency among colleges. Therefore, we analyze every college again with C2GS2 model. Put data into C2GS2 model, that is, formula (2), we can see that six colleges are inefficient and the others are efficient. According to formula (3) and (4), we figure out every index' improved target value. The computing result of College C is as table 3.

Table 3. Preliminary Calculating Result

Items Colleges	θ^* efficiency value	Evaluating Conclusion
College A	1.7682	DEA Efficiency, dimensions stable returns
College B	0.8810	DEA Inefficiency, dimensions diminishing returns
College C	0.6273	DEA Inefficiency, dimensions increasing returns
College D	1.6022	DEA Efficiency, dimensions stable returns
College E	0.8443	DEA Inefficiency, dimensions increasing returns
College F	1.0972	DEA Efficiency, dimensions stable returns
CollegeG	0.8120	DEA Inefficiency, dimensions diminishing returns
CollegeH	1.5806	DEA Efficiency, dimensions stable returns
College I	0.8665	DEA Inefficiency, dimensions increasing returns
College J	1.2651	DEA Efficiency, dimensions stable returns

$$x_{ij}^? = \theta^{j*} \cdot x_{ij} - S_i^{-*}, i=1, \dots, m \tag{2}$$

$$y_{rj}' = y_{rj} + S_r^{+*}, r=1, \dots, s \tag{3}$$

Table 4. The improved target value of College I

The assessing index		The real value	The improved value
The input index	Human resources input	0.771	0.539
	Financial resources input	0.428	0.332
	Material resources input	0.572	0.411
The output index	Graduates	0.747	0.904
	Awards	0.457	0.743

4.3 The Analysis of Computing Result

Compare the computing result of C2R model with that of C2GS2 model, we can see that College G and E are inefficient in C2R model, while efficient in C2GS2 model. The analytical result may not be completely consistent in C2R model and C2GS2 model. We'd better compute with the two models when assessing and then make analysis and comparison considering the actual conditions to make conclusions.

For vocational colleges those are inefficient, if we adjust every input and output index value to improved target value, those colleges will become DEA efficiency, that is, the input-output efficiency is higher.

Take College I as an example, only diminish every input, especially financial resources input and material resources input, and increase output, especially scientific research activity, can we increase input-output efficiency. Similarly, we can analyze the computing result of other colleges with DEA inefficiency and put forward improvable advice.

4.4 To Compare and Rank Colleges Efficiency

In the actual assessing activity, ranking of vocational colleges according to certain standard is an important aspect in analyzing. With DEA method, we can divide the 10 colleges into two types of efficiency and inefficiency.

But in the analytical result of C2R model and C2GS2 model, there are respectively five colleges and seven colleges with DEA efficiency. In vocational colleges with DEA efficiency, all their efficiency value θ^* are 1. We cannot rank colleges with DEA efficiency only with the above two models. In the following, we use a newer method to solve this problem.

We introduce an ideal DMU, that is, an ideal college, with the least input and largest output. When we seek the greatest efficiency of the ideal college, we can get a group of common weight. We can rank all the vocational colleges with the group of weight.

For every input index X_i , we choose all the colleges' minimum value X_{imin} , and these least input makes the least input vector, marking as $X_{min} = (X_{1min}, X_{2min}, X_{3min})$. Similarly, if we choose the maximum value of all the colleges' output, we can get the maximum output vector $Y_{max} = (Y_{1max}, Y_{2max})$. we consider (X_{min}, Y_{max}) as the corresponding production activity of ideal vocational colleges.

In this paper, $(X_{min}, Y_{max}) = (0.613, 0.177, 0.572, 1.358, 1.463)$. Then, with the method of fixing weight by DEA, we can make DEA model as follows:

$$\begin{cases} \max \frac{U^T Y_{\max}}{V^T X_{\min}} \\ s.t. \frac{U^T Y_j}{V^T X_j} \leq 1 \\ \frac{U^T Y_{\max}}{V^T X_{\min}} \leq 1 \\ V \geq 0, U \geq 0 \end{cases} \quad (4)$$

The ideal college is the optimal and ideal condition. In the model the ideal college is necessarily the most efficient one. Therefore, the model may be considered to be made for the ideal college to be efficient. The weight figured out in this sense may be reasonably applied to all colleges, which avoids the disadvantage that the traditional DEA model emphasized unilateralism figured out by every DMU.

Supposing the optimal solution of formula is U^* , V^* , and naming h_j^* as the ranking efficiency index, we can rank the vocational colleges with DEA efficiency according to every college's ranking efficiency index.

The running effectiveness order of the five vocational colleges with DEA efficiency is as following:

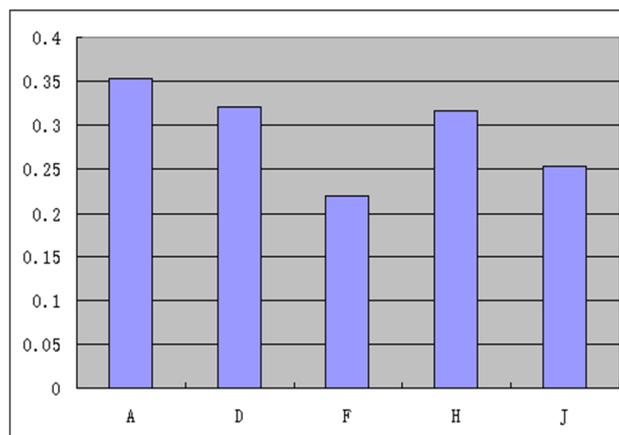


Fig .1 The running effectiveness order of the five vocational colleges

5. Conclusion

To make comprehensive assessment of vocational college educational efficiency with DEA, we can take the relative efficiency as assessing and ranking bases, and can provide measures for colleges' optimization as well.

References

- [1]. Huang Xinlin, Gao Jianmin, and Gao Zhiyong, "New Methodology of Signed Digraph Modeling Based on Causal Ordering Analysis," *Journal of Xi'an Jiaotong University*, vol. 44, no. 5, pp. 85-90, May 2010.
- [2]. ZHENG Lei-lei. "Application of FTA in information security risk Assessment". *Computer Science*, vol.38, no.10, pp.107-108, 2011.
- [3]. Chang P T, Lee E S, "Fuzzy decision networks and deconvolution," *Computers Math.Apphc*.37, pp. 53-63,1999.