STRATEGIES FOR IMPROVING ACCREDITATION PERFORMANCE IN HIGHER EDUCATION INSTITUTION

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Abstract: Numerous studies has focused on exploring input and output indicators of accreditation system; assessment quality assurance and accreditation of higher education; reviewing the status of quality assurance and accreditation system within higher education. However, few studies have explored strategies for improving institutional accreditation performance in higher education, and preventing decision makers from obtaining valuable cues for making accurate decisions to improve institutional accreditation performance to increase the logical thinking, reasoning ability and work competitiveness of graduate students. Therefore, the purpose of this study was to explore strategies for improving institutional accreditation performance using a new hybrid MCDM model combined with DANP (DEMATEL-based ANP). An empirical case was to demonstrate the effectiveness of the proposed model for evaluating institutional accreditation performance to identify institutional performance gaps and explore strategies for improving accreditation based on the influential relation map. Decision makers should increase the priority of the cause criteria in advance, to successfully improve institutional accreditation performance to achieve the aspiration levels and increase competiveness of students.

1 INTRODUCTION

Currently, the number and size of higher education institutions and the diversity of programs offered is significantly increasing (Aqlan et al., 2010). However, in the contemporary changing and uncertain world, all higher education institutions should respond favorably to social needs (Yarmohammadian et al., 2011). Evaluation thus is one of the strongest tools for strategic development in higher education environments (Saad, 2001). Professional higher education planners can use evaluation to identify their strengths and weaknesses and assume responsibility for educational needs at the national and global levels, and to continuously improve educational process and program quality (Yarmohammadian et al., 2011); (Wild, 1995); (ForoughiAbari et al., 2004). Consequently, interest is growing in establishing quality assurance and accreditation systems in higher education (Anaam et al., 2009).

Accreditation involves external quality review created and used by higher education authorities to assure and improve quality in colleges, universities and programs (Eaton, 2006). The accreditation process provides colleges and universities with an opportunity for reflection, honest assessment of strengths and weaknesses, and the development of strategies for continued improvement. Additionally, the accreditation process aims to guarantee the quality of educational programs by ensuring that graduates have acquired the necessary knowledge, skills and attitude to work successfully in their chosen profession, and that the educational programs/institutions are satisfactory to various stakeholders. Consequently, the main influences of an accreditation system include encouraging quality improvement initiatives by institutions, improving student enrolment quantity and quality, helping institutions attract and retain better quality faculty, helping institutions secure funding, enhancing graduate employability, facilitating trans-national recognition of degrees and mobility of graduates and professionals, motivating faculty to participate actively in academic and related institutional /departmental activities, helping create a sound and challenging academic environment in institutions

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and contributing to national social and economic development by producing high quality technical manpower (Campbell et al., 2002); (Anthony, 2004); (UNESCO, 2007); (Prasad and Bhar, 2010). Extensive literature has focused on exploring input and output indicators of accreditation system (Cavaller, 2011); assessment quality assurance and accreditation of higher education (Yarmohammadian et al., 2011); (Aqlan et al., 2010); and reviewing the status of quality assurance and accreditation system within higher education (Anaam et al., 2009). However, few studies have explored strategies to improve institutional accreditation performance for increasing higher education quality, and preventing decision makers from obtaining valuable cues for making accurate decisions to improve institutional accreditation performance to increase the logical thinking, reasoning ability and work competitiveness of graduate students.

MCDM (Multiple Criteria Decision Making) is scientifically analytical method that can help decision-makers selects the best alternative among multiple criteria (Tsaur et al., 1997); (Wang and Lee, 2009). Consequently, a hybrid MCDM method has been developed and is widely used in numerous fields. Tsaur et al. (1997) applied a Fuzzy MCDM to evaluate tourist risk. Furthermore, Ou Yang et al., (2008) combined DEMATEL technique and ANP to solve the dependence and feedback problems to suit the real world. Furthermore, Hung et al., (2011) used the hybrid MCDM model to solve this knowledge management systems adoption problem. Additionally, Kuan et al., (2011) used the hybrid MCDM model to assess the total performance of the new product development (NPD) process. Additionally, Yang and Tzeng (2011) demonstrated how the DEMATEL technique clarified the direct/indirect influential relationship of criteria. Decision-makers can use the influential relation map to identify the key criterion for improving institutional accreditation performance.

Based on the above discussion, this study attempts to explore the strategy for improving institutional accreditation performance using a new hybrid MCDM model that is combined with DANP (DEMATEL-based ANP). An empirical case is also presented to demonstrate the effectiveness of a new hybrid MCDM model combining DANP, and VIKOR is used to assess institutional accreditation performance to identify the performance gaps and explore strategies for improving institutional accreditation performance based on the influential relation map by DEAATEL technique. The best improvement strategy for promoting institutional accreditation performance to reduce the gaps in each criterion and achieve the aspiration levels can then be obtained and implemented.

The remainder of this paper is organized as follows. Section 2 develops a new hybrid MCDM model for exploring institutional accreditation performance improvement strategy. Section 3 then presents an empirical case analysis of institutional accreditation performance to illustrate the proposed model. Finally, the last section presents conclusions.

2 METHODOLOGY

This Section comprises four parts: the first part describes the data collection; the second part presents the DEMATEL technique for building a network relationship; the third part calculates the influential weights using DANP (DEMATEL-based ANP); finally, the last part uses VIKOR to evaluate total accreditation performance.

2.1 Data Collection

Table 1 lists criteria for evaluating accreditation performance based on Higher Education Evaluation & Accreditation Council of Taiwan (HEEACT). The survey targeted professors of university. First, this study used a four-point scale ranging from 0 (no influence) to 4 (very high influence) to identify the evaluation criteria and their influence on one another. Ten professors were then asked to assess the influence of the criteria on one another, and the consensus rates of the dimensions and criteria were 97.44% and 97.05% (both exceeding 97%), respectively. Finally, ten experts are asked to evaluate the level of importance and performance for each criterion. Furthermore, this study used VIKOR method to assess total accreditation performance, identify the gaps in performance, and explore the strategy for improving accreditation performance based on the influential relation map.

2.2 DEMATEL Technique for Establishing a Network Relationship

DEMATEL is an analytical technique for building a structural model (see **Appendix A, A1)**.

DEMATEL is mainly used to solve complex problems to clarify their essential nature. DEMATEL uses matrix and related mathematical theories (Boolean operation) to calculate the cause and effect relationships involved in each element. This technique is widely used to solve various complex studies, and particularly to understand complex problem structures and provide viable problem-solving methods (Tzeng et al., 2007).

Table 1: Evaluation criteria.

Dimensions	Criteria
Settings goals and features and self-improvement (D_1)	Cognition of teachers and students regarding educational goals (C_1)
	Teaching and learning activities reflect the goals of the educational institutions (C_2)
	Operations of the self-accreditation system(C_3)
	Effectiveness of the self-improvement system (C_4)
Course design and teaching (D_2)	Operations of the course planning system (C_5)
	Teacher quality and quantity meet student learning and teaching needs (C_6)
	Teachers teach students according to the syllabus (C_7)
	Institutions emphasize teacher professional development and teaching improvement (C_8)
Student learning and guidance (D_3)	Teaching meets student learning needs (C_9)
	Institution teaching resources meet students learning needs (C_{10})
	Institution provides student counselling, life coaching, career counselling, etc. (C_{11})
	Teachers provide students with a fixed interview time (C_{12})
	Institutions respond to student comments (C_{13})
	Students interact with advisors (C_{14})
Research and professional performance (D_4)	Research results and professional performance of teachers (C_{15})
	Teachers obtained research project grants (C_{16})
	Effectiveness of teacher participation in social services (C_{17})
	Performance of student learning outcomes (C_{18})
Graduate performance (D_5)	Institution established an effective channel for tracking graduate performance (C_{19})
	Job directors perceive satisfaction with graduates (C_{20})
	Graduate jobs, salary and other achievements (C_{21})

Source: Higher Education Evaluation & Accreditation Council of Taiwan (HEEACT).

The DEMATEL technique comprises five steps. The first step is to confirm the system has *n* elements and develop the evaluation scale, using a pair-wise of dimensions to perform the comparison, and also using the measuring scale 0, 1, 2, 3, 4, representing complete no influence (0), low influence (1), medium influence (2), high influence (3), and extremely high influence (4) as natural language by pair-wise comparison. The second step is to calculate the initial matrix to directly obtain influential matrix (Lin and Tzeng, 2009); (Chen et al., 2010). The third step is to normalize the matrix such that at least one column or row, but not all, sums to one. The forth step is to obtain the total influence matrix. Moreover, the fifth step is to obtain prominence and relation to build the influential relation map. DEMATEL is based on the concept of influential relation map, which can distinguish the direct/indirect influential relationship of the criteria, allowing decision-makers to identify the key criterion for developing strategies for improving accreditation performance in higher education of this study.

2.3 Finding the Influential Weights using the DANP

This study not only uses the DEMATEL technique to confirm the interactive relationship among the various dimensions/criteria, but also seeks the most accurate influential weights. This study found that ANP can serve this purpose. This study used the basic concept of ANP (Saaty, 1996), which eliminates the limitations of Analytic Hierarchy Process (AHP) and is applied to solve nonlinear and complex network relations (Saaty, 1996). ANP is intended to solve interdependence and feedback problems of criteria. This study thus applies the characteristics of influential weights ANP and combines them with DEMATEL (call DANP, DEMATEL-based ANP) to solve these kind of problems based on the basic concept of ANP (see **Appendix A, A2**). This approach yields more practical results.

2.4 Evaluating Competitiveness Gaps using VIKOR

Opricovic and Tzeng (2004) proposed the compromise ranking method (VIKOR) as a suitable technique for implementation within MCDM (Opricovic, 1998); (Tzeng et al., 2005); (Opricovic and Tzeng, 2004; 2007). VIKOR uses the class distance function (Yu, 1973) based on the concept of the Positive-ideal (or we adopt the Aspiration level) solution and Negative-ideal (or we adopt the Worst level) solution and puts the results in order. For normalized class distance function it is better to be near the positive-ideal point (the aspiration level) and far from the negative-ideal point (the worst value) for normalized class distance function (Lee et al., 2009); (Ho et al., 2011). VIKOR comprises the following steps: The first step is to check the best and worst values of the assessment criteria. The second step is to calculate the mean of group utility based on the sum of all individual-criterion regret (i.e., average overall performance gaps, as well as those for each dimension, and for each criterion; as well as strategies for reducing these gaps), and calculate the maximal regret of an individual-criterion for improvement priority, both overall and for each dimension. The third step is to obtain the comprehensive/integrating indicators and sorting results provided to the decision-maker to implement improvement strategies and reduce competitiveness gaps in overall and each dimensional performance (see **Appendix B)**.

3 AN EMPIRICAL CASE OF TAIWAN

This section presents an empirical case involving Taiwan to explore strategies for improving accreditation performance based on a new hybrid MCDM model. The contents include background and problem description, analysis results of accreditation performance, and measurement of the cause and effect relationships among the evaluation criteria; this framework is then used to identify institutional accreditation performance gaps and explore strategies for improving accreditation based on the influential relation map.

3.1 Background and Problem Description

The number of higher education institutions in Taiwan has recently increased rapidly, thus, the greatest challenge facing higher education in Taiwan is how to assure quality and competitiveness in the current era of globalization (Hou and Morse, 2009). Consequently, under the "University Law" revised in 2005, all Taiwanese universities and colleges are obliged to undergo regular assessments relating to standards and procedures by accrediting agencies chartered by the Ministry of Education (Hou and Morse, 2009). In the same year, the HEEACT was officially established and began to conduct evaluations of Taiwanese higher education programs in 2006 (HEEACT, 2008). However, Sadlak (2010) presented that universities and other higher education institutions are rightly seen as powerhouses and nurseries that are essential for economic development and global competitiveness. Given this situation, the best method of exploring strategies for improving accreditation to increase the quality of higher education in Taiwan has become important, and thus decision-makers can obtain valuable cues for making decisions to improve performance to the desired level.

3.2 Analysis of Results

The DEMATEL technique is used to construct an NRM (network relation map) that illustrates influential networks of five dimensions with 21 criteria of accreditation. Based on DEMATEL technique, this study obtained the total influence matrix $\boldsymbol{T}$ of the dimensions and criteria, as shown in Tables 2 to 4. According to the influential relation $(r_i - d_j)$, "Settings goals and features and self-improvement (D_1)" is the highest degree of an impact relationship that affects other dimensions directly. Otherwise, "Graduate performance (D_5)" is the most vulnerable to impact.

Table 3 lists all the criteria of the influential relation with each criterion. Table 4 lists the relationship between the extents of the direct or indirect impacts and compares them with other criteria. "Effectiveness of self-improvement system (C_4)" is the most important consideration criteria; additionally, "Effectiveness of teacher participation in social services (C_{17})" is the influence of all criteria in the least degree of other criteria. Furthermore, Table 4 shows that "Institution respond to student comments (C_{13})" is the highest degree of influential relationship in all the criteria. Otherwise, "Graduate jobs, salary, achievements (C_{21})" is the most vulnerable to impact of criteria that compare with other criteria.

Table 2: Total influence matrix of $\boldsymbol{T}_D$ and the sum of the influences on the dimensions.

	D_1	D_2	D_3	D_4	D_5	r_i	d_i	r_i+d_i	r_i-d_i
D_1	1.942	2.277	2.248	2.119	2.291	10.877	9.683	20.560	1.193
D_2	2.085	2.002	2.197	2.050	2.244	10.577	10.266	20.843	0.311
D_3	1.950	2.078	1.880	1.936	2.127	9.970	10.227	20.196	-0.257
D_4	1.848	1.943	1.920	1.655	2.005	9.370	9.587	18.957	-0.217
D_5	1.860	1.967	1.983	1.826	1.832	9.469	10.499	19.968	-1.031

Note: average gap = $\frac{1}{n(n-1)}\sum_{i=1}^{n}\sum_{j=1}^{n}\frac{\left|g_{ij}^{n}-g_{ij}^{n-1}\right|}{g_{ij}^{n}}\times 100\%$ =2.56% < 5%, n denotes the samples of 10 experts and the consensus rate is 97.44 %.

This study not only uses DEMATEL technique to confirm the interfering relationship with the criteria, but also expects to obtain the most accurate influential weights. ANP is applied to solve the interdependence and feedback problems of criteria.

Table 3: The total influence matrix of $\boldsymbol{T}_C$ for criteria.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}	C_{21}
C_1	0.258	0.330	0.321	0.339	0.320	0.320	0.276	0.337	0.314	0.334	0.285	0.263	0.269	0.303	0.275	0.237	0.224	0.288	0.258	0.264	0.264
C_2	0.310	0.281	0.328	0.350	0.324	0.325	0.280	0.338	0.311	0.329	0.284	0.265	0.271	0.301	0.279	0.245	0.228	0.290	0.258	0.272	0.272
C_3	0.313	0.339	0.278	0.348	0.322	0.321	0.285	0.342	0.316	0.343	0.291	0.277	0.280	0.307	0.286	0.250	0.234	0.290	0.269	0.269	0.267
C_4	0.321	0.358	0.354	0.314	0.342	0.351	0.304	0.363	0.332	0.354	0.306	0.296	0.299	0.363	0.299	0.269	0.244	0.309	0.291	0.293	0.293
C_5	0.296	0.324	0.310	0.333	0.259	0.307	0.274	0.323	0.299	0.316	0.265	0.253	0.262	0.287	0.268	0.236	0.211	0.283	0.240	0.257	0.260
C_6	0.315	0.345	0.329	0.353	0.324	0.283	0.297	0.349	0.324	0.339	0.292	0.276	0.285	0.314	0.281	0.255	0.231	0.293	0.264	0.280	0.280
C_7	0.253	0.277	0.271	0.286	0.268	0.272	0.196	0.279	0.258	0.273	0.238	0.230	0.227	0.252	0.226	0.209	0.188	0.240	0.208	0.218	0.220
C_8	0.307	0.327	0.322	0.340	0.315	0.322	0.277	0.283	0.305	0.329	0.283	0.268	0.280	0.310	0.286	0.259	0.231	0.286	0.253	0.267	0.267
C_9	0.325	0.347	0.342	0.364	0.344	0.347	0.292	0.350	0.278	0.353	0.306	0.289	0.295	0.320	0.290	0.259	0.233	0.305	0.278	0.289	0.292
C_{10}	0.312	0.337	0.328	0.348	0.332	0.337	0.287	0.340	0.319	0.290	0.305	0.288	0.294	0.319	0.282	0.247	0.231	0.302	0.269	0.279	0.281
C_{11}	0.285	0.311	0.302	0.319	0.303	0.309	0.259	0.305	0.292	0.323	0.230	0.262	0.264	0.296	0.257	0.229	0.208	0.278	0.248	0.255	0.255
C_{12}	0.246	0.263	0.249	0.264	0.243	0.256	0.222	0.261	0.249	0.269	0.238	0.183	0.233	0.255	0.207	0.185	0.171	0.229	0.219	0.218	0.221
C_{13}	0.304	0.324	0.311	0.328	0.308	0.318	0.275	0.318	0.305	0.326	0.286	0.271	0.228	0.299	0.251	0.223	0.208	0.276	0.265	0.258	0.259
C_{14}	0.273	0.300	0.287	0.305	0.286	0.288	0.249	0.302	0.281	0.297	0.258	0.246	0.252	0.240	0.263	0.241	0.219	0.279	0.245	0.248	0.246
C_{15}	0.281	0.294	0.294	0.306	0.284	0.299	0.245	0.313	0.277	0.296	0.258	0.234	0.240	0.284	0.218	0.252	0.230	0.281	0.233	0.250	0.244
C_{16}	0.242	0.258	0.259	0.272	0.250	0.266	0.218	0.279	0.244	0.262	0.227	0.210	0.213	0.255	0.245	0.172	0.200	0.247	0.211	0.222	0.218
C_{17}	0.215	0.227	0.225	0.237	0.216	0.229	0.191	0.238	0.212	0.225	0.199	0.182	0.189	0.217	0.208	0.188	0.137	0.215	0.192	0.196	0.194
C_{18}	0.306	0.320	0.313	0.329	0.312	0.316	0.268	0.325	0.302	0.318	0.282	0.263	0.269	0.305	0.282	0.244	0.227	0.245	0.263	0.283	0.283
C_{19}	0.244	0.271	0.264	0.278	0.261	0.256	0.219	0.263	0.248	0.263	0.233	0.215	0.230	0.249	0.226	0.201	0.181	0.237	0.182	0.228	0.224
C_{20}	0.246	0.271	0.263	0.280	0.262	0.256	0.218	0.263	0.244	0.262	0.233	0.212	0.222	0.240	0.227	0.198	0.184	0.231	0.224	0.188	0.244
C_{21}	0.216	0.233	0.230	0.241	0.223	0.228	0.192	0.230	0.215	0.234	0.206	0.185	0.202	0.224	0.202	0.177	0.162	0.214	0.207	0.212	0.167

Note: average gap = $\frac{1}{n(n-1)}\sum_{i=1}^{n}\sum_{j=1}^{n}\frac{\left|g_{ij}^{n}-g_{ij}^{n-1}\right|}{g_{ij}^{n}}\times 100\%$ = 2.95% < 5%, n denotes the samples of 10 experts and the consensus rate is 97.05%.

Therefore, this study builds the accreditation performance assessment model using DEMATEL technique, which is combined with the DANP (DEMATEL-based ANP) model to obtain the influential weights of each criterion, as shown in Table 4. Additionally, the critical criteria in accreditation performance assessment of University in Taiwan (a business school as example in accreditation performance assessment) are identified as “Job directors perceive satisfaction with graduates (C_{20}) ”, “Graduate jobs, salary and other achievements (C_{21})" and “Institution established an effective channel for tracking graduate performance (C_{19})”. Furthermore, the influential weights combine with the DEMATEL technique to assess the priority of problem-solving based on the performance gaps identified by VIKOR method and the influential relation map.

An empirical case involving University in Taiwan is used to evaluate the total accreditation performance using the VIKOR method, as listed in Table 5. The scores of each criterion and the total average gap (S_k) of University in Taiwan are obtained, using the relative influential weights from DANP to multiply the gap (r_{kj}). Consequently, this study obtains the total performance gap of University in Taiwan based on the scoring value. Additionally, the comprehensive/integrating indicator (R_k) can be obtained, which value of v can make decisions by the expert that is defined as $v=1$, $v=0.5$, and $v=0$ in this paper. This study obtains the result of the comprehensive/integrating indicators (R_k) as 0.313 (total average gap), 0.3814 (the majority of criteria), and 0.450 (maximal gap of priority improvement) representing that a business school as example in accreditation performance assessment (HEEACT) must improve the gap of accreditation performance. Furthermore, the ministry of education can find the problem-solving points according to the DEMATEL technique combined with DANP and VIKOR (called the hybrid MCDM model).

3.3 Discussions and Implications

This study adopted a new hybrid MCDM model using the DEMATEL technique combined with

Table 4: The sum of the effects, weights and rankings of each criterion.

Criteria	r_i	d_j	$r_i + d_j$	$r_i - d_j$	Degree of importance (Global weights)
D_1					**0.1930 (4)**
C_1	6.078	5.864	11.942	0.214	0.0454 (4)
C_2	6.141	6.339	12.480	-0.198	0.0491 (2)
C_3	6.228	6.180	12.408	0.048	0.0479 (3)
C_4	6.656	6.532	13.187	0.124	0.0506 (1)
D_2					**0.2043 (2)**
C_5	5.863	6.097	11.960	-0.234	0.0519 (3)
C_6	6.309	6.205	12.514	0.104	0.0528 (2)
C_7	5.087	5.322	10.409	-0.235	0.0452 (4)
C_8	6.116	6.400	12.516	-0.285	0.0544 (1)
D_3					**0.2035 (3)**
C_9	6.495	5.925	12.420	0.570	0.0353 (3)
C_{10}	6.326	6.335	12.661	-0.010	0.0377 (1)
C_{11}	5.785	5.505	11.290	0.280	0.0328 (4)
C_{12}	4.882	5.169	10.051	-0.287	0.0307 (6)
C_{13}	5.941	5.302	11.243	0.640	0.0316 (5)
C_{14}	5.604	5.939	11.543	-0.336	0.0354 (2)
D_4					**0.1906 (5)**
C_{15}	5.611	5.356	10.967	0.255	0.0508 (2)
C_{16}	4.968	4.776	9.744	0.192	0.0452 (3)
C_{17}	4.331	4.383	8.713	-0.052	0.0415 (4)
C_{18}	6.055	5.616	11.671	0.438	0.0531 (1)
D_5					**0.2086 (1)**
C_{19}	4.973	5.078	10.050	-0.105	0.0680 (3)
C_{20}	4.966	5.243	10.209	-0.277	0.0703 (1)
C_{21}	4.401	5.249	9.650	-0.848	0.0703 (1)

( ) denotes ranking

DANP (DEMATEL-based ANP) with VIKOR method to explore the improvement strategies of accreditation performance in the empirical case of a business school of University at Taiwan. Figure 1 shows valuable cues for making accurate decisions. The influential relation map demonstrate that the degrees of influence among dimensions and criteria. This study applies the most important and influential criteria as critical criteria to improve the maximal gap of accreditation performance. This list of critical criteria can provide a reference for Taiwanese ministry of education to develop the improving strategic to successfully improve institutional accreditation performance and increase competiveness of students.

The following recommendations are proposed to improve institutional accreditation performance of high education in Taiwan. This system structure model illustrates that University in Taiwan suffers

Table 5: The performance evaluation of the case study by VIKOR.

Dimensions / Criteria	Local weight	Global weight (by DANP)	Case study of Taiwan	
			Score	Gap (r_{kj})
D_1	**0.1930(4)**		**7.19**	**0.281**
C_1	0.2352	0.0454(4)	7.33	0.267
C_2	0.2544	0.0491(2)	7.33	0.267
C_3	0.2482	0.0479(3)	7.25	0.275
C_4	0.2622	0.0506(1)	6.83	0.317
D_2	**0.2043(2)**		**6.63**	**0.338**
C_5	0.2540	0.0519(3)	6.83	0.317
C_6	0.2584	0.0528(2)	7.17	0.283
C_7	0.2212	0.0452(4)	5.92	0.408
C_8	0.2663	0.0544(1)	6.58	0.342
D_3	**0.2035(3)**		**7.15**	**0.285**
C_9	0.1735	0.0353(3)	7.50	0.250
C_{10}	0.1853	0.0377(1)	7.42	0.258
C_{11}	0.1612	0.0328(4)	6.92	0.308
C_{12}	0.1509	0.0307(6)	6.33	0.367
C_{13}	0.1553	0.0316(5)	7.17	0.283
C_{14}	0.1740	0.0354(2)	7.58	0.242
D_4	**0.1906(5)**		**6.75**	**0.325**
C_{15}	0.2665	0.0508(2)	7.50	0.250
C_{16}	0.2371	0.0452(3)	6.67	0.333
C_{17}	0.2177	0.0415(4)	5.50	0.450
C_{18}	0.2786	0.0531(1)	7.33	0.267
D_5	**0.2086(1)**		**6.55**	**0.344**
C_{19}	0.3260	0.0680(3)	6.58	0.342
C_{20}	0.3370	0.0703(1)	6.75	0.325
C_{21}	0.3370	0.0703(1)	6.33	0.367
Total performances		-	**6.90**	-
Total gap (S_k)		-	-	**0.313**

significant gap in the “Graduate performance (D_5)" dimensions, making it necessary to pay attention to the “Settings goals and features and self-improvement (D_1)” , “Course design and teaching ((D_2)" , “Student learning and guidance (D_3)" , “Research and professional performance (D_4)" dimensions for improving accreditation performance of University in Taiwan.

Furthermore, for improving the settings goals and features and self-improvement (D_1) dimension, this study finds that the criterion of “Effectiveness of self-improvement system (C_4)" prioritizes improving the maximal performance gap. Figure 1 shows that the criteria of “Cognition of teachers and students regarding educational goals (C_1)" is the most important and influential criteria, and thus can be considered the critical criteria for improving effectiveness of self-improvement system. Thus, the criteria of “Cognition of teachers and students regarding educational goals (C_1)” can be considered the critical criterion for improving the settings goals and features, self-improvement.

For improving the course design and teaching (D_2) dimension, this study finds that the criterion of “Teachers teach student according to syllabus (C_7)" is the maximal performance gap. Furthermore, the criteria of “Teacher quality and quantity meet student learning and teaching needs (C_6)” is the most important and influential criteria, and thus can be considered the critical criteria for improving teachers according to syllabus to teach student. Thus, the criteria of “Teacher quality and quantity meet student learning and teaching needs (C_6)” can be considered the critical criterion for improving the course design and teaching.

For improving the student learning and guidance (D_3) dimension, this study finds that the criterion of “Teachers provide students with a fixed interview time (C_{12})” is the maximal performance gap. Furthermore, the criteria of “Teaching meets student learning needs (C_9) ” , “Institution provides student counselling, life coaching and career counselling etc. (C_{11})” and “Institution respond to student comments (C_{13}) ” is the most important and influential criteria, and thus can be considered the critical criteria for improving teachers provide students with a fixed interview time. Thus, the criteria of “Teaching meets student learning needs (C_9) ” , “Institution provides student counselling, life coaching and career counselling etc. (C_{11})” and “Institution respond to student comments (C_{13})” can be considered the critical criterion for improving the student learning and guidance.

For improving the research and professional performance (D_4) dimension, this study finds that the criterion of “Effectiveness of teachers participation in social services (C_{17}) ” is the maximal performance gap. Furthermore, the criteria of “Research results and professional performance of teachers (C_{15}) ” , “Teachers obtained research project grants (C_{16})” and “Performance of student learning outcomes (C_{18})” is the most important and influential criteria, and thus can be considered the critical criteria for improving the effectiveness of teachers to participate in social service. Thus, the criteria of “Research results and professional performance of teachers (C_{15})” , “Teachers obtained research project grants (C_{16})” and “Performance of student learning outcomes (C_{18})” can be considered the critical criterion for improving the research and professional performance.

4 CONCLUSIONS

This study can help decision-making to improve accreditation performance. Furthermore, this study uses the DEMATEL technique to develop cause-and-effect influential relationships, then, calculates the weight using DANP. Finally, this study uses VIKOR method to evaluate total and dimensional performances, thus contributing to subsequent research; for example, future studies should evaluate the effectiveness of implementing the improvement strategies of accreditation performance.

As noted above, this study can obtain valuable cues for making accurate decisions. The graduate’s performance dimensions exhibit a significant performance gap, and the “settings goals and features and self-improvement (D_1), course design and teaching (D_2), student learning and guidance (D_3), and research and professional performance (D_4) dimensions may need to be considered to improve accreditation performance. Furthermore, to improve the settings goals and features and self-improvement (D_1) dimension, this study finds the criterion of effectiveness of self-improvement system is the maximal performance gap. Therefore it is necessary to improve the priorities of the cause criteria, namely cognition of teachers and students regarding educational goals. To improve the course design and teaching (D_2) dimension, this study finds that the criterion of teachers according to syllabus to teach student exhibits the maximal performance gap. Furthermore, it is necessary to consider the need to improve quality and quantity of teacher meet student learning and teaching needs, to enhance course design and teaching. To improve the student learning and guidance (D_3) dimension, this study finds that the criterion of teachers provide students with a fixed interview time exhibits the maximal performance gap. Furthermore, it is necessary to consider the need to improve teaching meets student learning needs, institution provides student counselling, life coaching and career counselling etc. and institution respond to student comments. To improve the research and professional performance (D_4) dimension, this study finds that the criterion of the effectiveness of teachers participation in social services exhibits the maximal performance gap. Furthermore, it is necessary to consider the need to improve research results and professional performance of teachers, teachers obtained research project grants and performance of student learning outcomes.

Based on the above, the ministry of education should increase its prioritization of the cause criteria, allowing it to successfully improve accreditation performance to achieve the aspired/desired levels and increase competiveness of students.

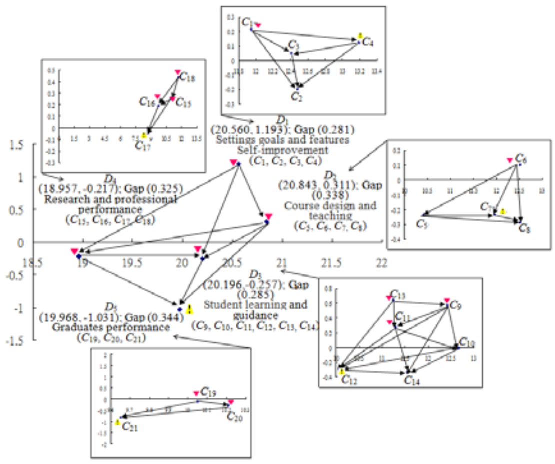

Figure 1: The influential relation map of each dimension and criteria.

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APPENDIX

A A HYBRID MCDM MODEL COMBINED WITH DEMATEL TECHNIQUE AND ANP

A.1 DEMATEL Technique

The DEMATEL technique is used to construct the interactions/interrelationship between criteria to build an influential relation map. The method is divided into three steps:

Step 1: Find the average influence matrix A

The first step is to calculate initial matrix, using pair of degree of interaction/interrelationship to obtain directly influence matrix $A=[a_{ij}]_{n\times n}$, where a_{ij} represents the degree of effect on *i* factor effects *j* factor (Lin and Tzeng, 2009); (Chen et al., 2010).

$$A=[a_{ij}]_{n\times n}=\frac{1}{H}\sum_{h=1}^{H}[a_{ij}^{h}]_{n\times n} \quad (1)$$

where *h* is the h^{th} expert and $h=1,2,...,H$.

Step 2: Calculate the normalized influence matrix $\boldsymbol{D}$

When the elements of *i* have a direct effect on the elements of *j*, then $a_{ij}\neq 0$, otherwise $a_{ij}=0$. The second step is to normalize the matrix. It can be obtained from Eq. (2) and (3). Its diagonal is 0, and maximum sum of row or column is 1.

$$\boldsymbol{D}=s\boldsymbol{A} \quad (2)$$

$$s=\min_{i,j}[1/\max_{1\le i\le n}\sum_{j=1}^{n}a_{ij},1/\max_{1\le j\le n}\sum_{i=1}^{n}a_{ij}] \quad i,j=1,2,...,n \quad (3)$$

Step 3: Compute the total influence matrix $\boldsymbol{T}$

The total-influence matrix $\boldsymbol{T}$ can be obtained through Eq. (4), in which $\boldsymbol{I}$ denotes the identity matrix.

$$\boldsymbol{T}=\boldsymbol{X}+\boldsymbol{X}^2+...+\boldsymbol{X}^g=\boldsymbol{X}(\boldsymbol{I}-\boldsymbol{X})^{-1} \quad \text{when } \lim_{g\to\infty}\boldsymbol{X}^g=[0]_{n\times n} \quad (4)$$

Explanation: $\boldsymbol{T}=\boldsymbol{X}+\boldsymbol{X}^2+\cdots+\boldsymbol{X}^g$
$=\boldsymbol{X}\left(\boldsymbol{I}+\boldsymbol{X}+\boldsymbol{X}^2+\cdots+\boldsymbol{X}^{h-1}\right)(\boldsymbol{I}-\boldsymbol{X})(\boldsymbol{I}-\boldsymbol{X})^{-1}$
$=\boldsymbol{X}(\boldsymbol{I}-\boldsymbol{X}^g)(\boldsymbol{I}-\boldsymbol{X})^{-1}$, then $T=\boldsymbol{X}(\boldsymbol{I}-\boldsymbol{X})^{-1}$, when $\lim_{g\to\infty}\boldsymbol{X}^g=[0]_{n\times n}$.

To sum of each row and column of the total effect matrix $\boldsymbol{T}=[t_{ij}]_{n\times n}$. Its will obtain the sum of all rows (vector $\boldsymbol{r}=\left[\sum_{j=1}^{n}t_{ij}\right]_{n\times 1}=[r_i]_{n\times 1}=(r_1,\ldots,r_i,\ldots,r_n)'$) and the sum of all columns (vector $\boldsymbol{d}=\left[\sum_{i=1}^{n}t_{ij}\right]_{n\times 1}=[d_j]_{n\times 1}$ $=(d_1,\ldots,d_j,\ldots,d_n)$). If r_i represents the sum of all rows of the total-influence matrix $\boldsymbol{T}$, meaning directly or/and indirectly affects to other criteria; d_j represents the sum of all columns of the total-influence matrix $\boldsymbol{T}$, meaning is affected by other criteria. r_i represents the factor which will affect other factors, d_j represents the factor that is affected by other factors. According to the definition, r_i+d_j presents the degree of relationship between the factors, meaning "prominence"; r_i-d_j presents the degree of effect and effected for the factors, meaning "relation" (Tzeng et al., 2007).

A.2 To find the Weights by DANP Model

DANP is divided into following steps:

Step 1: Develop the structure of the question

The questions are clearly described then break them down to level structure.

Step 2: Develop Unweighted Supermatrix

Firstly, each level with total degree of effect that obtains from the total-influence matrix $\boldsymbol{T}$ of DEMATEL as shown in Eq. (5).

$$\boldsymbol{T}_c=\begin{array}{c}D_1\;\begin{array}{c}c_{11}\\c_{12}\\\vdots\\c_{1m_1}\end{array}\\\vdots\\D_i\;\begin{array}{c}c_{i1}\\c_{i2}\\\vdots\\c_{im_i}\end{array}\\\vdots\\D_n\;\begin{array}{c}c_{n1}\\c_{n2}\\\vdots\\c_{nm_n}\end{array}\end{array}\overset{\begin{array}{ccccc}D_1 & & D_j & & D_n\\ c_{11}\ldots c_{1m_1} & \cdots & c_{j1}\ldots c_{jm_j} & \cdots & c_{n1}\ldots c_{nm_n}\end{array}}{\begin{bmatrix}\boldsymbol{T}_c^{11} & \cdots & \boldsymbol{T}_c^{1j} & \cdots & \boldsymbol{T}_c^{1n}\\ \vdots & & \vdots & & \vdots\\ \boldsymbol{T}_c^{i1} & \cdots & \boldsymbol{T}_c^{ij} & \cdots & \boldsymbol{T}_c^{in}\\ \vdots & & \vdots & & \vdots\\ \boldsymbol{T}_c^{n1} & \cdots & \boldsymbol{T}_c^{nj} & \cdots & \boldsymbol{T}_c^{nn}\end{bmatrix}} \tag{5}$$

Normalize $\boldsymbol{T}_c$ with total-influence will be obtained T_c^{α} that shows in Eq. (6).

$$\boldsymbol{T}_c^{\alpha}=\begin{array}{c}D_1\;\begin{array}{c}c_{11}\\c_{12}\\\vdots\\c_{1m_1}\end{array}\\\vdots\\D_i\;\begin{array}{c}c_{i1}\\c_{i2}\\\vdots\\c_{im_i}\end{array}\\\vdots\\D_n\;\begin{array}{c}c_{n1}\\c_{n2}\\\vdots\\c_{nm_n}\end{array}\end{array}\overset{\begin{array}{ccccc}D_1 & & D_j & & D_n\\ c_{11}\ldots c_{1m_1} & \cdots & c_{j1}\ldots c_{jm_j} & \cdots & c_{n1}\ldots c_{nm_n}\end{array}}{\begin{bmatrix}\boldsymbol{T}_c^{\alpha 11} & \cdots & \boldsymbol{T}_c^{\alpha 1j} & \cdots & \boldsymbol{T}_c^{\alpha 1n}\\ \vdots & & \vdots & & \vdots\\ \boldsymbol{T}_c^{\alpha i1} & \cdots & \boldsymbol{T}_c^{\alpha ij} & \cdots & \boldsymbol{T}_c^{\alpha in}\\ \vdots & & \vdots & & \vdots\\ \boldsymbol{T}_c^{\alpha n1} & \cdots & \boldsymbol{T}_c^{\alpha nj} & \cdots & \boldsymbol{T}_c^{\alpha nn}\end{bmatrix}} \tag{6}$$

Normalize $\boldsymbol{T}_c^{\alpha 11}$ will be obtained by Eqs. (7) and (8), according to the same fashion will be obtained $\boldsymbol{T}_c^{\alpha nn}$.

$$d_i^{11}=\sum_{j=1}^{m_1}t_{C\,ij}^{\;11},\; i=1,2,\ldots,m_1 \tag{7}$$

$$\boldsymbol{T}_c^{\alpha 11}=\begin{bmatrix}t_{c\,11}^{\,11}/d_1^{11} & \cdots & t_{c\,1j}^{\,11}/d_1^{11} & \cdots & t_{c\,1m_1}^{\,11}/d_1^{11}\\ \vdots & & \vdots & & \vdots\\ t_{c\,i1}^{\,11}/d_i^{11} & \cdots & t_{c\,ij}^{\,11}/d_i^{11} & \cdots & t_{c\,im_1}^{\,11}/d_i^{11}\\ \vdots & & \vdots & & \vdots\\ t_{c\,m_1 1}^{\,11}/d_{m_1}^{11} & \cdots & t_{c\,m_1 j}^{\,11}/d_{m_1}^{11} & \cdots & t_{c\,m_1 m_1}^{\,11}/d_{m_1}^{11}\end{bmatrix}$$
$$=\begin{bmatrix}t_{c\,11}^{\alpha 11} & \cdots & t_{c\,1j}^{\alpha 11} & \cdots & t_{c\,1m_1}^{\alpha 11}\\ \vdots & & \vdots & & \vdots\\ t_{c\,i1}^{\alpha 11} & \cdots & t_{c\,ij}^{\alpha 11} & \cdots & t_{c\,im_1}^{\alpha 11}\\ \vdots & & \vdots & & \vdots\\ t_{c\,m_1 1}^{\alpha 11} & \cdots & t_{c\,m_1 j}^{\alpha 11} & \cdots & t_{c\,m_1 m_1}^{\alpha 11}\end{bmatrix} \tag{8}$$

And then, total-influence matrix is normalized into Supermatrix according to the group in relying relationship to obtain Unweighted Supermatrix as show in Eq. (9).

$$\boldsymbol{W}=(\boldsymbol{T}_c^{\alpha})'=\begin{array}{c}D_1\;\begin{array}{c}c_{11}\\c_{12}\\\vdots\\c_{1m_1}\end{array}\\\vdots\\D_j\;\begin{array}{c}c_{j1}\\c_{j2}\\\vdots\\c_{jm_j}\end{array}\\\vdots\\D_n\;\begin{array}{c}c_{n1}\\c_{n2}\\\vdots\\c_{nm_n}\end{array}\end{array}\overset{\begin{array}{ccccc}D_1 & & D_i & & D_n\\ c_{11}\ldots c_{1m_1} & \cdots & c_{i1}\ldots c_{im_i} & \cdots & c_{n1}\ldots c_{nm_n}\end{array}}{\begin{bmatrix}\boldsymbol{W}^{11} & \cdots & \boldsymbol{W}^{i1} & \cdots & \boldsymbol{W}^{n1}\\ \vdots & & \vdots & & \vdots\\ \boldsymbol{W}^{1j} & \cdots & \boldsymbol{W}^{ij} & \cdots & \boldsymbol{W}^{nj}\\ \vdots & & \vdots & & \vdots\\ \boldsymbol{W}^{1n} & \cdots & \boldsymbol{W}^{in} & \cdots & \boldsymbol{W}^{nn}\end{bmatrix}} \tag{9}$$

In addition, we will be obtained matrix $\boldsymbol{W}^{11}$ and $\boldsymbol{W}^{12}$ by Eq. (10). If blank or 0 shown in the matrix means the group or criteria is independent, according to the same fashion will be obtained matrix $\boldsymbol{W}^{nn}$.

$$\boldsymbol{W}^{11}=(\boldsymbol{T}^{11})'=\begin{array}{c}c_{11}\\\vdots\\c_{1j}\\\vdots\\c_{1m_1}\end{array}\overset{\begin{array}{ccccc}c_{11} & \cdots & c_{1i} & \cdots & c_{1m_1}\end{array}}{\begin{bmatrix}t_{c11}^{\alpha 11} & \cdots & t_{ci1}^{\alpha 11} & \cdots & t_{cm_1 1}^{\alpha 11}\\ \vdots & & \vdots & & \vdots\\ t_{c1j}^{\alpha 11} & \cdots & t_{cij}^{\alpha 11} & \cdots & t_{cm_1 j}^{\alpha 11}\\ \vdots & & \vdots & & \vdots\\ t_{c1m_1}^{\alpha 11} & \cdots & t_{cim_1}^{\alpha 11} & \cdots & t_{cm_1 m_1}^{\alpha 11}\end{bmatrix}} \tag{10}$$

Step 3: Obtain Weight Supermatrix

Let each dimension of total-influence matrix $\boldsymbol{T}_D$ as (11) be normalized with total degree of influence to obtain $\boldsymbol{T}_D^{\alpha}$, the result as Eq. (12).

$$d_i = \sum_{j=1}^{n} t_D^{ij}\ ,\ i=1,2,...,n$$

$$\boldsymbol{T}_D = \begin{bmatrix} t_D^{11} & \cdots & t_D^{1j} & \cdots & t_D^{1n} \\ \vdots & & \vdots & & \vdots \\ t_D^{i1} & \cdots & t_D^{ij} & \cdots & t_D^{in} \\ \vdots & & \vdots & & \vdots \\ t_D^{n1} & \cdots & t_D^{nj} & \cdots & t_D^{nn} \end{bmatrix} \quad (11)$$

$$\boldsymbol{T}_D^{\alpha} = \begin{bmatrix} t_D^{11}/d_1 & \cdots & t_D^{1j}/d_1 & \cdots & t_D^{1n}/d_1 \\ \vdots & & \vdots & & \vdots \\ t_D^{i1}/d_2 & \cdots & t_D^{ij}/d_2 & \cdots & t_D^{in}/d_2 \\ \vdots & & \vdots & & \vdots \\ t_D^{n1}/d_n & \cdots & t_D^{nj}/d_n & \cdots & t_D^{nn}/d_n \end{bmatrix} = \begin{bmatrix} t_D^{\alpha 11} & \cdots & t_D^{\alpha 1j} & \cdots & t_D^{\alpha 1n} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha i1} & \cdots & t_D^{\alpha ij} & \cdots & t_D^{\alpha in} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha n1} & \cdots & t_D^{\alpha nj} & \cdots & t_D^{\alpha nn} \end{bmatrix} \quad (12)$$

Then, drive the normalized $\boldsymbol{T}_D^{\alpha}$ into Unweight Supermatrix $\boldsymbol{W}$ to obtain Weight Supermatrix $\boldsymbol{W}^{\alpha}$, the result as shown in Eq. (13).

$$\boldsymbol{W}^{\alpha} = \boldsymbol{T}_D^{\alpha} \times \boldsymbol{W} = \begin{bmatrix} t_D^{\alpha 11} \times \boldsymbol{W}^{11} & \cdots & t_D^{\alpha i1} \times \boldsymbol{W}^{i1} & \cdots & t_D^{\alpha n1} \times \boldsymbol{W}^{n1} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha 1j} \times \boldsymbol{W}^{1j} & \cdots & t_D^{\alpha ij} \times \boldsymbol{W}^{ij} & \cdots & t_D^{\alpha nj} \times \boldsymbol{W}^{nj} \\ \vdots & & \vdots & & \vdots \\ t_D^{\alpha 1n} \times \boldsymbol{W}^{1n} & \cdots & t_D^{\alpha in} \times \boldsymbol{W}^{in} & \cdots & t_D^{\alpha nn} \times \boldsymbol{W}^{nn} \end{bmatrix} \quad (13)$$

Step 4: Obtain limit supermatrix

According to the weighted spuermatrix $\boldsymbol{W}^{\alpha}$, it multiplies by itself multiple times to obtain limit supermatrix. Then, the ANP weights of each criterion can be obtained by $\lim_{z\to\infty}(\boldsymbol{W}^{\alpha})^z$, where z represents any number for power.

B EVALUATING THE TOTAL PERFORMANCE BY VIKOR

VIKOR can be divided into follow steps:

Step 1: Check the best value f_j^* and the worse value f_j^-

There f_j^* represents the positive-ideal point, that means the expert gives the scores of the best value (aspired levels) in each criterion and f_j^- represents the negative-ideal point, that means the expert gives the scores of the worst values in each criterion. We use Eqs. (14) and (15) to obtain the results.

$f_j^* = \max_k f_{kj}$, $j = 1, 2, \ldots, n$ (traditional approach)
or setting the aspired levels, vector $f^* = (f_1^*, f_2^*, \cdots, f_n^*)$ (14)

$f_j^- = \min_k f_{kj}$, $j = 1, 2, ..., n$ (traditional approach)
or setting the worst values, vector $f^- = (f_1^-, f_2^-, \cdots, f_n^-)$ (15)

Step 2: Calculate the mean of group utility S_k and maximal regret Q_k.

There S_k represents the ratios of distance to the positive-ideal, it means the synthesized gap for all criteria; w_j represents the influential weights of the criteria from DANP; r_{kj} represents the average gap-ratios (regret) of normalized distance to the aspired level point, and Q_k represents the maximal gap-ratios (regret) of normalized distance to the aspired level in all criteria, it means the maximal gap in j criteria for prior improvement. Those values can be computed respectively by Eqs. (16) and (17).

$$S_k = \sum_{j=1}^{n} w_j r_{kj} = \sum_{j=1}^{n} w_j \left(\left|f_j^* - f_{kj}\right|\right) \Big/ \left(\left|f_j^* - f_j^-\right|\right) \quad (16)$$

$$Q_k = \max_j \left\{ r_{kj} \middle| j = 1, 2, \ldots, n \right\} \quad (17)$$

Step 3: Obtain the comprehensive indicator R_k and sorting results.

The values can be computed respectively by Eq. (18).

$$R = v(S_k - S^*)/(S^- - S^*) + (1-v)(Q_k - Q^*)/(Q^- - Q^*) \quad (18)$$

Those values derived from $S^* = \min_k S_k$ or setting $S^* = 0$ (the aspired level), $S^- = \max_k S_k$ or setting $S^- = 1$ (the worst situation); $Q^* = \min_k Q_k$ or setting $Q^* = 0$ (the aspired level), and $Q^- = \max_k Q_k$ or setting $Q^- = 1$ (the worst situation). Therefore, when $S^* = 0$ and $S^- = 1$, and $Q^* = 0$ and $Q^- = 1$, we can re-write the Eq.(18) as $R_k = vS_k + (1-v)Q_k$. Weight $v = 1$ represents only to be consider the average gap (average regret) weight and weight $v = 0$ represents only to be consider the max gap to be prior improvement. It can provide the decision-makers by experts. Generally $v = 0.5$ (the majority of criteria), it could be adjusted depends on the situation.