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The Teaching Quality Evaluation of Chinese-Foreign Cooperation in Running Schools from the Perspective of Education for Sustainable Development

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Abstract: As one of the important ways to cultivate internationalized and highly competitive talents, Chinese-foreign cooperation in running schools (CFCRS) is very significant to education for sustainable development (ESD). From the perspective of ESD, we developed a teaching quality evaluation model using 18 indicators in 4 dimensions: resource input, faculty environment, teaching process, and teaching outcome. The DANP (Decision-Making Trial and Evaluation Laboratory-Based Analytic Network Process) method is used to explore the mutual influence relationship of teaching quality in CFCRS, and the TOPSIS (Technique for Order Preference by Similarity to an Ideal Solution) method is used in this empirical study. The results show that the evaluation dimensions listed by impact level from big to small are as follows: teaching outcome, teaching process, faculty environment, and resource input. Among them, resource input and faculty environment are the cause dimensions, while teaching process and teaching outcome are the result dimensions. Academic support is the most influential indicator, followed by teaching resource and teaching management, and the teacher's nationality is the least influential indicator. The CFCRS A of a comprehensive university in the developed region of China has the highest comprehensive score, followed by the CFCRS C of an applied science and technology university and CFCRS B of a comprehensive university in the underdeveloped region. The teaching quality of CFCRS can be improved by increasing the frequency of academic activities, strengthening teacher training, reinforcing curriculum and discipline management, and encouraging students to participate in competitions and paper publications.

Keywords: Chinese–foreign cooperation in running schools; teaching quality; DANP; TOPSIS; empirical research

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1. Introduction

In 1992, Agenda 21 pointed out that education should be redefined and used to implement sustainable development [1]. All governments recognized that education played a vital role in sustainable development. In December 2002, the United Nations General Assembly launched the "Decade of Education for Sustainable Development (ESD)", promoting countries to carry out the process of ESD in various forms [2]. In 2015, the United Nations Summit released the 2030 Agenda for Sustainable Development, which formulated 17 global sustainable development goals and 169 sub-goals from the fields of economy, natural environment, and society [3]. Cross-border education has become one of the orientations of ESD. Cooperation between multiple countries in the education of talents can eliminate ethnic, linguistic, and cultural barriers to some extent and make it easier for students to learn a variety of advanced ideas, cultures, and technologies. Ultimately, the talents produced will be engaged in practical production in various industries, thus contributing to the healthy and sustainable development of the global economy and culture.

In 2010, the Ministry of Education of China issued the Outline of the National Medium and Long Term Education Reform and Development Plan (2010–2020), pointing out that global and regional education cooperation can be realized by running schools and projects of Chinese–foreign cooperation, cultivating internationally competitive talents, and promoting the healthy development of ESD [4]. Focusing on and studying Chinese–foreign cooperative education can help administrators better identify current problems with the aim to further perfect development.

As of June 2022, with the exception of Hong Kong, Macao, and Taiwan, there are 127 Chinese-foreign cooperation in running schools (CFCRS) with a bachelor's degree or above registered on the information platform of the Ministry of Education [5]. As an important part of higher education internationalization in China, CFCRS helps the connotative development of higher education in China. At the same time, there are still some problems, such as weak cooperation efficiency, insufficient advantages, and imperfect system construction in CFCRS [6]. These problems can lead to a decline in the teaching quality of CFCRS, which will not nurture excellent international talents, thus failing to promote ESD. As a new educational model integrating higher educational resources of China and other foreign countries, how CFCRS can use their own superior resources to improve teaching quality and cultivate more international elite talents is the foundation of their development [7]. Only by improving the quality of CFCRS's own teaching can the ESD be better served. At the same time, the richness of CFCRS teaching quality-related research also provides a reference for the subsequent research of CFCRS. Therefore, it is particularly important to evaluate the teaching quality of CFCRS.

At present, scholars mostly study the development status, student satisfaction, and talent training mode of CFCRS. Based on an analysis of the research status of CFCRS, Lee et al. believed that the normal operation of relevant courses in CFCRS should be ensured by strengthening the supervision of introduced courses from foreign universities, formulating relevant policies, and strictly examining the process [5,8]. Liu et al. analyzed the teaching process of CFCRS in detail and concluded that academic support and personal development had the greatest influence on students' satisfaction [9]. In view of the current situation of domestic embedded professional CFCRS, Shi proposed a new approach to the cultivation mode of embedded professional talents in CFCRS from the aspect of introducing foreign advanced education concepts, setting up the school mode, training objectives, and the curriculum system [10]. To sum up, few scholars have studied the teaching quality of CFCRS at this stage. As one of the important ways to realize ESD, the teaching quality in CFCRS is crucial. This is due to the fact that the quality of teaching of CFCRS has a direct impact on the cultivation of outstanding international talents in various industries. Only CFCRS with high teaching quality can produce excellent international elite talents. Therefore, it is essential to clarify the influences on teaching quality, construct an evaluation system, evaluate the teaching quality of the existing CFCRS, and make suggestions to improve the teaching quality and cultivate international elite talents of CFCRS.

The DANP method combines the advantages of the DEMATEL (Decision-Making Trial and Evaluation Laboratory) method and the ANP (Analytic Network Process) method, which can reflect reality more objectively using the process of weight calculation [11–13]. In recent years, the DANP method has been well applied in evaluation research in the fields of online catering platform evaluation [14], vehicle purchase evaluation [15], open government data [16], and open government data platforms [17]. Few scholars use the DANP method to evaluate CFCRS. Therefore, based on the perspective of sustainable development education, this study applies the DANP method to build a teaching quality evaluation model for CFCRS. To sum up, the investigation aimed to:

(1) Clarify the influencing factors and the evaluation dimensions and indicators of the teaching quality of CFCRS based on the perspective of ESD.
(2) Identify the influence relationship and weight of each evaluation dimension and indicator of the teaching quality of CFCRS using the DANP method, so as to establish a teaching quality evaluation model of CFCRS.

(3) Apply the established evaluation model of the teaching quality of CFCRS to evaluate the teaching quality of three representative CFCRS in China and analyze the development status of their teaching quality.
(4) Put forward some management suggestions to enhance the teaching quality of CFCRS, which are based on the research results.

The remainder of this article is arranged as follows: Section 2 reviews the current state of research on ESD and the evaluation of teaching quality in educational institutions. According to the preliminary studies, Section 3 forms the evaluation dimensions and indicators of the teaching quality of CFCRS from the perspective of ESD. Section 4 outlines the methodology, introducing the DANP method and TOPSIS method used in this paper. The data analysis including the data collection and evaluation weights calculation are presented in Section 5. Section 6 includes an empirical study to evaluate the current state of teaching quality in three representative CFCRS in China. Section 7 describes the research results and management recommendations.

2. Literature Review

2.1. ESD

In recent years, scholars have mainly studied both the implementation and impact of ESD. By constructing an environmental learning-knowledge-as-a-service model, Karanjal et al. describe how usable knowledge can be extracted from environmental learning systems to contribute to the achievement of the ESD goals [18]. Based on previous literature about quality assurance in e-learning, Timbi-Sisalima et al. proposed the self-assessment guidelines, a self-assessment model, and a methodology for applying the model from an accessibility perspective, which is an indispensable aspect of ESD [19]. Through presenting international examples of the development and implementation of e-learning for the quality assurance of learning, Ghanem pointed out the important role of E-learning in achieving quality education and lifelong learning in the context of the ESD goals during the COVID-19 epidemic [20]. Using a worldwide survey involving higher education institutions across all continents, Filho et al. found that the COVID-19 blockade triggered a boom in online teaching, which may contribute to the purpose of showing how university teaching affects sustainability [21]. Using a review of the plethora of studies published between 2020 and 2022 on the implementation of emergency remote teaching in higher education, Vlachopoulos found that most institutions implemented an unplanned distance education practice [22]. In response, this study points to the need for a wide-scale uptake of blended learning in higher education to promote the quality of education and ESD [22]. According to the research results related to the use of educational platforms in Scopus and Web of Science for the period 2015–2021, Llamoca held that the use of educational platforms can contribute to the further development of higher education, thus achieving ESD and quality education for all [23]. On the basis of the current situation and possible challenges in political education in the management of poor students in the online environment, Liu et al. deemed that ideological and political education should be focused on achieving education for sustainable development in poor areas [24]. Based on the results of an argument for a comprehensive, feasible, and applicable pedagogical framework, Huang et al. argued that using values based on the concept of ESD as a pedagogical principle to teach students about emotions can contribute to the sustainable development of society [25]. While exploring how engineering schools can train engineers to address environmental issues, Castellanos et al. found that ESD and environmental education can help universities achieve education on environmental issues [26]. In view of the existing results on the sustainability thoughts of engineering students, Pokholkov et al. constructed a quantitative assessment standard system of sustainability thought and pointed out the importance of ESD for the training of future engineers [27]. Taking ATHENA as an example, Escudeiro et al. noted the importance of ESD for quality university education and social development using a description of its specific activities directly related to ESD, such as competency clusters, embedded mobile culture, and assistive technologies [28].

In summary, in the existing studies on ESD, scholars have mainly focused on how to achieve the goals of ESD and the impact of ESD on social development, while few scholars have integrated ESD into their own development goals and measured their own development status in this way. Put forward by the Ministry of Education of China, the CFCRS is an important measure to realize global and regional educational cooperation, cultivate internationally competitive talents, and promote the healthy development of ESD. Only by implementing the goals of ESD, such as quality education and lifelong education, and strengthening the teaching quality of CFCRS can we better cultivate international elites in various industries for the world and promote the sustainable development of society. Thus, by refining the goals of ESD into the evaluation criteria of the development status, this study explores the development status of CFCRS from the perspective of ESD.

2.2. Teaching Quality Evaluation of Teaching Institutions

In recent years, scholars have mainly studied general institutions to evaluate the teaching quality of educational institutions in terms of innovative education quality, curriculum quality, student satisfaction, teaching effectiveness, and other subdivisions. According to a four-dimensional indicator system for evaluating the quality of university innovation education by the government, university, society, and students, Yan conducted a case study with the Nanyang Institute of Science and Technology as an example [29]. Based on the specific features of the THEOL learning management system, Han et al. put forward a framework for evaluating web-assisted courses to help administrators and teaching staff conduct course quality analysis [30]. On the basis of course website positioning and existing literature, Wang et al. established a website evaluation indicator system for high-quality university courses and verified its rationality with specific cases [31]. By using a "handover questionnaire" to assess student satisfaction in higher education, Anilkumar et al. found that the facilities provided to students had the greatest impact on student satisfaction [32]. In accordance with the teaching quality evaluation system, Guo et al. used the AHP (Analytic Hierarchy Process), a fuzzy comprehensive evaluation method, to construct a university teaching effectiveness evaluation system [33]. Based on the current situation and influencing factors of multimedia teaching quality management, Li et al. established a multimedia teaching quality evaluation indicator system in universities and believed that the role of systematic quality control should be emphasized [34]. Combining the requirements of students' comprehensive development, Han et al. established a scientific and reasonable quality evaluation index system for college students and tested its consistency and reliability [35]. In light of the results of measuring the satisfaction of the participants in the educational process, Movchan et al. developed a quality measurement model for the comprehensive evaluation of the quality of the educational environment, which elaborates on the importance of the quality of the educational environment for the educational process [36]. Using a survey, Bloch et al. found that students, teachers, and managers across sectors all think that students' academic skills and practical ability play a very key role in the implementation of teaching quality in higher education [37]. Bijlsma et al. used the Bayesian item response theory (IRT)-model approach to investigate students' ratings of 26 teachers who used the digital tool Impact! and found that more likeable and more experienced teachers received higher ratings [38].

In summary, the existing studies on the evaluation of teaching quality in educational institutions have been more prominent in general universities. They mainly focus on the subdivision aspects of curriculum, teaching, and student management, and few scholars focus on the overall effect of teaching quality in educational institutions. As for the managers of educational institutions, only by doing a good job in teaching and learning can they ensure their continued good long-term development. Therefore, this study focuses on the teaching quality of educational institutions, taking CFCRS among educational institutions as an example, and examines them with evaluation methods and empirical methods.

2.3. Evaluation of Chinese–Foreign Cooperative Education

Recently, there have been fewer studies on the evaluation of Chinese–foreign cooperative education. Only a few scholars have evaluated aspects such as the competitiveness and mode of operation of CFCRS. According to the influencing factors of competitiveness, Wang et al. proposed an evaluation system and evaluation method for the competitiveness of CFCRS based on AHP [39]. Based on the existing data, Zheng et al. built an evaluation model of CFCRS by using convolutional neural network deep learning technology, and found that CFCRS should learn from the learning model of international students to improve their own school-running model, so that the students trained can achieve the same effect as those studying abroad in China [40]. Individual scholars have conducted evaluation studies on the teaching quality of Sino–foreign cooperative schools. Drawing lessons from the international vision of OECD and UNESCO and the research results of American Baldrige AUQA Education Quality Award, Ma built a project quality evaluation system for Sino–foreign cooperative education projects [41].

To sum up, among the existing studies, scholars mostly study the competitiveness, mode, and teaching quality for the evaluation of CFCRS. Few scholars have evaluated the teaching quality of CFCRS. As one of the types of educational institutions, the teaching quality of CFCRS is the key to its long-term development. Therefore, this study evaluates the teaching quality of CFCRS from the perspective of ESD. According to the evaluation results, it proposes targeted correspondence and recommendations for the further improvement and development of CFCRS.

3. Evaluation Dimensions and Indicators

During the construction process of CFCRS, the input of various resources takes a positive role in facilitating the cultivation of international elite talents [8]. Strengthening the management of faculty construction and building a high-level faculty meeting international requirements is an important foundation for the sustainable development of CFCRS [42]. The teaching process of CFCRS is a direct link between teachers and students. Whether the teaching process can be carried out smoothly is directly related to students' satisfaction and learning achievements, and it is helpful to improve the teaching quality of CFCRS [9]. From the perspective of ESD, in order to improve the quality of education and the results of running a school, administrators should not only ensure the input of resources, guarantee the faculty, and improve the teaching process but also emphasize teaching results all the time [43]. Only in this way can the sustainable development of CFCRS be realized. For CFCRS, the excellence of the international talents eventually cultivated is a visual representation of its teaching quality. According to the above research results, the resource input, faculty environment, teaching process, and teaching outcome are all crucial to the teaching quality and talent cultivation effectiveness of CFCRS. Consequently, based on the perspective of ESD, this study selects four dimensions: resource input, faculty environment, teaching process, and teaching outcome to construct a teaching quality evaluation model for CFCRS.

3.1. Resource Input Dimension

The investment of various resources in CFCRS not only helps them to better cultivate the elite talents needed for internationalization, but also promotes the achievement of ESD goals and their own sustainable development [8,43]. Teaching resources such as multimedia and experimental resources such as laboratories can affect the effectiveness of talent cultivation in CFCRS [23,44,45]. Liu et al. found that the academic resource support provided to students by CFCRS in the early stages had a significant impact on the final talent development outcomes [9]. Given the special nature of CFCRS, the introduction and operation of foreign programs are very important. Coupled with the impact of the new crown epidemic, there is a need to strengthen the introduction and management of online courses and improve the input of information technology resources [8,45]. To this end, four indicators, including teaching resource, laboratory resource, academic support, and informatization level, are used to evaluate the resource input dimension.

3.2. Faculty Environment Dimension

The faculty environment is the foundation of the sustainable development of CFCRS and strengthening its construction and management can improve the quality of the final talent cultivation [42,46]. The proportion of full-time faculty reflects the adequacy of the number of faculty in CFCRS and can visually reflect the degree of construction of the faculty environment [45]. Teacher education is a visual reference indicator of the quality of teachers in CFCRS [45]. The more teachers with a master's degree or higher, the higher the overall quality level of teachers. "Dual-teachers" refers to teachers who are qualified to teach and work in vocational education at the same time, which is an indicator for monitoring and evaluating the level of teachers [45]. The higher the proportion of "dual-teachers", the higher the level of teachers, which helps improve the quality of teaching and the cultivation of students' vocational skills in CFCRS [45]. All other things being equal, the more teachers with senior professional and technical positions, the higher the overall business level of the faculty and the stronger the faculty [45]. An internationalized and high-level faculty is important for the construction of CFCRS. Therefore, qualified teachers from multicultural backgrounds should be introduced to improve their internationalization and openness to cooperation [42,45]. To this end, five indicators, including the percentage of full-time teachers, teacher qualification, percentage of "dual-teachers", teaching ability, and teacher nationality, are used to evaluate the faculty environment dimension.

3.3. Teaching Process Dimension

The teaching process is a joint effort by teachers and students to complete the teaching task, which is an essential implementation part of CFCRS teaching [4]. In this process, teachers impart to students ideas, culture, and technology to understand and transform the world, and students learn the content of knowledge they need through the teacher's words and example. As the closest link between teachers and students, the teaching process of CFCRS is critical to student satisfaction and the quality of the talent training [9,47]. The teaching content of CFCRS is closely related to the quality of talent cultivation, which can be enriched using the introduction of foreign curriculum and foreign language teaching materials to improve the teaching quality [8,48]. Ma et al. found that the clarity of course hours and the detailed arrangement of the instructional management process had a significant impact on the quality of teaching in CFCRS [46]. The number of disciplines and specialties at CFCRS has a significant effect on its content, student satisfaction, and teaching quality, thus producing a diverse and elite international workforce [9,49,50]. For this purpose, four indicators, including curriculum, teaching management, introduction of teaching materials, and subject setting, are used to evaluate the teaching process dimension.

3.4. Teaching Outcome Dimension

The ESD goals state that the teaching outcome component should be included when evaluating the quality of education [43]. Kurkovsky found that student performance can be used in ESD analysis [51]. The better the student performance, the better the quality of education at the CFCRS. The employment rate of students reflects the match between the education of CFCRS and the actual needs of the society [45]. The higher the student employment rate is, the better the match between its professional settings and education quality and the requirements of society. Guo et al. argued that improving students' innovative abilities can alleviate the difficulties currently encountered by CFCRS to achieve the training of innovative talents [52]. Fahim et al. held that the number of publications of papers and patents plays an important role in the achievement of ESD, in which the number of students who participate is an important reflection of the student's research ability and one of the teaching outcomes of CFCRS [48,53]. Students' English proficiency is both a prerequisite for the smooth implementation of CFCRS and a demonstration of their teaching achievements, which helps promote the cultivation of international talents [45,54]. To this end, five indicators, including GPA, employment rate, innovation ability, research ability, and English proficiency, are used to evaluate the teaching outcome dimension. The final evaluation dimensions and indicators are shown in Table 1.

Table 1. Evaluation dimensions and indicators of teaching quality in CFCRS.

Dimension	Indicator	Label	Descriptions	References
Resource Input (D_1)	Teaching Resource	C_{11}	The proportion of multimedia classrooms to the total number of classrooms	[8,9,23,43–45]
	Laboratory Resource	C_{12}	The ratio of the total laboratory area to the total number of students in school (Unit: m^2/student)	
	Academic Support	C_{13}	Annual average number of academic conferences, lectures, and reports	
	Informatization Level	C_{14}	The proportion of network courses in the total number of courses	
Faculty Environment (D_2)	Percentage of Full-time Teachers	C_{21}	The proportion of full-time teachers in the total number of faculty	[42,45,46]
	Teacher Qualification	C_{22}	The proportion of teachers with a master's degree or above	
	Percentage of "Dual-Teachers"	C_{23}	The proportion of teachers with both teacher qualification and industry competence qualification	
	Teaching Ability	C_{24}	The proportion of teachers with senior professional positions (i.e., professors and associate professors)	
	Teacher Nationality	C_{25}	The proportion of foreign teachers in the total number of full-time teachers	
Teaching Process (D_3)	Curriculum	C_{31}	The proportion of foreign courses introduced	[8,9,46–50]
	Teaching Management	C_{32}	Whether the course hours and detailed arrangements are clear (if yes, score 1 point; if no, score 0 point)	
	Introduction of Teaching Materials	C_{33}	The proportion of foreign textbooks (including bilingual textbooks)	
	Subject Setting	C_{34}	The number of disciplines set up by this institution	
Teaching Outcome (D_4)	GPA	C_{41}	The average grade point of students	[43,45,48,51–54]
	Employment Rate	C_{42}	The initial employment rate of students	
	Innovation Ability	C_{43}	The number of innovative competition students who have won awards above the school level	
	Research Ability	C_{44}	The number of papers and patents participated by students	
	English Proficiency	C_{45}	The proportion of students who have passed the international English standardized test in the total number of students in school	

4. Methodology

4.1. DANP Method

Currently, the DANP method has been well applied in the fields of online restaurant platform evaluation [14], vehicle procurement evaluation [15], open government data [16], and open government data platforms [17]. Therefore, this study uses the DANP method to calculate the evaluation dimension and indicator weights and to construct the influential network relation map (INRM). Based on the above findings, this paper also presents strategies and recommendations for the construction of CFCRS.

Combining the DEMATEL method and the ANP method, the DANP method is used to obtain the element weights by using the combined influence matrix of DEMATEL directly as the unweighted super-matrix of ANP and deriving the stable limit super-matrix [55]. The DANP method makes up for the shortcomings of ANP by combining the advantages of both methods, reducing the number of two-by-two comparisons between elements, and enabling a more objective reflection of reality in the calculation of weights [56]. The specific steps are as follows:

Step 1: Build a direct impact matrix. The direct impact relationship matrix A can be obtained by calculating the arithmetic average of the scoring table of the direct impact degree of two indicators scored by experts, as shown in Equation (1).

$$A = \left[a_{ij}\right]_m \tag{1}$$

Step 2: Calculate the normalized matrix.

$$D = s \times A \tag{2}$$

$$s = \min\left\{\frac{1}{\max_{1\le i\le n}\sum_{j=1}^{n} a_{ij}}, \frac{1}{\max_{1\le i\le n}\sum_{i=1}^{n} a_{ij}}\right\} \tag{3}$$

Step 3: Calculate the combined impact matrix of dimensions and indicators separately. The normalized matrix D is passed through Equation (4) to derive the combined impact matrix of dimensions and indicators as matrices G_Y and G_y.

$$G = D + D^2 + D^3 + \ldots = D(E - D)^{-1} \tag{4}$$

Step 4: Calculate the standardized matrix. The combined impact matrix G_Y and G_y is normalized according to Equations (5)–(7) to obtain the normalization matrix G_Y^C and G_y^c, in which $G_y^{c_{ij}}$ is the submatrix of order $m_i \times m_j$ in G_y^c.

$$G_Y^C = \left[g_Y^{c_{ij}}\right]_{m\times m} = \begin{bmatrix} g_Y^{11}/d_1 & \ldots & g_Y^{1j}/d_1 & \ldots & g_Y^{1m}/d_1 \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ g_Y^{i1}/d_i & \ldots & g_Y^{ij}/d_i & \ldots & g_Y^{im}/d_i \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ g_Y^{m1}/d_m & \ldots & g_Y^{mj}/d_m & \ldots & g_Y^{mm}/d_m \end{bmatrix} \tag{5}$$

$$d_i = \sum_{j=1}^{m} g_Y^{ij}, i = 1, 2, \ldots, m \tag{6}$$

$$G_y^c = \begin{bmatrix} G_y^{c_{11}} & \ldots & G_y^{c_{1j}} & \ldots & G_y^{c_{1m}} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ G_y^{c_{i1}} & \ldots & G_y^{c_{ij}} & \ldots & G_y^{c_{im}} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ G_y^{c_{m1}} & \ldots & G_y^{c_{mj}} & \ldots & G_y^{c_{mm}} \end{bmatrix} \tag{7}$$

Step 5: Calculate the unweighted super-matrix W_{ij}. The normalized matrix G_y^c obtained in the previous step is transposed using Equation (8).

$$W = \left(G_y^c\right)^T \tag{8}$$

Step 6: Calculate the weighted super-matrix W^c.

$$W^c = G_y^c W \tag{9}$$

Step 7: Calculate the limit super-matrix. The weighted super-matrix is multiplied until convergence to determine the dimensional and factor weights.

$$W^\mu = \lim_{\mu\to\infty} (W^c)^\mu \tag{10}$$

4.2. TOPSIS Method

The TOPSIS method, also known as the ideal point method, was first presented by Hwang and Yoon in 1981 [57]. The main idea of the TOPSIS method is to first determine the positive and negative ideal values of each indicator. The positive ideal value is the hypothetical optimal value solution, which achieves the best value of each attribute value among the candidates as the positive ideal goal, while the negative ideal solution is the alternative hypothetical worst value solution as the negative ideal goal. Next, the Euclidean distance is applied to find the distance between each scenario and the positive and negative ideal values. Finally, the closeness of each solution to the affirmative ideal goal is derived, and the closest to the affirmative ideal goal and the farthest from the negative ideal goal is the optimal result. The distance of each evaluation objective from the affirmative ideal objective and the negative ideal objective is calculated separately for multiple solutions, and the ranking is derived according to the closeness of the ideal solution. The specific steps are as follows:

Step 1: Establish a decision matrix. The evaluation indicator scoring table is designed, and the evaluation index scoring table contains qualitative and quantitative indicators. Usually there are m evaluation targets $D_1, D_2, \ldots, D_M$, and each target has n evaluation indicators $x_1, x_2, \ldots, x_n$. The characteristic matrix D is shown in Equation (11).

$$D = \begin{bmatrix} x_{11} & \ldots & x_{1j} & \ldots & x_{1n} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ x_{i1} & \ldots & x_{ij} & \ldots & x_{in} \\ \ldots & \ldots & \ldots & \ldots & \ldots \\ x_{m1} & \ldots & x_{mj} & \ldots & x_{mn} \end{bmatrix} = \begin{bmatrix} D_1(X_1) \\ \ldots \\ D_i(X_j) \\ \ldots \\ D_m(X_n) \end{bmatrix} \tag{11}$$

Step 2: Calculate the normalized matrix. Build the normalization matrix of the specification vector r_{ij}, in which $i = 1, 2, \ldots, m$, $j = 1, 2, \ldots, n$, as shown in Equation (12).

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{12}$$

Step 3: Obtain the weighted decision matrix by dotting the weights of each indicator in the matrix with the elements in the normalization matrix Z.

Step 4: Determine the positive ideal solution z^+ and negative ideal solution z^- using Equations (13) and (14), in which $i = 1,2, \ldots, m$.

$$z^+ = \max(Z_{i1}, Z_{i2}, \ldots, Z_{in}) \tag{13}$$

$$z^- = \min(Z_{i1}, Z_{i2}, \ldots, Z_{in}) \tag{14}$$

Step 5: Compute the Euclidean distance between each evaluation factor and the positive ideal solution D^+ and negative ideal solution D^- using Equations (15) and (16).

$$D_i^+ = \sqrt{\sum_{j=1}^{n} \left(r_{ij} - z_j^+\right)^2} \tag{15}$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} \left(r_{ij} - z_j^-\right)^2} \tag{16}$$

Step 6: Calculate the ideal closeness, as shown in Equation (17). The evaluation objectives are ranked according to the magnitude of the ideal posting progress value C_i. The larger the value, the closer the evaluation objective is to the positive ideal solution.

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \tag{17}$$

5. Data Analysis

5.1. Data Collection

An expert questionnaire was used to collect data for this study (Supplementary Materials). The questionnaire consisted of three parts: questionnaire description, expert attributes, and comparison questions. Questionnaires were distributed to the experts in person to fill in following relevant instructions. The time to complete each questionnaire was 1–1.5 h. Experts were asked to rate the degree of interaction between two indicators in the same level, with a score of 0–4 representing "no impact", "low impact", "medium impact", "high impact", and "very high impact", in that order. The survey was completed in August 2022. A total of 8 questionnaires were returned, of which 6 experts had senior titles and 7 experts had worked for more than 15 years. The inconsistency rate of the questionnaire was 1.64% < 5%, indicating that the questionnaire could reflect the true situation and the additional number would not change the overall results. As shown in Appendix A, the reliability of the expert questionnaire was calculated to be 96.2%, which exceeds 95%. Combining the reliability and inconsistency rate, this questionnaire had high reliability and validity, which can be used for the next DANP weighting calculation.

5.2. Calculation of Weight

After normalizing the recovered questionnaire data using Equations (1)–(3), the centrality and the causality of each dimension and indicator were obtained using Equation (4). The weighted super-matrix is calculated using Equations (5)–(9). Finally, the limit super-matrix is obtained using Equation (10), as shown in Table 2. In terms of dimension, the cause degree values for the teaching process and teaching outcome dimensions are negative, meaning these are the result factors, while the cause degree values for the resource input and faculty environment dimensions are positive, meaning these are the cause factors. The faculty environment dimension has the highest reason degree value, which can influence the remaining three evaluation dimensions.

The weights of the four dimensions in the teaching quality evaluation model of CFCRS are relatively similar. The teaching outcome dimension has the greatest weight, followed by the teaching process and faculty environment dimensions. The smallest weight value for the resource input dimension indicates its relative least importance, which is consistent with the result of the lowest cause value in Table 2. From the teaching quality evaluation indicators of CFCRS, academic support is the one with the highest weight, followed by teaching resource and teaching management. Teacher nationality is the least weighted indicator. This is because the nationality of a teacher does not affect the teacher's ability to teach. Teachers with excellent teaching abilities are available in every country.

Looking within each evaluation dimension: under the teaching outcome dimension, research ability has the highest weight, that is, the most important indicator under the teaching outcome dimension. This is followed by innovation ability, GPA, and employment rate. English proficiency has the lowest weight. Under the teaching process dimension, teaching management is the most important indicator, followed by the curriculum, and the difference in weight between the two is small. The subject setting is ranked third in weight, while the introduction of teaching materials ranks last under the teaching process dimension. Under the dimension of the faculty environment, teaching ability is the most important indicator, followed by the percentage of full-time teachers, teacher qualification, and percentage of "dual-teachers". The lowest weight for teacher nationality indicates that it is the least important for the faculty environment dimension. Under the resource input dimension, academic support is the most important indicator, followed by teaching resource and informatization level, with the lowest indicator weighting for laboratory resource.

Table 2. Calculation results of evaluation dimensions and indicators.

Dimension	Indicator	Dimension Centrality	Dimension Cause	Indicator Weight	Indicator Ranking	Dimension Weight	Dimension Ranking
Resource Input (D_1)	C_{11}	2.247	0.007	0.259	2	0.243	4
	C_{12}			0.217	9		
	C_{13}			0.284	1		
	C_{14}			0.240	7		
Faculty Environment (D_2)	C_{21}	2.375	0.093	0.214	10	0.244	3
	C_{22}			0.198	15		
	C_{23}			0.194	16		
	C_{24}			0.224	8		
	C_{25}			0.171	18		
Teaching Process (D_3)	C_{31}	2.281	−0.037	0.255	4	0.252	2
	C_{32}			0.259	3		
	C_{33}			0.242	6		
	C_{34}			0.244	5		
Teaching Outcome (D_4)	C_{41}	2.338	−0.063	0.204	13	0.261	1
	C_{42}			0.199	14		
	C_{43}			0.206	12		
	C_{44}			0.211	11		
	C_{45}			0.179	17		

5.3. INRM Construction

With the central degree as the horizontal coordinate and the cause degree as the vertical coordinate, the INRM of dimensions and indicators is drawn, as shown in Figure 1. In general, the resource input and faculty environment dimensions influence the teaching process and teaching outcome dimensions. In the resource input dimension, teaching resource was the cause factor with the highest cause degree influencing the informatization level, academic support, and laboratory resource. Laboratory resource is the indicator with the lowest cause degree, which is affected to the greatest extent by the others. In the faculty environment dimension, teaching ability is the result factor, which is influenced by teacher qualification, teacher nationality, percentage of full-time teachers, and percentage of "dual-teachers". In the teaching process dimension, curriculum and subject setting manifest as cause factors that influence the introduction of teaching materials and teaching management. Among the teaching outcome dimension, English proficiency as a cause factor affects GPA, employment rate, innovation ability, and research ability.

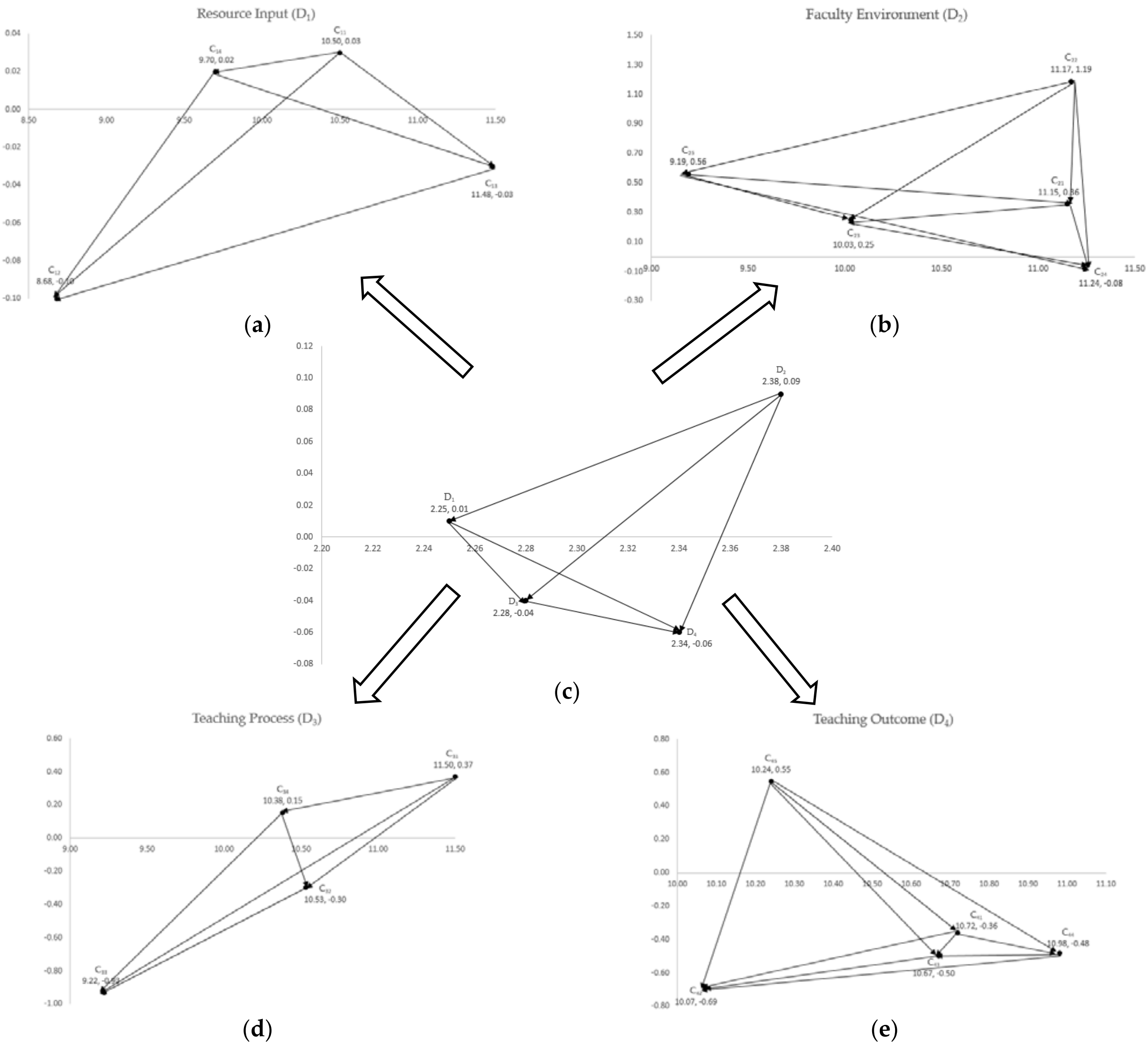

Figure 1. Influential Network Relation Map (INRM). (**a**) INRM among the resource input dimension; (**b**) INRM among the faculty environment dimension; (**c**) INRM among all dimensions; (**d**) INRM among the teaching process dimension; (**e**) INRM among the teaching outcome dimension.

6. Empirical Research

One of the objectives of this study is to analyze the current teaching situation using the teaching quality evaluation model for CFCRS from the perspective of ESD in order to help administrators identify weaknesses in the current construction and suggestions for future improvement. Therefore, this study considers a data set from China and conducts an empirical study with the help of the constructed teaching quality evaluation model of CFCRS. To ensure the representativeness of the samples, the CFCRS A of a comprehensive university in a developed region of China, CFCRS B of a comprehensive university in a less developed region, and CFCRS C of a university of applied science and technology were selected for this study. Sample data are from actual interviews. According to the meanings of the indicators in Table 1, we conducted face-to-face interviews with the managers from three CFCRS to collect and organize the relevant indicator data. Data collection took place on 16 September 2022. The data were compiled by managers based on their own CFCRS, which is consistent with the actual situation of their respective CFCRS. As first-hand interview data, the data used in this study are not related to the data used in the existing literature. The normalized standardization method was used to de-quantize the magnitude data in the original data. Combining the evaluation dimension weights calculated using the DANP method, the TOPSIS method was used to rank and calculate the three CFCRS A, B, and C. The positive and negative ideal solutions are calculated according to Equations (11)–(16) as shown in Table 3. Equation (17) is then used to calculate the ideal proximity of three CFCRS A, B, and C. The results are shown in Table 4, which show that CFCRS A has the highest overall ranking in teaching quality, followed by CFCRS C. CFCRS B has the worst overall ranking in terms of teaching quality.

Table 3. Results of positive and negative ideal solution.

	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{31}	C_{32}	C_{33}	C_{34}	C_{41}	C_{42}	C_{43}	C_{44}	C_{45}
z^+	0.086	0.121	0.170	0.183	0.087	0.066	0.131	0.103	0.075	0.132	0.086	0.110	0.140	0.072	0.069	0.137	0.152	0.101
z^-	0.086	0.007	0.051	0.005	0.053	0.066	0.014	0.055	0.032	0.046	0.086	0.060	0.035	0.065	0.064	0.009	0.011	0.036

Table 4. Results of the ranking of three CFCRS in China.

CFCRS	D_i^+	D_i^-	C_i	Ranking Result
A	0.174	0.315	0.645	1
B	0.278	0.155	0.358	3
C	0.314	0.183	0.368	2

The evaluation dimension and indicator scores of the three CFCRS are shown in Figures 2 and 3. In terms of resource input and teaching process, CFCRS A performs the best job, followed by CFCRS B and C. Regarding the faculty environment and teaching outcome, CFCRS A performs the best job, followed by CFCRS C and B. Separately, CFCRS A has the highest rating for the teaching process dimension and the lowest rating for the teaching outcome dimension. It has the highest rating for the informatization level, research ability, and subject setting, and the lowest rating for innovation ability. For CFCRS B, the highest rating is given to the resource input dimension, and the lowest rating is given to the teaching outcome dimension. The highest rating is given to the laboratory resource and teaching ability, and the lowest rating is given to the percentage of “dual-teachers”. The teaching outcome dimension of CFCRS C has the highest rating, and the teaching process dimension has the lowest rating. The highest rating is given to the academic support and innovation ability, and the lowest rating to the research ability, laboratory resource, and informatization level.

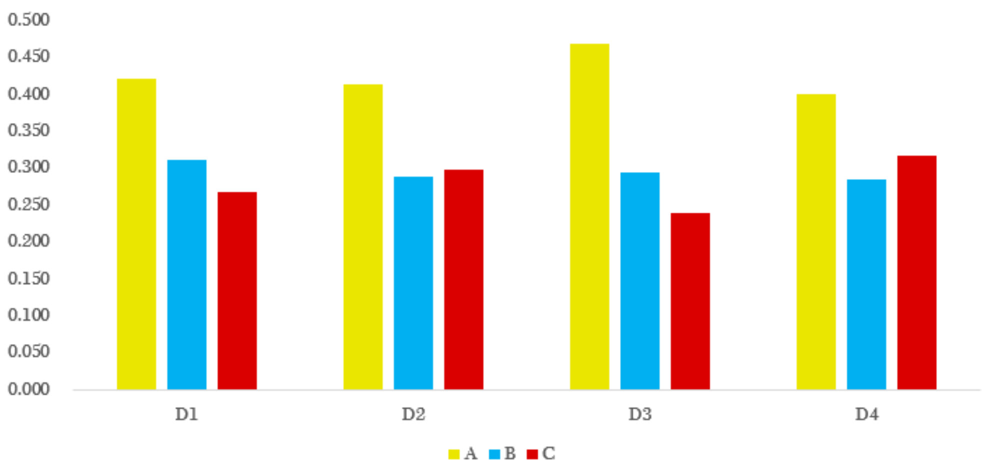

Figure 2. Dimension scoring results of three CFCRS.

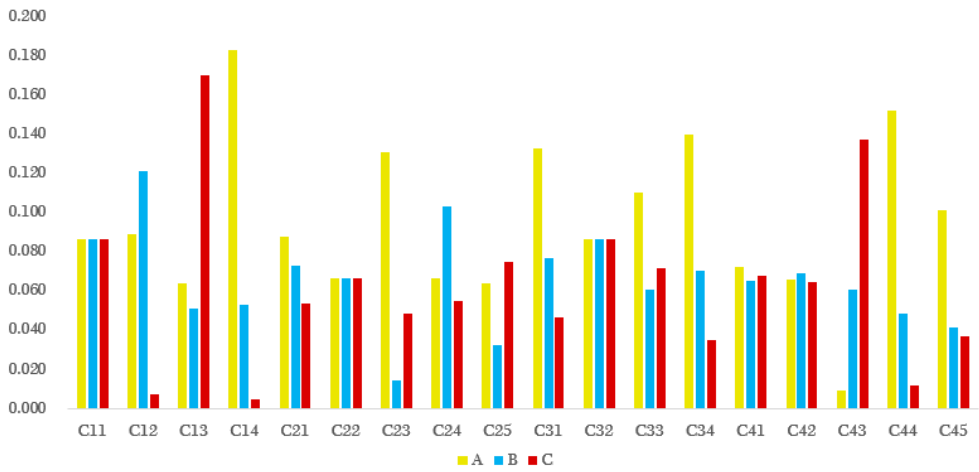

Figure 3. Indicator scoring results of three CFCRS.

7. Conclusions

7.1. Results

First, in terms of the influence on the teaching quality of CFCRS, resource input and faculty environment are the cause factors, and the teaching process and teaching outcome are the result factors. In other words, among the four influencing dimensions of teaching quality in CFCRS, the resource input and faculty environment dimensions influence the teaching process and teaching outcome dimensions, and then ultimately affect the teaching quality. The faculty environment dimension has the highest cause degree, influencing the other three evaluation dimensions. The teaching outcome dimension has the lowest cause degree, which is influenced by the other three dimensions. Specifically, among the resource input dimension, teaching resource is the indicator with the highest causality, thus affecting the informatization level and academic support. Laboratory resource is the indicator with the lowest causality, which is influenced by the other three indicators. In the faculty environment dimension, teacher qualification has the highest cause degree, followed by teacher nationality, percentage of full-time teachers, and percentage of "dual-teachers". Teaching ability is the indicator with the lowest reason, which is influenced by the other four indicators. Under the teaching process dimension, the curriculum and subject setting are the cause factors, which influence the two result factors of teaching management and introduction of teaching materials. Under the teaching outcome dimension, English proficiency is the only cause factor, which affects the four result factors of GPA, employment rate, innovation ability, and research ability. The employment rate is the indicator with the lowest degree of cause, which is influenced by the other four indicators. This finding is consistent with the study of Cai et al. [46].

Second, in terms of weight, the teaching outcome dimension has the highest weight, followed by the teaching process dimension and the faculty environment dimension. The resource input dimension has the lowest weight. Academic support is the highest weighted of all the indicators, followed by teaching resource and teaching management. Teacher nationality is the lowest weighted of the indicators. This is due to the fact that with the increasing internationalization of education, the source of teachers' knowledge and ability development is no longer limited by their own nationality. Consequently, when evaluating the current state of teaching quality in CFCRS, administrators do not focus on the international aspect of teachers. Specifically, academic support is the most important indicator of the resource input dimension. Teaching ability is the most important indicator of the faculty environment dimension, which is consistent with Nagahi et al.'s study [44]. Teaching management and research ability are the most important indicators in the teaching process dimension and teaching outcome dimension, respectively.

Finally, from the results of the empirical study, the teaching quality of CFCRS A is the best, followed by CFCRS C. CFCRS B does the worst in terms of teaching quality. In detail, CFCRS A has the lowest rating in terms of teaching outcome. CFCRS B performs poorly in terms of faculty environment and teaching outcome. There is an urgent need to strengthen the resource input and teaching process of CFCRS C. The scoring results show that CFCRS A does the best job in terms of teaching process, especially in subject setting and curriculum. However, it does the worst in terms of teaching outcome, especially in innovation ability. CFCRS B performs the best job in terms of resource input, especially the larger input in laboratory resource. However, it performs the worst in terms of faculty environment and teaching outcome, especially in the percentage of "dual-teachers", teacher nationality, English proficiency, and research ability. CFCRS C performs the best job in terms of teaching outcome, especially in innovation ability. It performs the worst in terms of teaching process, especially in subject setting and curriculum.

7.2. Suggestions

In general, according to the results of the above study, CFCRS should increase the frequency of academic activities to improve academic resources input. The findings of this study revealed that the resource input dimension is the cause factor, influencing the other factors. Moreover, as the highest weighted indicator, academic support has the greatest impact on the resource input dimension. As one of the important components of higher education, the academic resources provided to students by CFCRS have an important impact on the final results of talent cultivation. Therefore, the long-term sustainable investment of academic resources can be ensured by increasing the number of academic activities.

Secondly, teacher training should be continuously strengthened to create a highly knowledgeable, highly competent, and qualified faculty. The results show that the faculty environment dimension is the cause dimension with the highest cause degree, affecting both the teaching process and teaching outcome dimensions. According to the empirical results, CFCRS B performs poorly in terms of the faculty environment, especially in the percentage of "dual-teachers". Therefore, CFCRS should gradually assemble a highly knowledgeable, competent, and qualified faculty by strengthening teacher training, providing more opportunities to further education, and improving their academic level and teaching ability, so as to realize the long-term sustainable development of teacher resources.

Third, the curriculum and subject management should be strengthened to help realize the curriculum refinement of teaching process. The results reveal that CFCRS C performs poorly in the teaching process, especially in curriculum and subject setting. Therefore, the introduction of high-quality foreign courses and the reasonable setting of subject numbers can make the management of courses and subjects more refined to improve the teaching quality in CFCRS.

Finally, teachers should encourage students to actively participate in disciplinary competitions and paper publications to cultivate their innovation and research ability. The results indicate that all three CFCRS have very low ratings in the teaching outcome dimension, especially CFCRS B. Of these, CFCRS A performs the worst in innovative ability. Therefore, managers can gradually develop the innovation and research ability of students by adding incentive clauses and encouraging them to participate in disciplinary competitions and related activities such as the publication of papers. By promoting the cultivation of students' innovation and research ability, the cultivation of international and highly competitive talents can be realized with the objective of promoting the sustainable and healthful evolution of education.

7.3. Limitation of Research

From the perspective of ESD, this study constructs a teaching quality evaluation system of 18 indicators in 4 dimensions for CFCRS and verifies the usability of the evaluation system by taking three CFCRS in China as examples. However, there are still some limitations that exist. This study mainly considers CFCRS, but it does not cover related projects. A follow-up study can extend the proposed teaching quality evaluation system to

Chinese–foreign cooperation in running projects. The combination of schools and projects can promote the development of international and highly competitive talent for ESD.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/su15031975/s1, Questionnaire.

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Appendix A. Results in Detail

In this study, the teaching quality evaluation system of CFCRS was established using the DANP method, and the influence relationships of 4 dimensions and 18 indicators were analyzed. An average initial direct impact matrix of 18 $\times$ 18 was obtained from the questionnaire of 8 experts to form the average responses, as shown in Table A1. Then, the normalization matrix was obtained using Equations (2) and (3), as shown in Table A2. Tables A3 and A4 show the degree of influence among the 18 indicators and between the 4 dimensions. Table A5 gives the unweighted super-matrix W_{ij}, which was obtained by transposing the normalized influence matrix based on Equations (5)–(8). The weighted super-matrix W^c was obtained using Equation (9), as shown in Table A6. Finally, the limiting super-matrix W was obtained using Equation (10), as shown in Table A7.

In the empirical study, this study used the TOPSIS method to rank and analyze three representative CFCRS in China. First, the normalized decision matrix was constructed using Equation (12), as shown in Table A8. Combining the determined indicator weights and the collected objective data, the final weighted decision matrix was calculated, as shown in Table A9.

Table A1. The average initial direct influence matrix.

	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{31}	C_{32}	C_{33}	C_{34}	C_{41}	C_{42}	C_{43}	C_{44}	C_{45}
C_{11}	0.000	2.875	3.125	2.250	3.125	3.000	2.500	3.125	2.250	3.625	3.125	2.500	2.875	3.000	2.750	2.750	2.625	2.250
C_{12}	2.500	0.000	2.875	2.375	2.375	1.500	2.125	2.875	1.625	2.375	2.500	1.625	2.375	2.250	2.375	2.750	2.875	1.375
C_{13}	3.125	3.000	0.000	2.750	3.625	3.625	3.000	2.750	2.500	3.250	2.750	2.750	3.125	3.500	3.125	3.500	3.625	2.250
C_{14}	3.000	2.375	3.000	0.000	2.125	2.000	2.250	3.375	2.250	2.375	3.250	2.000	2.500	2.500	2.500	3.375	3.250	2.000
C_{21}	3.500	2.500	3.625	2.500	0.000	3.500	2.750	3.750	2.125	3.125	2.750	2.875	3.125	4.000	2.875	3.250	3.375	2.750
C_{22}	3.750	2.625	4.125	3.000	4.000	0.000	3.125	4.125	2.875	3.250	2.750	2.875	3.250	3.625	3.125	3.250	3.625	3.125
C_{23}	2.500	2.250	3.250	2.250	2.750	2.625	0.000	3.000	2.000	2.750	3.000	2.875	2.875	2.750	3.125	3.125	3.000	2.625
C_{24}	2.875	2.375	3.125	2.500	2.625	3.000	2.625	0.000	2.375	2.750	3.125	3.000	3.125	4.250	3.375	3.375	3.500	3.000
C_{25}	3.000	1.750	3.000	2.625	2.625	2.125	2.375	2.500	0.000	2.750	2.875	3.125	2.125	2.250	2.125	2.625	2.750	3.625
C_{31}	2.875	2.625	3.250	3.625	3.250	2.500	2.875	3.375	2.250	0.000	3.500	3.500	3.500	3.125	3.375	2.750	3.125	2.875

Table A1. *Cont.*

	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{31}	C_{32}	C_{33}	C_{34}	C_{41}	C_{42}	C_{43}	C_{44}	C_{45}
C_{32}	2.750	2.125	3.000	2.500	2.875	2.750	2.875	3.125	2.375	2.625	0.000	3.125	2.875	3.250	2.625	2.500	2.625	2.500
C_{33}	2.750	1.500	2.250	2.125	2.125	2.000	1.625	2.625	2.250	2.625	2.125	0.000	1.750	2.000	2.125	2.250	2.250	2.875
C_{34}	3.000	2.375	2.625	3.125	3.500	3.375	2.375	3.000	2.375	2.875	2.875	2.875	0.000	2.500	2.875	2.875	2.875	2.375
C_{41}	2.125	1.750	2.875	2.500	3.125	3.000	3.000	3.125	2.500	3.000	3.375	2.625	2.375	0.000	3.500	2.625	2.875	2.625
C_{42}	2.125	2.000	2.125	2.375	2.625	2.250	2.500	2.750	1.875	3.000	3.250	1.875	2.750	2.625	0.000	3.000	2.750	2.500
C_{43}	2.250	2.375	3.375	2.500	2.625	2.500	3.375	2.500	2.250	2.875	2.625	2.625	2.875	2.875	2.875	0.000	3.625	2.125
C_{44}	2.500	2.500	3.625	2.375	2.875	2.625	2.375	2.875	1.875	2.875	3.000	2.750	2.750	3.000	3.000	3.625	0.000	3.125
C_{45}	3.250	2.625	3.500	2.625	2.875	2.625	2.500	3.000	3.250	2.500	2.500	3.125	2.125	2.750	3.125	3.375	3.625	0.000

Note: The average gap-ratio in consensus (%) = $\sum_{i=1}^{k}\sum_{j=1}^{k}\left(\frac{\left|d_{ij}^{s}-d_{ij}^{s-1}\right|}{d_{ij}^{s}}\right) \times 100\% = 1.64\% < 5\%$, where k is the number of indicators (k = 18), s is the number of experts (s = 8), and the significant confidence reach 96.2% (more than 95%).

Table A2. The normalized matrix.

	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{31}	C_{32}	C_{33}	C_{34}	C_{41}	C_{42}	C_{43}	C_{44}	C_{45}
C_{11}	0.000	0.051	0.055	0.040	0.055	0.053	0.044	0.055	0.040	0.064	0.055	0.044	0.051	0.053	0.049	0.049	0.046	0.040
C_{12}	0.044	0.000	0.051	0.042	0.042	0.027	0.038	0.051	0.029	0.042	0.044	0.029	0.042	0.040	0.042	0.049	0.051	0.024
C_{13}	0.055	0.053	0.000	0.049	0.064	0.064	0.053	0.049	0.044	0.058	0.049	0.049	0.055	0.062	0.055	0.062	0.064	0.040
C_{14}	0.053	0.042	0.053	0.000	0.038	0.035	0.040	0.060	0.040	0.042	0.058	0.035	0.044	0.044	0.044	0.060	0.058	0.035
C_{21}	0.062	0.044	0.064	0.044	0.000	0.062	0.049	0.066	0.038	0.055	0.049	0.051	0.055	0.071	0.051	0.058	0.060	0.049
C_{22}	0.066	0.046	0.073	0.053	0.071	0.000	0.055	0.073	0.051	0.058	0.049	0.051	0.058	0.064	0.055	0.058	0.064	0.055
C_{23}	0.044	0.040	0.058	0.040	0.049	0.046	0.000	0.053	0.035	0.049	0.053	0.051	0.051	0.049	0.055	0.055	0.053	0.046
C_{24}	0.051	0.042	0.055	0.044	0.046	0.053	0.046	0.000	0.042	0.049	0.055	0.053	0.055	0.075	0.060	0.060	0.062	0.053
C_{25}	0.053	0.031	0.053	0.046	0.046	0.038	0.042	0.044	0.000	0.049	0.051	0.055	0.038	0.040	0.038	0.046	0.049	0.064
C_{31}	0.051	0.046	0.058	0.064	0.058	0.044	0.051	0.060	0.040	0.000	0.062	0.062	0.062	0.055	0.060	0.049	0.055	0.051
C_{32}	0.049	0.038	0.053	0.044	0.051	0.049	0.051	0.055	0.042	0.046	0.000	0.055	0.051	0.058	0.046	0.044	0.046	0.044
C_{33}	0.049	0.027	0.040	0.038	0.038	0.035	0.029	0.046	0.040	0.046	0.038	0.000	0.031	0.035	0.038	0.040	0.040	0.051
C_{34}	0.053	0.042	0.046	0.055	0.062	0.060	0.042	0.053	0.042	0.051	0.051	0.051	0.000	0.044	0.051	0.051	0.051	0.042
C_{41}	0.038	0.031	0.051	0.044	0.055	0.053	0.053	0.055	0.044	0.053	0.060	0.046	0.042	0.000	0.062	0.046	0.051	0.046
C_{42}	0.038	0.035	0.038	0.042	0.046	0.040	0.044	0.049	0.033	0.053	0.058	0.033	0.049	0.046	0.000	0.053	0.049	0.044
C_{43}	0.040	0.042	0.060	0.044	0.046	0.044	0.060	0.044	0.040	0.051	0.046	0.046	0.051	0.051	0.051	0.000	0.064	0.038
C_{44}	0.044	0.044	0.064	0.042	0.051	0.046	0.042	0.051	0.033	0.051	0.053	0.049	0.049	0.053	0.053	0.064	0.000	0.055
C_{45}	0.058	0.046	0.062	0.046	0.051	0.046	0.044	0.053	0.058	0.044	0.044	0.055	0.038	0.049	0.055	0.060	0.064	0.000

Table A3. The total-influence matrix of indicators.

	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{31}	C_{32}	C_{33}	C_{34}	C_{41}	C_{42}	C_{43}	C_{44}	C_{45}
C_{11}	0.249	0.258	0.327	0.269	0.310	0.288	0.276	0.322	0.244	0.315	0.310	0.284	0.293	0.315	0.303	0.312	0.317	0.269
C_{12}	0.245	0.171	0.272	0.228	0.250	0.220	0.227	0.268	0.195	0.248	0.253	0.225	0.240	0.254	0.250	0.264	0.271	0.212
C_{13}	0.323	0.278	0.299	0.297	0.340	0.319	0.304	0.340	0.266	0.331	0.327	0.309	0.318	0.346	0.331	0.348	0.357	0.289
C_{14}	0.280	0.234	0.304	0.213	0.274	0.254	0.254	0.305	0.228	0.275	0.293	0.257	0.268	0.286	0.279	0.302	0.306	0.247
C_{21}	0.331	0.271	0.360	0.295	0.281	0.319	0.301	0.357	0.261	0.331	0.329	0.313	0.319	0.356	0.329	0.345	0.355	0.299
C_{22}	0.355	0.290	0.391	0.321	0.369	0.280	0.326	0.385	0.290	0.354	0.350	0.333	0.341	0.371	0.354	0.367	0.381	0.324
C_{23}	0.286	0.243	0.322	0.264	0.298	0.277	0.228	0.314	0.235	0.295	0.302	0.285	0.287	0.304	0.303	0.312	0.317	0.270
C_{24}	0.312	0.262	0.343	0.287	0.317	0.303	0.292	0.286	0.258	0.316	0.326	0.307	0.311	0.350	0.328	0.338	0.348	0.295
C_{25}	0.282	0.224	0.304	0.258	0.282	0.257	0.256	0.292	0.191	0.282	0.287	0.277	0.262	0.283	0.274	0.291	0.299	0.274

Table A3. *Cont.*

	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{31}	C_{32}	C_{33}	C_{34}	C_{41}	C_{42}	C_{43}	C_{44}	C_{45}
C_{31}	0.319	0.271	0.351	0.310	0.333	0.300	0.301	0.349	0.261	0.276	0.338	0.320	0.323	0.339	0.334	0.335	0.348	0.298
C_{32}	0.289	0.239	0.317	0.266	0.298	0.278	0.275	0.315	0.240	0.292	0.251	0.288	0.285	0.311	0.294	0.301	0.309	0.267
C_{33}	0.243	0.191	0.254	0.218	0.239	0.221	0.212	0.257	0.200	0.245	0.239	0.191	0.222	0.242	0.238	0.248	0.253	0.230
C_{34}	0.300	0.250	0.319	0.283	0.316	0.294	0.274	0.321	0.246	0.303	0.307	0.290	0.244	0.307	0.305	0.315	0.321	0.271
C_{41}	0.282	0.236	0.318	0.269	0.305	0.285	0.280	0.318	0.245	0.301	0.310	0.283	0.281	0.260	0.311	0.306	0.317	0.272
C_{42}	0.258	0.221	0.281	0.246	0.273	0.250	0.250	0.287	0.215	0.277	0.285	0.248	0.264	0.280	0.229	0.288	0.290	0.248
C_{43}	0.279	0.242	0.321	0.265	0.293	0.272	0.282	0.303	0.237	0.294	0.294	0.278	0.284	0.303	0.296	0.257	0.324	0.259
C_{44}	0.291	0.251	0.334	0.270	0.305	0.282	0.273	0.317	0.237	0.302	0.308	0.288	0.290	0.314	0.306	0.326	0.272	0.282
C_{45}	0.310	0.259	0.340	0.281	0.312	0.288	0.281	0.327	0.265	0.304	0.307	0.300	0.286	0.317	0.315	0.329	0.340	0.237

Table A4. The total-influence matrix of dimensions.

	C_{11}	C_{12}	C_{13}	C_{14}
C_{11}	0.000	2.875	3.125	2.250
C_{12}	2.500	0.000	2.875	2.375
C_{13}	3.125	3.000	0.000	2.750
C_{14}	3.000	2.375	3.000	0.000

Table A5. The un-weighted super-matrix $W_{ij.}$.

	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{31}	C_{32}	C_{33}	C_{34}	C_{41}	C_{42}	C_{43}	C_{44}	C_{45}
C_{11}	0.226	0.268	0.270	0.272	0.263	0.262	0.256	0.259	0.264	0.255	0.260	0.268	0.261	0.255	0.257	0.252	0.254	0.261
C_{12}	0.234	0.186	0.232	0.227	0.216	0.214	0.218	0.218	0.210	0.217	0.215	0.211	0.217	0.213	0.219	0.219	0.219	0.218
C_{13}	0.296	0.297	0.249	0.295	0.287	0.288	0.289	0.285	0.285	0.281	0.285	0.281	0.277	0.288	0.279	0.290	0.291	0.286
C_{14}	0.244	0.249	0.248	0.207	0.234	0.237	0.237	0.238	0.241	0.248	0.240	0.241	0.246	0.244	0.245	0.239	0.236	0.236
C_{21}	0.215	0.215	0.217	0.208	0.185	0.223	0.220	0.218	0.221	0.216	0.212	0.211	0.218	0.213	0.214	0.211	0.216	0.212
C_{22}	0.200	0.190	0.203	0.193	0.210	0.170	0.205	0.208	0.201	0.194	0.198	0.196	0.203	0.199	0.196	0.196	0.199	0.196
C_{23}	0.191	0.195	0.194	0.193	0.198	0.198	0.169	0.200	0.200	0.195	0.196	0.187	0.189	0.195	0.196	0.203	0.193	0.191
C_{24}	0.224	0.231	0.217	0.232	0.235	0.234	0.232	0.196	0.229	0.226	0.224	0.227	0.221	0.222	0.225	0.219	0.224	0.222
C_{25}	0.169	0.168	0.169	0.173	0.172	0.176	0.174	0.177	0.149	0.169	0.171	0.177	0.170	0.171	0.169	0.171	0.168	0.180
C_{31}	0.262	0.257	0.258	0.252	0.256	0.257	0.252	0.251	0.255	0.219	0.262	0.273	0.265	0.256	0.258	0.256	0.255	0.254
C_{32}	0.258	0.262	0.254	0.268	0.254	0.254	0.259	0.259	0.259	0.269	0.225	0.267	0.268	0.264	0.265	0.255	0.259	0.256
C_{33}	0.236	0.233	0.241	0.235	0.242	0.242	0.244	0.243	0.250	0.255	0.258	0.213	0.254	0.241	0.231	0.242	0.242	0.251
C_{34}	0.243	0.248	0.247	0.245	0.247	0.248	0.245	0.247	0.236	0.257	0.256	0.248	0.213	0.239	0.246	0.247	0.244	0.239
C_{41}	0.208	0.203	0.207	0.201	0.211	0.207	0.202	0.211	0.199	0.205	0.210	0.200	0.202	0.177	0.210	0.211	0.209	0.206
C_{42}	0.200	0.200	0.198	0.196	0.196	0.197	0.201	0.198	0.193	0.202	0.198	0.197	0.201	0.212	0.171	0.206	0.204	0.205
C_{43}	0.206	0.211	0.208	0.213	0.205	0.204	0.207	0.204	0.205	0.202	0.203	0.205	0.207	0.209	0.216	0.179	0.217	0.214
C_{44}	0.209	0.217	0.214	0.216	0.211	0.212	0.210	0.209	0.211	0.210	0.209	0.209	0.212	0.216	0.217	0.225	0.181	0.221
C_{45}	0.177	0.170	0.173	0.174	0.177	0.180	0.179	0.178	0.193	0.180	0.180	0.190	0.179	0.185	0.186	0.180	0.188	0.154

Table A6. The weighted super-matrix W^C.

	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{31}	C_{32}	C_{33}	C_{34}	C_{41}	C_{42}	C_{43}	C_{44}	C_{45}
C_{11}	0.054	0.064	0.064	0.065	0.065	0.064	0.063	0.064	0.065	0.063	0.064	0.066	0.064	0.062	0.063	0.061	0.062	0.064
C_{12}	0.056	0.044	0.055	0.054	0.053	0.052	0.053	0.053	0.051	0.053	0.053	0.052	0.053	0.052	0.054	0.053	0.053	0.053
C_{13}	0.070	0.071	0.059	0.070	0.070	0.071	0.071	0.070	0.070	0.069	0.070	0.069	0.068	0.070	0.068	0.071	0.071	0.070
C_{14}	0.058	0.059	0.059	0.049	0.057	0.058	0.058	0.058	0.059	0.061	0.059	0.059	0.061	0.060	0.060	0.058	0.058	0.058
C_{21}	0.053	0.053	0.053	0.051	0.044	0.053	0.052	0.052	0.052	0.053	0.052	0.052	0.054	0.052	0.053	0.052	0.053	0.052
C_{22}	0.049	0.047	0.050	0.047	0.050	0.040	0.049	0.049	0.048	0.048	0.049	0.048	0.050	0.049	0.048	0.048	0.049	0.048
C_{23}	0.047	0.048	0.048	0.047	0.047	0.047	0.040	0.048	0.048	0.048	0.048	0.046	0.046	0.048	0.048	0.050	0.047	0.047
C_{24}	0.055	0.057	0.053	0.057	0.056	0.055	0.055	0.047	0.054	0.056	0.055	0.056	0.054	0.055	0.055	0.054	0.055	0.054
C_{25}	0.042	0.041	0.042	0.043	0.041	0.042	0.041	0.042	0.035	0.042	0.042	0.044	0.042	0.042	0.041	0.042	0.041	0.044
C_{31}	0.067	0.065	0.066	0.064	0.065	0.065	0.064	0.064	0.065	0.054	0.064	0.067	0.065	0.065	0.066	0.065	0.065	0.064
C_{32}	0.066	0.067	0.065	0.068	0.065	0.064	0.066	0.066	0.066	0.066	0.055	0.066	0.066	0.067	0.067	0.065	0.066	0.065
C_{33}	0.060	0.059	0.061	0.060	0.061	0.061	0.062	0.062	0.063	0.063	0.063	0.052	0.062	0.061	0.059	0.061	0.062	0.064
C_{34}	0.062	0.063	0.063	0.062	0.063	0.063	0.062	0.063	0.060	0.063	0.063	0.061	0.052	0.061	0.063	0.063	0.062	0.061
C_{41}	0.054	0.053	0.054	0.053	0.056	0.054	0.053	0.056	0.052	0.054	0.055	0.052	0.053	0.045	0.054	0.054	0.054	0.053
C_{42}	0.052	0.052	0.052	0.052	0.052	0.052	0.053	0.052	0.051	0.053	0.052	0.051	0.052	0.054	0.044	0.053	0.052	0.052
C_{43}	0.054	0.055	0.055	0.056	0.054	0.054	0.055	0.054	0.054	0.053	0.053	0.053	0.054	0.053	0.055	0.046	0.056	0.055
C_{44}	0.055	0.057	0.056	0.057	0.056	0.056	0.056	0.055	0.056	0.055	0.055	0.055	0.055	0.055	0.056	0.058	0.046	0.057
C_{45}	0.047	0.044	0.045	0.046	0.047	0.048	0.047	0.047	0.051	0.047	0.047	0.050	0.047	0.047	0.048	0.046	0.048	0.039

Table A7. The limit super-matrix W^{μ}.

	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{31}	C_{32}	C_{33}	C_{34}	C_{41}	C_{42}	C_{43}	C_{44}	C_{45}
C_{11}	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
C_{12}	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053
C_{13}	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069
C_{14}	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058	0.058
C_{21}	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052
C_{22}	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048	0.048
C_{23}	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047
C_{24}	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055
C_{25}	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
C_{31}	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064	0.064
C_{32}	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.065
C_{33}	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061	0.061
C_{34}	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062	0.062
C_{41}	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053	0.053
C_{42}	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.052
C_{43}	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054
C_{44}	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055
C_{45}	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047

Table A8. The normalized decision matrix of three CFCRS.

	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{31}	C_{32}	C_{33}	C_{34}	C_{41}	C_{42}	C_{43}	C_{44}	C_{45}
A	0.333	0.410	0.224	0.762	0.408	0.333	0.676	0.295	0.372	0.519	0.333	0.455	0.571	0.352	0.330	0.044	0.719	0.565
B	0.333	0.557	0.179	0.219	0.342	0.333	0.074	0.460	0.190	0.299	0.333	0.250	0.286	0.318	0.348	0.292	0.228	0.231
C	0.333	0.033	0.597	0.019	0.250	0.333	0.250	0.244	0.438	0.182	0.333	0.295	0.143	0.330	0.322	0.664	0.054	0.203

Table A9. The weighted decision matrix of three CFCRS.

	C_{11}	C_{12}	C_{13}	C_{14}	C_{21}	C_{22}	C_{23}	C_{24}	C_{25}	C_{31}	C_{32}	C_{33}	C_{34}	C_{41}	C_{42}	C_{43}	C_{44}	C_{45}
A	0.086	0.089	0.064	0.183	0.087	0.066	0.131	0.066	0.064	0.132	0.086	0.110	0.140	0.072	0.065	0.009	0.152	0.101
B	0.086	0.121	0.051	0.052	0.073	0.066	0.014	0.103	0.032	0.076	0.086	0.060	0.070	0.065	0.069	0.060	0.048	0.041
C	0.086	0.007	0.170	0.005	0.053	0.066	0.048	0.055	0.075	0.046	0.086	0.071	0.035	0.068	0.064	0.137	0.011	0.036

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