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Analysis on the Influencing Factors of Graduate Training Quality Based on Grey Relevance Theory

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***Abstract* - This paper focuses on the theme of the quality of postgraduate training, and from a systematic point of view, analyzes the various factors and their impacts. Following the research framework of positivism and applying the relational analysis method of grey system theory, this paper quantifies the internal relations and changing situation of each teaching link in the process of postgraduate cultivation, excavates the knowledge of common laws from objective data, and carries out extended analysis on this basis, aiming at finding an effective way to improve the quality of Postgraduate cultivation.**

Key words: dissertation quality; grey relational matrix; relevance; relational order

I INTRODUCTION

Postgraduate training is complex system engineering, involving many factors, the relationship between the elements is complicated, and the system and there is interaction between system and environment [1]. All countries in the world attach great importance to the cultivation of postgraduates [2]. How to determine the main factors affecting the quality of postgraduate education simply and reliably becomes the premise of deepening the reform of postgraduate education, implementing the vigorous development of postgraduate education and continuously improving the quality of postgraduate cultivation [3].

In order to determine the impact of various factors on the quality of postgraduate training, traditional research work is generally limited to the use of correlation analysis, regression analysis, variance analysis and significance test [4]. Their drawbacks lie in that various sample values need to obey a typical probability distribution and require a large number of data, which is difficult to meet these restrictions in the application process. Sometimes the discreteness is large, which makes it difficult to guarantee the reliability of the conclusions.

The characteristic of grey relational degree analysis is that it can determine the primary and secondary relationship of the factors affecting the quality of cultivation more accurately without too many samples, which is the basis of raising the problem and choosing the method [5].

II MODEL SELECTION OF GREY RELATIONAL DEGREE ANALYSIS

A. Basic Ideas of Grey Relational Degree Analysis

Postgraduate education system contains many factors, the results of which determine the development trend of the system [6]. These are the issues of great concern in system analysis [7]. Grey system theory puts forward the concept of grey relational degree analysis for each subsystem [8]. Through some effective methods, the numerical relationship among subsystems (or factors) in the system is sought. In this sense, grey relational degree analysis provides a measurement tool and method for the quantitative study of system development and change situation, which is very suitable for the analysis of dynamic process [9].

The so-called correlation analysis refers to the systematic factor analysis. The problems it needs to solve include: among lots of factors contained in a system, which are primary and which are secondary; which have great influence and which have little effect; which are obvious and which ones are potential; which need to be developed and which need to be suppressed.

Specifically, the grey correlation expresses the uncertainty relationship between things, or between the system factors and the main behavior. For the factors between two systems, the measure of the magnitude of the correlation that changes with time or different objects is called the correlation degree, or relevant grade.

In the process of system development, if the trend of the two factors is consistent, that is, the degree of synchronous change is higher, or, it can be said, the degree of correlation between them is higher; on the contrary, it is lower. Therefore, the grey relational analysis method is a means to measure the degree of correlation among factors according to the similarity or difference degree of development trend among factors (i.e. "grey relational degree").

To analyze a system, the first job is to select the data sequence that reflects the system behavior characteristics, that is, find the mapping quantity of the system behavior, and use the mapping quantity to indirectly represent the system behavior, furthermore, clarify the effective factors affecting the main performance of the system on the basis of the system manifestation characteristics data and related factors data.

Let χ_i be the system factor, and its observation data on serial number k are as follows:

$$\chi_i(k), k = 1,2,\cdots,n$$

Then called

$$\chi_i = \chi_i = (\chi_i(1), \chi_i(2),..., \chi_i(n))$$

as the behavior sequence of factor χ_i;

Whether for time series data, index series data or horizontal series data, they can all be used for correlation analysis.

Then, the system behavior sequence is dimensionless by operator action. Its transformation methods and corresponding operators are respectively mean transformation corresponding to mean operator D_1, initial transformation corresponding to initial operator D_2 and interval transformation corresponding operator D_3.

B. Model selection

There are three kinds of grey system correlation degree analysis models, which are called A-type, B-type and C-type correlation analysis in turn. According to the characteristics of the research problems, we choose A-type correlation to analyze the order of the factors affecting a certain index, so as to lay a necessary foundation for decision-making. The ideological method is to see the degree of correlation between things from the development process.

There are basic models and correlation matrix analysis models in type "A" correlation analysis. The traditional correlation matrix analysis needs to calculate two matrices, which is rather complicated to do. Focusing on the improvement the definition of correlation coefficient, any two correlation degrees in the correlation matrix should be comparable. We choose the correlation matrix analysis method with the full comparability in the latter model. Specific mathematical descriptions are as follows:

Assuming a sequence of factors:

$$yi(k), x_j(k), i \in M, j \in N, k \in L,$$

Define the following:

$$\Delta_{min} = \min_{i \in M} \min_{j \in N} \min_{k \in L} \left| yi(k) - x_j(k) \right|$$

$$\Delta_{min} = \max_{i \in M} \max_{j \in N} \max_{k \in L} \left| yi(k) - x_j(k) \right|$$

$$\Delta_{ijk} = \left| yi(k) - x_j(k) \right|$$

So, we have,

$$\xi_{i,j}(k) = \frac{\Delta_{\min} + \zeta \Delta_{\max}}{\Delta_{ijk} + \zeta \Delta_{\max}} \quad (1)$$

$$ri, j = \frac{1}{l} \sum_{k=1}^{l} \zeta_{i,j}(k), i \in M, j \in N \quad (2)$$

$$R = (r_{i,j})_{mxn} \quad (3)$$

Name $\xi_{i,j}(k)$ as the relevance number of Y_i and X_j at the Moment k, $\gamma_{i,j}$ is the relevance degree of Y_i and X_j, R is the association matrix of $Y_1, Y_2 \ldots, Y_m$ and $X_1, X_2 \ldots, X_n$.

In this definition, $\xi_{i,j}(k)$ is the relative difference between curve Y_i and curve X_j at the moment k, and, $\xi_{i,j}(k)$ is related to all factors $Y_i(i \in M), X_j(j \in N)$, which reflects the integrity of the system.

Therefore, it is more reasonable to define the correlation number of Y_i and X_j at the moment k by formula (1).

Consider arbitrary factors Y_i, X_j, Y_p, X_q, when $\xi_{i,j}(k) > \xi_{p,q}(k)$, there must be:

$$\left| Y_i(k) - X_j(k) \right| < \left| Y_p(k) - X_q(k) \right|$$

This shows that the larger the correlation coefficient is, the smaller the distance between the curves is, and the more similar the shape of the curves is.

While, correlation degree of $\gamma_{i,j}$ and $\gamma_{p,q}$ is the concentrated expression of $\xi_{i,j}(k)(k \in L)$ and $\xi_{pq}(k)(k \in L)$.

So, the comparison of any two correlation degrees $r_{i,j}$ and $r_{p,q}$ is meaningful.

The elements of R defined by formula (3) have arbitrary comparability. R can be analyzed in rows and columns. Therefore, R can replace R and R* correlation matrix in the definition to do advantage analysis, which can simplify the analysis process.

III FACTORS AFFECTING THE QUALITY OF POSTGRADUATE TRAINING

The factor analysis of postgraduate training quality needs to follow a scientific method and process to ensure the reliability of the results of empirical analysis [12].

A. Data collection and preparation

Step 1: Systematically collect two kinds of statistical data of fifteen colleges of a university: one is the summary table of the personnel awarded master's degree every year, the other is the summary table of the thesis proposal of each doctoral and master's degree.

Step 2: Depending on the basic data collected by separate colleges, various statistical data and attribute data are extracted and managed by two-dimensional spreadsheet. Samples (objects of observation) form rows of spreadsheets, and variables (attributes) form columns of them. N samples with M variables form a table matrix of N rows and M columns.

Set the corresponding Master's Degree Personnel Number in line N (001, 002, 003,...) and the corresponding series of sample information; The M-list shows attribute variables, the variable 01 corresponds to the average grade of degree courses; the variable 02 refers to the total credit of courses; the variable

03 is the defense grade of thesis; the variable 04 points out the report grade of opening questions; and the variable 05 corresponds to the number of papers published in academic journals. If it is for doctoral students, variables 04 correspond to the total number of achievements (publicly published papers, monographs, special issues, research awards at provincial and ministerial levels, engineering applications, etc.) while variables 05 correspond to the number of articles included in SCI, EI and ISTP (CPCI); other variables are the same as the above table.

Step 3: Store data in spreadsheet. There are two kinds of file formats: binary format and text format, both of which have their own advantages and disadvantages, and there are great differences. But after importing the spreadsheet, they are identical and without any difference. The conversion between the two file formats can be realized by the "save" function of the file.

B. Call and execute grey relational analysis program

Taking X College as the research object, the concrete operation examples are as follows:

Operation 1: Call out the data tables Data2 and UMS corresponding to X College;

Operation 2: Execute grey relational program GR

Screen display data sequence, parent sequence elements, subsequence elements; select the average for data pre-processing, display the data table and grey relational degree matrix after the average processing.

Operation 3: Output grey correlation matrix as table 1, the calculation is completed.

TABLE I. GRAY RELEVANCE MATRIX OF COLLEGE X

	Variable 01	Variable 02	Variable 03	Variable 04	Variable 05
Variable 01	1.00	0.97	0.97	0.93	0.78
Variable 02	0.97	1.00	0.97	0.93	0.78
Variable 03	0.97	0.97	1.00	0.93	0.78
Variable 04	0.93	0.93	0.93	1.00	0.78
Variable 05	0.87	0.86	0.88	0.88	1.00

C. Repeat the above three operations one by one for each college, and output the results page by page.

Extract the association order matrix from the output college correlation matrix, as shown in Table 2.

That is:

$$R_i = \begin{Bmatrix} \text{Dissertation defense score} & - & \text{Score of degree courses} \\ \text{Dissertation defense score} & - & \text{Total credits of courses} \\ \text{Dissertation defense score} & - & \text{Thesis proposal} \\ \text{Dissertation defense score} & - & \text{Number of published papers} \end{Bmatrix}$$

TABLE II. THE RESPECTIVE ASSOCIATIONS OF COLLEGES

Colleges	R_1	R_2	R_3	R_4	R_5	R_6	R_7	R_8	R_9	R_{10}	R_{11}	R_{12}	R_{13}	R_{14}	R_{15}
Relevancy Degree	0.92	0.97	0.98	0.96	0.96	0.92	0.92	0.93	0.96	0.90	0.89	0.96	0.97	0.96	0.92
	0.93	0.97	0.98	0.95	0.95	0.91	0.92	0.93	0.91	0.82	0.90	0.94	0.93	0.90	0.89
	0.86	0.93	0.93	0.90	0.91	0.93	0.85	0.90	0.87	0.80	0.84	0.86	0.81	0.72	0.80
	0.81	0.87	0.87	0.85	0.87	0.90	0.81	0.82	0.83	0.79	0.82	0.84	0.77	0.63	0.76

D. Relevance analysis

Analyzing Table 1, taking the grey relational degree matrix of College X as an example, the maximum values are found row by row, which are $r_{13}, r_{23}, r_{43}, r_{53}$ respectively; the maximum values are still found column by column, remain $r_{13}, r_{23}, r_{43}, r_{53}$.

From the perspective of correlation analysis, the corresponding comparative series can be regarded as the "superiority" of the relevant factors, ranking the importance from high to low. Obviously, among the five factors, the degree thesis have the greatest impact; every college has no exception.

In Table 2, the total average association order of 15 colleges is: *0.94 > 0.92 > 0.86 > 0.82*; the average Association order of science and engineering is: *0.94 > 0.92 > 0.86 > 0.82*; while the average Association order of culture and management is: *0.95 > 0.93 > 0.86 > 0.82*. That is to say, the order of influence on dissertation quality from strong to general is degree course, general credit, opening report and the number of publishing articles.

E. Extended Analysis

(1) Through the analysis of the correlation matrix, it is found that the writing scores and defense results of postgraduate dissertations have the greatest impact among the five factors, which indicates that the dissertation is an important content in the postgraduate teaching plan, an significant process of cultivating the comprehensive ability of postgraduates, and also an assessment process of their application and creativity. The level of dissertation directly marks the quality of personnel training. A survey of postgraduate dissertations shows that 78% of postgraduates have different degrees of problems in their dissertation writing. This is in good agreement with the results of this study and quantitative analysis. In recent years, the Ministry of

Education has further strengthened the sampling and punishment of graduate dissertations, and graduate training units have improved the quality of dissertations by institutionalizing the selection of tutors and standardizing dissertation defense.

(2) Through the analysis of the correlation sequence matrix, it is proved that the correlation between the average grade of degree courses and the quality of dissertation is the strongest, followed by the correlation between the total course credits [11]. This conclusion can be understood from two aspects. First, learning ability is a reflection of research ability. The higher the average score of the course is got, the stronger the learning ability of the students, and the stronger the research ability of the students with strong learning ability. Therefore, the quality of the dissertation is high. Secondly, degree courses are generally core professional courses. The content of courses is closely related to the content of dissertation research. Learning degree courses well is of great benefit to dissertation research. This also shows that the reality and the laws revealed by quantitative analysis are completely consistent.

(3) The thesis proposal is an important preliminary work in the preparation of dissertations, which is directly related to the quality of degree. In theory, it should rank first in the degree of relevance, but only third in the degree of relevance. The author has worked in graduate school, and has a better understanding of the actual situation of the graduate thesis proposal work. In recent years, the importance of topic selection and the proposal of the paper research have not been got enough attention by the students and the tutors, which lead to the fact that the relevance between the research proposal and the quality of the dissertation is not as strong as expected. This shows that the quality of this work needs to be improved.

(4) The number of papers published and the quality of degree papers rank fourth, which can be understood as follows: First, because some graduate students published small papers and their dissertations research topics and content are not the same, so the correlation is not strong. Secondly, some schools regard publishing paper as one of the conditions for graduation defense. Graduate students can only publish article to meet this requirement, which does not directly and fundamentally improve the quality of dissertations. Survey data show that only 3% of students' papers are published in core journals, while 97% of them are published at a lower level, and some students even have some academic misconduct. These problems seriously affect the quality of postgraduate training. In fact, there are many repeated and controversial policies on whether postgraduates have to publish papers before defence, which further proves that there is no strong correlation between the quality of papers and degree thesis.

IV CONCLUSION

Society needs a large number of highly educated talents. Strengthening the cultivation and quality improvement of postgraduates has become an important issue for colleges and universities. Through process management, quality control can be realized in an all-round and all-process way, which can provide certain guarantee for graduate training. The results of grey relational degree study confirm that the dissertation is the first indicator of postgraduate training quality, and the most important measurement basis to test the quality of postgraduate training. There is a strong to weak correlation between it and the average score of degree courses, total credits, opening reports and the number of papers published.

In order to improve the quality of postgraduate dissertations and take it as an important link in enhancing the quality of postgraduate training, a series of effective measures should be adopted, such as sending dissertations to other schools for blind examination by professors, strengthening the supervision of tutors, supervisory examination, in-hospital evaluation, and strict examination by the degree committee, etc., so as to organically integrate multiple elements and links of the quality management system for postgraduate training. On the purpose of ensuring the quality of postgraduate training and degree award and train more high-level talents for the country, it is necessary to explore more effective and pragmatic training mode.

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