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An Extension Fuzzy Analysis Model of the Performance of Education Management for Higher Education

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Abstract

Many factors hold key to educational management for higher learning. An analysis of the performance of educational management is crucial to help higher education institutions enhance teaching ability and quality. This paper proposes an extension fuzzy analysis model to evaluate the performance of education management for higher education. First, it constructs a comprehensive index system for the performance of education management. And standardize quantitative and qualitative indicators in the index system. It then constructs an extension distance model of different performance evaluation indicators about the classical domain and the section domain. And a performance evaluation model based on fuzzy and extension correlation is established. The performance of education management is measured by correlation. Finally, a case study has proved that the model is practical and available.

Keywords: *higher education; educational management; performance analysis; extensive theory; fuzzy theory*

1. Introduction

With science and technology change with every passing day, the educational goal and management mode for higher education are taking a new shape. It owes to educators to coordinate higher education and social development [1-4]. Evaluating the performance of educational management has received widely attentions in that it is an effective way to measure the teaching ability and quality of higher education. Research has been conducted with fruitful results [5-9]. However, there is still much room to improve. Weaknesses of current research include: (1) the selection of indicators is not objective enough, so that the study cannot reach a generalized conclusion; (2) qualitative analysis weights more than quantitative analysis and no quantitative model is applied. So the analysis is not reliable enough. (3) fuzzy information is not deal with in a proper way. Though some studies abide by fuzzy theory, much subjectivity is added to fuzzy analysis, influencing the effectiveness of the result.

Therefore, based on previous research, this paper follows fuzzy theory [10-12] and extension theory [13-15] and proposes a fuzzy and extension correlation model of the performance of educational management for higher education. It aims at stressing the importance of educational management and improving the ability and quality of educational management of higher education.

2. Index System for the Performance of Education

This paper investigates current educational management of higher education. It constructs the index system for the performance of education management for higher education from three perspectives, namely, school management, teacher management and

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student management. The index system is established based on previous research and analysis and under the guiding principle of scientific, objective, systematic, representable, measurable, and hierarchical.

School management: it mainly studies how administrators play a role in the performance of educational management. Administrators are the planner and server of educational management. Their management ability, the efficiency, the organizing mechanism and software and hard wares are key factors for the analysis.

Teacher management: it mainly studies teachers' ability of teaching and research in the performance of educational management. Teachers are executers of educational management. Their overall quality and teaching ability are important links of the analysis.

Student management: it mainly studies students' overall quality and ability to measure the effect of educational management. It directly reflects the teaching ability and quality of higher education.

The index system for the performance of education management for higher education is shown in Table 1.

Table1. Index System for the Performance of Education Management for Higher Education

Class of indicators	First class indicator	Second class indicator	Type of indicator
Index system for the performance of education management for higher education U	School management U_1	Completeness of organizing structure u_{11}	Qualitative
		Rationality of the incentive mechanism u_{12}	Qualitative
		Efficiency of the service department u_{13}	Quantitative
		Rationality of course setting u_{14}	Qualitative
		Satisfaction to the administration u_{15}	Quantitative
		School investment u_{16}	Qualitative
		Discipline platform building ability u_{17}	Qualitative
		Decision making ability u_{18}	Qualitative
	Teacher management U_2	Teaching quality u_{21}	Qualitative
		Number of course reform u_{22}	Quantitative
		Course planning ability u_{23}	Qualitative
		Number of core papers and textbooks u_{24}	Quantitativ e
		Number of research papers, journals and academic works u_{25}	Quantitativ e
		Number of research project u_{26}	Quantitativ e
		Number of teaching achievement prize u_{27}	Quantitativ e
		Number of research	Quantitativ

		achievement prize u_{28}	e
		Industry-university collaboration u_{29}	Qualitative
	Student management U_3	Style of study u_{31}	Qualitative
		Practice and innovation ability u_{32}	Qualitative
		Professional knowledge u_{33}	Qualitative
		Science and technology service ability u_{34}	Qualitative
		School enrollment u_{35}	Qualitative
		Graduate rate u_{36}	Quantitative
		Employment satisfaction u_{37}	Qualitative

3. Extension Fuzzy Analysis Model of the Performance of Educational Management for Higher Learning

From the abovementioned index system, the performance analysis of educational management is a multi-layer one with various factors. Some factors and fuzzy and uncertain. Thus, we need to analyze the hidden information of fuzzy indicators according to fuzzy theory and extension theory.

3.1 Constructing Factor Set for the Performance Analysis of Educational Management

The factor set for the performance analysis of educational management has two layers of indicators. The first class of factor set is expressed by U :

$$U=\{U_1,U_2,U_3\} \tag{1}$$

The second class of factor set is expressed by U_i

$$U_1=\{u_{11},u_{12},u_{13},u_{14},u_{15},u_{16},u_{17},u_{18}\} \tag{2}$$

$$U_2=\{u_{21},u_{22},u_{23},u_{24},u_{25},u_{26},u_{27},u_{28},u_{29}\} \tag{3}$$

$$U_3=\{u_{31},u_{32},u_{33},u_{34},u_{35},u_{36},u_{37}\} \tag{4}$$

3.2 Standardization of Indicators

As there are two types of indicators, namely, qualitative and quantitative indicator, we need to standardize them.

1. Standardize qualitative indicator

If the value of quantity of a qualitative indicator u_i is expressed by membership degree $f(u_i)$, when it is a cost indicator, its standardized value of quantity v_i of u_i is:

$$v(u_i)=1-f(u_i) \tag{5}$$

When u_i is a benefit indicator, its standardized value of quantity v_i of u_i is:

$$v(u_i)=f(u_i) \tag{6}$$

If the qualitative indicator u_i is described by qualitative fuzzy language, then use the scale of 0-1 to get the value of quantity. Its standardized value of quantity v_i of u_i is:

$$v_i = \left[v_i^{min}, v_i^{max} \right],\ 0 \le v_i^{min} \le v_i^{max} \le 1 \tag{7}$$

2. Standardize qualitative indicator

Suppose the original value of quantity of indicator u_i is $p(u_i) = \left[p_i^{min}, p_i^{max} \right]$, and $p_i^{min} \le p_i^{max}$, when u_i is a benefit indicator, the standardized value of quantity v_i of u_i is:

$$v_i = \left[v_i^{min}, v_i^{max} \right] = \left[\frac{p_i^{min} - inf\left(p_i^{min}\right)}{sup\left(p_i^{max}\right) - inf\left(p_i^{min}\right)}, \frac{p_i^{max} - inf\left(p_i^{min}\right)}{sup\left(p_i^{max}\right) - inf\left(p_i^{min}\right)} \right] \tag{8}$$

In particular, when $p_i^{min} = p_i^{max}$, the standardized value of quantity v_i of u_i is:

$$v_i = \frac{p(u_i) - inf\left(p(u_i)\right)}{sup\left(p(u_i)\right) - inf\left(p(u_i)\right)} \tag{9}$$

When u_i is a cost indicator, the standardized value of quantity v_i of u_i is:

$$v_i = \left[v_i^{min}, v_i^{max} \right] = \left[\frac{sup\left(p_i^{max}\right) - p_i^{min}}{sup\left(p_i^{max}\right) - inf\left(p_i^{min}\right)}, \frac{sup\left(p_i^{max}\right) - p_i^{max}}{sup\left(p_i^{max}\right) - inf\left(p_i^{min}\right)} \right] \tag{10}$$

In particular, when $p_i^{min} = p_i^{max}$, the standardized value of quantity v_i of u_i is:

$$v_i = \frac{sup\left(p(u_i)\right) - p(u_i)}{sup\left(p(u_i)\right) - inf\left(p(u_i)\right)} \tag{11}$$

3.3 Obtain the Weight Set for Indicator Analysis

The influence of second class indicators on first class indicators does not vary too much from each other. And the first class indicators pose influence on the performance of educational management from three perspectives. In this paper, we allocate weight to second class indicators based on AHP.

According to the grade of first class indicators given by experts, we can get the judgment matrix $\boldsymbol{G}$ for first class indicators:

$$\boldsymbol{G} = \begin{bmatrix} g_{11} & g_{12} & \cdots & g_{1n} \\ g_{21} & g_{22} & \cdots & g_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ g_{n1} & g_{n2} & \cdots & g_{nn} \end{bmatrix}_{n \times n} \tag{12}$$

With the maximum eigenvalue $max\left(\lambda_{(\boldsymbol{G})}\right)$ of e judgment matrix $\boldsymbol{G}$, we can construct the consistent indicators:

$$\begin{cases} CI = \left(max\left(\lambda_{(\boldsymbol{G})}\right) - n \right) / n - 1 \\ CR = CI / RI \end{cases} \tag{13}$$

If a first class indicator meets the requirement of a consistent indicator, the weight of this indicator is:

$$w_i = \left(\sum_{j=1}^{n} g_{ij} \right) / \left(\sum_{i=1}^{n} \sum_{k=1}^{n} g_{ik} \right) \tag{14}$$

The sequence W of the first class indicator for performance evaluation is:

$$W = \{ w_1, w_2, w_3 \},\ 0 \le w_1, w_2, w_3 \le 1,\ w_1 + w_2 + w_3 = 1 \tag{15}$$

3.4 Construct Evaluation Set and Classical Domain

The evaluation set for the performance analysis of educational management is for the purpose of evaluating the grade of educational management. After consulting with experts, this paper select excellent, good, mediocre and poor to form an evaluation set Ω.

$$\Omega = \{\Omega_{EL}, \Omega_{GL}, \Omega_{ML}, \Omega_{PL}\} \tag{16}$$

Thus, we can construct element for classical domain $R(\Omega_x)$ and element for section domain $R(\Omega_o)$ under different grades:

$$R(\Omega_x) = \begin{bmatrix} N_x & c_{x1} & v_{x1} \\ & c_{x2} & v_{x2} \\ & \vdots & \vdots \\ & c_{xn} & v_{xn} \end{bmatrix} \tag{17}$$

$$R(\Omega_o) = \begin{bmatrix} N_0 & c_1 & [min(v_{x1}), max(v_{x1})] \\ & c_2 & [min(v_{x2}), max(v_{x2})] \\ & \vdots & \vdots \\ & c_n & [min(v_{xn}), max(v_{xn})] \end{bmatrix} \tag{18}$$

Where x refers to EL, GL, ML, PL.

3.5 Extension Fuzzy Distance of the Performance Analysis

If the value of quantity for indicator u_i after standardization is v_i, the extension distance ρ_{xi}^R between classical domain $R(\Omega_x)$ and indicator u_i is:

$$\rho_{xi}^R = \left| v_i - \frac{v_{xi}^{min} + v_{xi}^{max}}{2} \right| + \frac{v_{xi}^{min} - v_{xi}^{max}}{2} \tag{19}$$

Correspondingly, the extension distance ρ_{oi}^R between section domain $R(\Omega_o)$ and indicator u_i is:

$$\rho_{oi}^R = \left| v_i - \frac{v_{oi}^{min} + v_{oi}^{max}}{2} \right| + \frac{v_{oi}^{min} - v_{oi}^{max}}{2} \tag{20}$$

If the value of quantity for indicator u_i after standardization is $v_i = [v_i^{min}, v_i^{max}]$, the extension distance ρ_{xi}^R between classical domain $R(\Omega_x)$ and indicator u_i is:

$$\rho_{xi}^R = \frac{\left| v_i^{min} - \frac{v_{xi}^{min} + v_{xi}^{max}}{2} \right| + \left| v_i^{max} - \frac{v_{xi}^{min} + v_{xi}^{max}}{2} \right| + \left(v_{xi}^{min} - v_{xi}^{max} \right)}{2} \tag{21}$$

Correspondingly, the extension distance ρ_{oi}^R between section domain $R(\Omega_o)$ and indicator u_i is:

$$\rho_{oi}^R = \frac{\left| v_i^{min} - \frac{v_{oi}^{min} + v_{oi}^{max}}{2} \right| + \left| v_i^{max} - \frac{v_{oi}^{min} + v_{oi}^{max}}{2} \right| + \left(v_{oi}^{min} - v_{oi}^{max} \right)}{2} \tag{22}$$

3.6. Extension Fuzzy Correlation Degree for the Performance Analysis

With the extension distance obtained, we can get the correlation extension coefficient K_{xi}^{R} between classical domain $R(\Omega_x)$ and indicator u_i :

$$K_{xi}^{R}=\begin{cases}-\rho_{xi}^{R}/|v_{xi}| & v_i\vee\left(v_i^{min},v_i^{max}\right)\in\left(v_{oi}^{min},v_{oi}^{max}\right)\\ \rho_{xi}^{R}/\left(\rho_{oi}^{R}-\rho_{xi}^{R}\right) & v_i\vee\left(v_i^{min},v_i^{max}\right)\notin\left(v_{oi}^{min},v_{oi}^{max}\right)\end{cases} \tag{23}$$

If there are N second class indicators, the extension fuzzy correlation τ_{xi}^{II} of second class indicators is:

$$\tau_i^{II}=\frac{1}{N}\sum_{i}^{N}K_{xi}^{R} \tag{24}$$

If the weight of first class indicator is considered, the weighed extension fuzzy correlation τ_{xi}^{I} of first class indicators is:

$$\tau_{xi}^{I}=\sum_{i=1}^{M}\left(w_i*\tau_{xi}^{II}\right) \tag{25}$$

According to the optimization principle, if there is:

$$\tau_0=\max_{1\le x\le T}\left(\tau_{xi}^{I}\right)=\varphi_t,1\le t\le T \tag{26}$$

Where T refers to the grade of current performance analysis, then the educational management of the higher education being analyzed belongs to t -th performance level.

4. Case Study

This paper takes the educational management of a key university at province-level as the example to check the efficacy of the algorithm. After surveys, indicators are standardizing (See Table 2). AHP is applied to allocate weight for first class indicators.

Table 2. Performance Analysis of Educational Management for Higher Education

First class indicator	Weight	Second class indicator	Original value of quantity	Standardized value of quantity	Classical domain			
					$R(\Omega_{EL})$	$R(\Omega_{GL})$	$R(\Omega_{ML})$	$R(\Omega_{PL})$

According to the extension distance and extension correlation function model, it can acquire extension distance and extension correlation function between classical domains and different indicators for this university, as is shown in Table 3.

Table 3. Extension Distance and Extension Correlation Function

Second class indicator	Extension distance				Correlation function			
	$R(\Omega_{EL})$	$R(\Omega_{GL})$	$R(\Omega_{ML})$	$R(\Omega_{PL})$	$R(\Omega_{EL})$	$R(\Omega_{GL})$	$R(\Omega_{ML})$	$R(\Omega_{PL})$

With the weight of the first class indicators considered, and using the comprehensive extension fuzzy correlation model, we can get the comprehensive extension fuzzy correlation sequence $\tau=(-0.162,-0.038,-0.182,-0.491)$ between different grades of classical domains for this university. Thus, we can judge that the educational management of this university can be marked as “good”.

5. Conclusion

Aimed at solving current problems in performance evaluation of educational management of higher education, this paper proposes a new index system for the performance analysis. It constructs the classical domain and the section domain for evaluating indicators after standardizing quantitative and qualitative indicator. It then computes the extension distance and extension correlation coefficient between classical domain and section domain to further establish the extension fuzzy correlation model, so as to evaluate the performance level of educational management. This model is simple, operable and easy to achieve on the computer. Case study has proved its

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