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A novel assessment approach to EFQM driven institutionalization using integrated fuzzy multi-criteria decision-making methods

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Abstract. It is becoming increasingly difficult for enterprises to survive under competitive conditions. Enterprises with high levels of institutionalization are able to survive and reap more advantages than their competitors. Excellence models are widespread tools for measuring the degree of institutionalization of enterprises. In this study, European Foundation for Quality Management (EFQM) criteria are evaluated with fuzzy multi-criteria decision-making techniques. The fuzzy DEMATEL method is used to determine the interactions amongst the main EFQM criteria. According to the relationship diagram obtained from the Fuzzy DEMATEL method, the weights of the subcriteria are calculated according to the expert evaluations using fuzzy analytic network process method. The criterion "Business Results" has been determined to be the most important criterion. The weights of the criteria are taken as input for the VIKOR method. Then, the institutionalization levels of six institutions, previously evaluated by EFQM, are re-evaluated by the proposed approach. As a result, institutions A, B, E, and F achieve Excellence Award, while institutions C and D are assessed to deserve the 4-star competency certificate. The institutional scores obtained by the proposed method and the scores given by the EFQM evaluators are statistically analyzed to demonstrate that the proposed method has produced meaningful results.

1. Introduction

In today's competitive environment, enterprises must develop new planning and control mechanisms in order to survive, realize their goals, and use their limited resources in the most efficient ways. Enterprises seek new ways to evaluate their business performance and improve their strategic goals [1]. Enterprises can achieve success in a shorter amount of time when they more accurately and effectively assess performance results in terms of resources and energy. Enterprises should attempt to achieve sustainable growth and reach excellence [2]. They will succeed in excellence when they effectively evaluate their performance results.

Excellence allows companies to survive or thrive based on customer orientation, leadership, sustainable goals, processes, continuous improvement, mutually beneficial partnerships, and social responsibility concepts [3]. Many enterprises prefer excellence models to measure their excellence levels. The main aim of the models is to provide business excellence. The European

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Table 1. Illustration of related literature on EFQM.

Ref.	Method + EFQM	Aim of the study	Application Area	Year
[6]	Fuzzy AHP	Determining a new score of each indicator	Hotel industry	2017
[7]	Fuzzy DEMATEL	Assessing causal relationships of EFQM model criteria	Tovseeh Taavon Bank	2016
[8]	Fuzzy AHP	Identifying and ranking the factors affecting organizational agility	Isfahan University of Medical Sciences	2016
[9]	Fuzzy ANP + fuzzy TOPSIS + fuzzy ELECTRE	Improving projects of the EFQM	Calcimine company	2016
[10]	Fuzzy expert system	A new performance assessment system	Yazd Regional Electricity Co. in Iran	2016
[11]	Fuzzy logic + AHP + operations research	Determining improvement projects with high priority	Yazd Regional Electricity Co. in Iran	2015
[12]	TOPSIS	Assessing the organization's performance	An organization	2013
[13]	AHP	Evaluating the business performance excellence	Firms in different sectors in Turkey	2012
[14]	Fuzzy logic	A new assessment system	A mega car manufacturing firm	2011
[15]	Fuzzy MCDM	Best selection of areas for improvement	A mega car manufacturing firm	2011
[16]	Fuzzy logic	A new assessment system	—	2011

Foundation for Quality Management (EFQM) is used by approximately 70% of European enterprises to conduct self-assessments [4]. It measures the excellence levels of enterprises, identifies their strengths and weaknesses, and helps them to develop solutions to problems [5]. In older versions of EFQM, criteria weights were revised according to current conditions. Although these weights are determined using expert opinions, an analytical approach is not used when taking interactions among the criteria into account. In the proposed method, criteria weights are obtained by taking the effects of criteria on each other into consideration and using the group decision-making approach by acquiring the opinion of many experts. The aim of this study is to propose an approach that enables criteria weights to be obtained analytically by introducing a different perspective on the EFQM excellence model. Selected studies for examining EFQM, fuzzy logic, and multi-criteria decision-making methods are briefly described in Table 1.

The rest of the paper is organized as follows. Section 2 briefly describes institutionalization as a concept. Section 3 contains the technical background and implementation of the study. In Section 4, the validation of the proposed approach is expressed, while conclusions are provided in Section 5.

2. Institutionalization

The creation of an institutional culture via a consistent management philosophy in the long term plays an important role in institutionalization. An organizational structure should be innovative and sensitive to changes by placing importance on vision, mission, and

long-term strategic planning. Systemic continuity is necessary for the future of institutionalization [17]. Factors affecting institutionalization in general include effective leadership, highly trained employees, a strong information system, and the establishment of an organizational structure and culture [18]. The self-assessment process, crucial to businesses' ability to sustain their assets, enables enterprises to measure the level of institutionalization and evaluate and improve their corporate performance. Most studies in the literature focus on concepts that affect the level of institutionalization. Few studies have been conducted regarding the measurement of the level of institutionalization of enterprises [19]. Accordingly, Uygun et al. [20] proposed institutionalization criteria for Small- and Medium-sized Enterprises (SMEs) and evaluated the readiness assessment of several SMEs using Multi-Criteria Decision-Making (MCDM) methods. Today, there are several well-known excellence models used to measure institutionalization levels of enterprises. These models include the Deming Prize, Malcolm Baldrige Model, Canada Awards, Singapore Quality Award, and so on. In addition to these models, the EFQM model was developed by the European Foundation for Quality Management in 1991.

2.1. Excellence models

In today's competitive environment, enterprises require assessments from an objective perspective to improve their processes and level of institutionalization. There are three popular business excellence models used for determining the institutionalization level of organizations. The Deming model (since 1951), Baldrige criteria for performance excellence model (since 1987), and European Foundation for Quality Management Excellence Model (since 1991) evaluate organizations based on business excellence criteria to determine their institutionalization tendencies. Each criterion in an excellence model provides a standardized structure in which the performance of an organization can be measured. Such standardization allows for benchmarking and identification of the best performance. Enterprises entitled to receive one of these awards are highly valued in terms of prestige. The criteria and weights of Deming model include policy (10%), organization (10%), information (10%), standardization (10%), human resources (10%), quality assurance (10%), maintenance (10%), improvement (10%), effects (10%), and future plans (10%). The criteria weights of the Baldrige Model are leadership (10%), information and analysis (5%), strategic planning (10%), human resource focus (17%), process management (17%), business results and company performance (24%), and customer focus and satisfaction (17%). The EFQM excellence model has five input criteria and four output criteria, which are given in the next section.

The similarities and differences of three models are briefly described in Table 2.

2.2. EFQM excellence model

The EFQM excellence model was created in 1991 by the European Foundation for Quality Management (EFQM) as a tool for self-assessment. This model facilitates an objective and detailed organizational analysis for reaching the intended outcomes from the perspective of total quality management. It maintains a balance by associating different aspects of the organization. The EFQM excellence model not only deals with the issue of quality, but also provides important tools for establishing an effective management system that permeates each stage of management. EFQM is a large organization that brings together more than 400 members from different geographies of the world. The EFQM excellence model consists of 9 main criteria and 32 subcriteria. The main criteria and their weights are "leadership (C1-10%), strategy (C2-10%), people (C3-10%), partnerships and resources (C4-10%), and processes, products and services (C5-10%)" whose criteria constitute the "enablers", while "customer (C6-15%), people (C7-10%), society (C8-10%), and business results (C9-15%)" constitute the "Results" criteria [5]. The input criteria or enablers are concerned with how the organization performs its activities while the output criteria deal with organizational accomplishments.

The recognition levels of the organizations are determined according to their scores as 3-star (300+ points), 4-star (400+ points), and 5-star (500+ points). Organizations, receiving scores of 600 and over, have the "prize(s) winner" based on 8 fundamental concepts (adding value for customers, creating a sustainable future, developing organizational capability, harnessing creativity & innovation, leading with vision, inspiration & integrity, managing with agility, succeeding through the talent of people, and sustaining outstanding results). The best organization(s) in realizing these 8 fundamental concepts is entitled to be "award winner".

3. Methods and implementation

An integrated fuzzy DEMATEL, fuzzy ANP, and VIKOR methods are used in the proposed approach. The details and equations of the methods are not given here due to text restrictions, but related references are provided for readers who are interested in more details about the methods.

The DEMATEL method provides meaningful structural relationships between parameters in the solution of complex problems. The method is frequently used in solutions such as strategic analysis [22], performance evaluation [23], selection of alternatives [24], etc. Fuzzy DEMATEL method is developed for gathering group ideas and analyzing the cause and effect

Table 2. Similarities and differences of the excellence models [21].

Criteria	Deming model	Baldrige model	EFQM model
Leadership	Less influential than the other models	Explained by the concepts of organizational leadership and community responsibility	More influential than the other models
Strategic planning	Strategic approaches stated in policy criterion	Creation and dissemination of strategies	Creation and dissemination of strategies
Assessment and evaluation	Including the improvement and effects criteria of the model	One of the main criteria in the model. Measurement and analysis with an important place	Input and output criteria focus on performance results
Human resource management	Human resources criterion includes the use of statistical methods and the development of human resources	Human resources focus criterion including performance evaluation, recruitment, career development and working environment	Human resources planning, identification of competencies, and authorization concepts are included different from other models
Process oriented	Stated as process analysis, control and improvement concepts in quality assurance criterion	Stated in process management criterion and its importance clearly emphasized	One of the main criteria (5th) of the model and its importance is clearly emphasized
Continuous improvement	Having an important place in the model since improvement criterion is among the main criteria	Backed up by major improvements made every two years	Carried out by analyzing the self-assessment report provided by EFQM assessors and their feedbacks
Social responsibility	Stated in effect criteria about relations with companies and societies	Included in criteria of business results and social responsibilities subcriteria	One of the main criteria (8th) of the model
Focusing on output performance	Including impacts and future plans criteria	Stated in strategic planning criterion and its importance is clearly emphasized	Its importance indicated in strategy criterion
Geographical region	Japan, world-wide	North America	Europe

relationship of complex problems in fuzzy environments by Lin and Wu [25,26]. Their developed model is preferred for implementation in this study while obtaining interrelationships among the main EFQM criteria. The fuzzy ANP method will be based on these interrelationships. ANP is based on Analytic Hierarchy Process (AHP) and was developed by Saaty [27] to deal with the problems where interrelationships among the criteria were taken into consideration. There are many fuzzy AHP methods, developed in the literature, available for obtaining the supermatrix in the ANP method. Due to having relatively easier steps than the other developed methods, Chang's extent analysis method [28] is utilized in this study. The weight of each EFQM subcriterion is found analytically by fuzzy ANP method. More details on how to apply fuzzy ANP based on Chang's fuzzy AHP could be found in [20].

In the next step, the scores given to the enterprises by the experts in terms of 32 EFQM subcriteria and the weights of the criteria obtained from the fuzzy

ANP have been transferred to the VIKOR method. With this method, the institutionalization level of each organization is evaluated and, then, the organizations are ranked. VIKOR method was developed by Opricovic [29] that focused on the selection of the most appropriate alternative by ranking the alternatives among conflicting criteria. The details and the steps of VIKOR method are explained in [30].

The proposed approach and implementation steps are given in Figure 1. During the implementation of the integrated methods, linguistic expressions were transformed into triangular fuzzy numbers by consulting experts who are trained in EFQM, have participated in EFQM applications in their own enterprises, and also have the EFQM evaluator certificate.

In the first step, the effects of the main criteria on each other are evaluated using linguistic expressions by three experts. The experts assess criteria using five linguistic variables {No influence (No), Very Low influence (VL), Low influence (L), High influence (H), and Very High influence (VH)}.

Linguistic expressions of each expert are transformed into triangular fuzzy numbers as in Table 3. Then, the arithmetic mean values of the triangular fuzzy numbers are calculated to obtain the direct relation fuzzy matrix.

After that, the normalized direct relation fuzzy matrix is calculated and presented in Table 4. The normalized direct relation fuzzy matrix is transformed into the total relation fuzzy matrix, as shown in Table 5. Then, the fuzzy numbers are defuzzified using center of gravity method, as shown in Table 6, which gives the defuzzified total relation matrix. The threshold value was set to 0.3585 to determine the relationship between the criteria. The values above the threshold value are represented in bold in Table 6, describing the cause-and-effect relationship between the criteria.

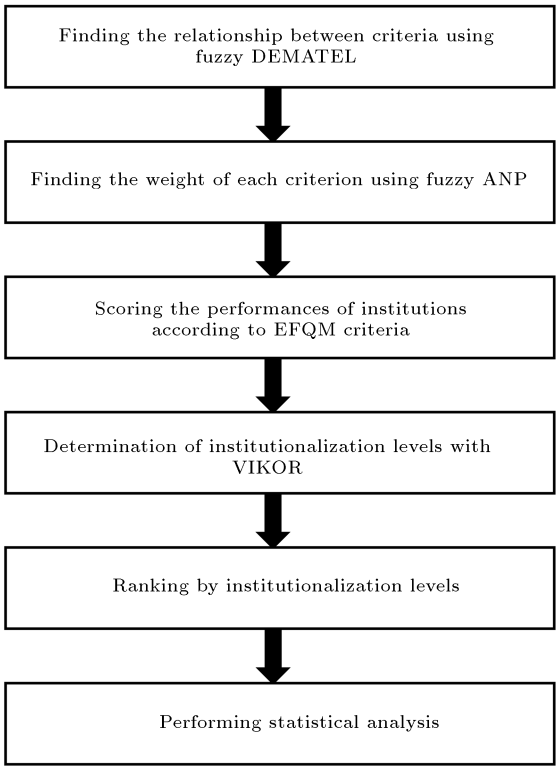

Figure 1. Steps of the proposed approach and implementation.

According to the interrelationships obtained from the fuzzy DEMATEL method, pairwise comparisons are made to calculate the weights of the sub-criteria of the EFQM excellence model using the fuzzy ANP method. Experts assess sub-criteria according to their importance by using fuzzy linguistic expressions. For example, since the strategy (C2) criterion affects the criterion of collaborations and resources (C4), the subcriteria of C4 are evaluated with regard to each subcriterion of C2. Experts use five linguistic variables Equally Important (EI), Moderately Important (MI), Important (I), Very Important (VI), and Absolutely Important (AI) for the evaluation. Linguistic variables and the corresponding fuzzy numbers for one of the experts are shown in Table 7, while the geometric averages from all experts, as well as calculated local weights according to ANP procedure, are presented in Table 8.

Similarly, the rest of the interrelationships obtained from fuzzy DEMATEL method are evaluated by the fuzzy ANP process in order to derive all the local weights, which are then put into the unweighted supermatrix. Table 9 gives the unweighted supermatrix in which the local weights given in Table 8 are presented in bold. Then, the weighted supermatrix is calculated by normalizing the unweighted supermatrix. After obtaining the weighted supermatrix, the limit supermatrix is calculated by taking the power of the weighted supermatrix until the values of each column are identical. As seen in Table 10, any column of the limit supermatrix shows the weights of the corresponding subcriteria.

The criteria weights are obtained by calculating the sum of the related subcriteria weights given in Table 10. As a result, the weights of the nine main criteria of the EFQM model are 5, 15, 10, 7, 15, 9, 10, 7, and 22%, respectively.

The weight of the business results (C9) criterion is much higher than those of the other criteria according to the results of the fuzzy ANP method. The leadership (C1) criterion has the least weight in percentage in the model, because experts consider that business results include leadership criteria while evaluating business results. On the other hand, the literature shows that leadership criteria can comprise other criteria [31].

The VIKOR method has been applied using

Table 3. Triangular fuzzy numbers corresponding to the linguistic evaluation of an expert.

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C1			C2			C3			C4			C5			C6			C7			C8			C9		
C1	0	VH	L	H	H	L	L	L	H	0.00	0.00	0.00	0.75	1.00	1.00	0.25	0.50	0.75	0.50	0.75	1.00	0.50	0.75	1.00	0.25	0.50	0.75	0.25	0.50	0.75	0.25	0.50	0.75	0.50	0.75	1.00
C2	VL	0	VL	H	VH	L	L	L	H	0.00	0.25	0.50	0.00	0.00	0.00	0.00	0.25	0.50	0.50	0.75	1.00	0.75	1.00	1.00	0.25	0.50	0.75	0.25	0.50	0.75	0.25	0.50	0.75	0.50	0.75	1.00
C3	VL	VL	0	VL	L	VL	VH	VL	VL	0.00	0.25	0.50	0.00	0.25	0.50	0.00	0.00	0.00	0.00	0.25	0.50	0.25	0.50	0.75	0.00	0.25	0.50	0.75	1.00	1.00	0.00	0.25	0.50	0.00	0.25	0.50
C4	H	H	L	0	L	H	L	L	H	0.50	0.75	1.00	0.50	0.75	1.00	0.25	0.50	0.75	0.00	0.00	0.00	0.25	0.50	0.75	0.50	0.75	1.00	0.25	0.50	0.75	0.25	0.50	0.75	0.50	0.75	1.00
C5	L	L	L	L	0	VH	L	L	H	0.25	0.50	0.75	0.25	0.50	0.75	0.25	0.50	0.75	0.25	0.50	0.75	0.00	0.00	0.00	0.75	1.00	1.00	0.25	0.50	0.75	0.25	0.50	0.75	0.50	0.75	1.00
C6	H	H	VL	H	H	0	No	No	L	0.50	0.75	1.00	0.50	0.75	1.00	0.00	0.25	0.50	0.50	0.75	1.00	0.50	0.75	1.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.25	0.25	0.50	0.75
C7	H	H	VH	L	L	No	0	No	L	0.50	0.75	1.00	0.50	0.75	1.00	0.75	1.00	1.00	0.25	0.50	0.75	0.25	0.50	0.75	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.50	0.75
C8	H	H	VL	H	VL	No	No	0	L	0.50	0.75	1.00	0.50	0.75	1.00	0.00	0.25	0.50	0.50	0.75	1.00	0.00	0.25	0.50	0.00	0.00	0.25	0.00	0.00	0.25	0.00	0.00	0.00	0.25	0.50	0.75
C9	VH	VH	L	H	H	L	L	L	0	0.75	1.00	1.00	0.75	1.00	1.00	0.25	0.50	0.75	0.50	0.75	1.00	0.50	0.75	1.00	0.25	0.50	0.75	0.25	0.50	0.75	0.25	0.50	0.75	0.00	0.00	0.00

Table 4. Normalized direct relation fuzzy matrix.

	C1			C2			C3			C4			C5			C6			C7			C8			C9		
C1	0.000	0.000	0.000	0.098	0.131	0.131	0.066	0.098	0.123	0.066	0.098	0.123	0.074	0.107	0.131	0.066	0.098	0.123	0.057	0.090	0.115	0.066	0.098	0.123	0.090	0.123	0.131
C2	0.033	0.066	0.098	0.000	0.000	0.000	0.049	0.082	0.115	0.057	0.090	0.123	0.090	0.123	0.131	0.057	0.090	0.123	0.057	0.090	0.123	0.049	0.082	0.115	0.090	0.123	0.131
C3	0.033	0.066	0.098	0.041	0.074	0.107	0.000	0.000	0.000	0.025	0.057	0.090	0.066	0.098	0.123	0.033	0.066	0.090	0.098	0.131	0.131	0.016	0.049	0.082	0.066	0.098	0.115
C4	0.033	0.066	0.098	0.057	0.090	0.123	0.033	0.066	0.098	0.000	0.000	0.000	0.049	0.082	0.115	0.057	0.090	0.123	0.025	0.057	0.090	0.057	0.090	0.123	0.074	0.107	0.131
C5	0.033	0.066	0.098	0.049	0.082	0.115	0.049	0.082	0.115	0.049	0.082	0.115	0.000	0.000	0.000	0.090	0.123	0.131	0.066	0.098	0.123	0.066	0.098	0.123	0.090	0.123	0.131
C6	0.049	0.082	0.115	0.066	0.098	0.131	0.025	0.057	0.090	0.041	0.074	0.107	0.074	0.107	0.131	0.000	0.000	0.000	0.008	0.025	0.057	0.016	0.033	0.066	0.074	0.107	0.123
C7	0.041	0.074	0.107	0.066	0.098	0.131	0.090	0.123	0.131	0.025	0.057	0.090	0.057	0.090	0.123	0.016	0.033	0.066	0.000	0.000	0.000	0.008	0.025	0.057	0.066	0.098	0.123
C8	0.033	0.066	0.098	0.049	0.082	0.115	0.008	0.041	0.074	0.041	0.074	0.107	0.041	0.074	0.107	0.016	0.033	0.066	0.000	0.016	0.049	0.000	0.000	0.000	0.057	0.090	0.115
C9	0.074	0.107	0.123	0.098	0.131	0.131	0.049	0.082	0.115	0.057	0.090	0.123	0.074	0.107	0.131	0.066	0.098	0.123	0.049	0.082	0.115	0.041	0.074	0.107	0.000	0.000	0.000

Table 5. Total direct-relation fuzzy matrix.

	C1			C2			C3			C4			C5			C6			C7			C8			C9		
C1	0.041	0.180	0.867	0.153	0.351	1.117	0.106	0.280	1.001	0.106	0.279	1.018	0.132	0.332	1.127	0.112	0.285	0.994	0.099	0.265	0.947	0.101	0.259	0.944	0.155	0.366	1.134
C2	0.066	0.223	0.923	0.052	0.209	0.963	0.084	0.246	0.960	0.091	0.251	0.983	0.136	0.319	1.088	0.097	0.258	0.959	0.091	0.245	0.921	0.080	0.227	0.904	0.143	0.338	1.095
C3	0.059	0.202	0.829	0.081	0.251	0.951	0.033	0.151	0.762	0.053	0.200	0.858	0.104	0.272	0.973	0.065	0.212	0.837	0.124	0.262	0.838	0.041	0.176	0.787	0.109	0.288	0.972
C4	0.060	0.203	0.879	0.097	0.265	1.021	0.060	0.209	0.900	0.030	0.148	0.827	0.089	0.259	1.023	0.088	0.235	0.915	0.053	0.194	0.850	0.081	0.215	0.869	0.117	0.296	1.043
C5	0.067	0.223	0.915	0.100	0.285	1.056	0.083	0.245	0.951	0.083	0.244	0.967	0.053	0.209	0.962	0.125	0.284	0.957	0.097	0.249	0.912	0.093	0.239	0.903	0.142	0.337	1.085
C6	0.073	0.208	0.838	0.103	0.261	0.965	0.053	0.193	0.839	0.069	0.208	0.867	0.110	0.269	0.974	0.035	0.147	0.753	0.038	0.160	0.773	0.044	0.159	0.772	0.116	0.284	0.973
C7	0.066	0.202	0.835	0.103	0.263	0.970	0.116	0.255	0.879	0.053	0.195	0.857	0.097	0.258	0.973	0.050	0.180	0.818	0.035	0.142	0.724	0.034	0.152	0.768	0.109	0.280	0.978
C8	0.050	0.169	0.747	0.076	0.216	0.863	0.028	0.152	0.745	0.061	0.183	0.787	0.068	0.209	0.864	0.041	0.152	0.735	0.020	0.127	0.690	0.020	0.104	0.636	0.087	0.236	0.876
C9	0.105	0.263	0.952	0.147	0.334	1.090	0.087	0.252	0.970	0.094	0.259	0.993	0.126	0.315	1.099	0.107	0.272	0.970	0.087	0.245	0.924	0.075	0.226	0.908	0.065	0.238	0.990

Table 6. Defuzzified total relation matrix.

	C1	C2	C3	C4	C5	C6	C7	C8	C9
C1	0.3170	**0.4933**	**0.4167**	**0.4207**	**0.4808**	**0.4190**	**0.3938**	**0.3910**	**0.5055**
C2	**0.3588**	0.3581	**0.3838**	**0.3941**	**0.4658**	**0.3929**	**0.3755**	**0.3594**	**0.4787**
C3	0.3230	**0.3834**	0.2743	0.3277	**0.4050**	0.3314	**0.3713**	0.2953	**0.4141**
C4	0.3359	**0.4122**	0.3444	0.2884	**0.4076**	**0.3685**	0.3228	0.3453	**0.4379**
C5	0.3570	**0.4313**	**0.3810**	**0.3846**	0.3583	**0.4122**	**0.3769**	**0.3682**	**0.4756**
C6	0.3315	**0.3975**	0.3192	0.3382	**0.4055**	0.2704	0.2828	0.2835	**0.4143**
C7	0.3265	**0.3998**	**0.3763**	0.3249	**0.3964**	0.3069	0.2606	0.2764	**0.4118**
C8	0.2839	0.3426	0.2695	0.3034	0.3372	0.2700	0.2410	0.2161	**0.3586**
C9	**0.3958**	**0.4761**	**0.3904**	**0.4011**	**0.4637**	**0.4051**	**0.3749**	**0.3588**	**0.3827**

Table 7. Pairwise comparison matrix showing that an expert evaluates sub-criteria of C4 according to C2a.

	Linguistic variables						**Corresponding fuzzy numbers**														
	4a	**4b**	**4c**	**4d**	**4e**		**4a**			**4b**			**4c**			**4d**			**4e**		
4a	EI	VI	VI	I	VI	**4a**	1	1	1	5	7	9	5	7	9	3	5	7	5	7	9
4b		EI	MI	EI		**4b**	1/9	1/7	1/5	1	1	1	1	3	5	1	1	1	1/5	1/3	1
4c			EI			**4c**	1/9	1/7	1/5	1/5	1/3	1	1	1	1	1/5	1/3	1	1/5	1/3	1
4d			MI	EI		**4d**	1/7	1/5	1/3	1	1	1	1	3	5	1	1	1	1/5	1/3	1
4e		MI	MI	MI	EI	**4e**	1/9	1/7	1/5	1	3	5	1	3	5	1	3	5	1	1	1

Table 8. Geometric averages and calculated weights of sub-criteria of C4 according to C2a.

	4a				**4b**			**4c**			**4d**			**4e**			**Wi**
4a	1.00	1.00	1.00	1.00	1.53	3.00	3.87	5.92	7.94	3.00	5.00	7.00	1.00	1.53	3.00	**0.38**
4b	0.33	0.65	1.00	1.00	1.00	1.00	1.73	3.87	5.92	1.73	2.24	2.65	0.20	0.33	1.00	**0.24**
4c	0.13	0.17	0.26	0.17	0.26	0.58	1.00	1.00	1.00	0.45	0.58	1.00	0.17	0.26	0.58	**0.00**
4d	0.14	0.20	0.33	0.38	0.45	0.58	1.00	1.73	2.24	1.00	1.00	1.00	0.17	0.26	0.58	**0.03**
4e	0.33	0.65	1.00	1.00	3.00	5.00	1.73	3.87	5.92	1.73	3.87	5.92	1.00	1.00	1.00	**0.34**

both newly calculated subcriteria weights and original weights of the EFQM model to evaluate the levels of institutionalization of six public institutions. Ranking results are compared for both different subcriteria weights. Institutions are scored in the range of 0-100 for each criterion by experts. In Table 11, these scores and their maximum and minimum values are presented. For each institution, mean of group benefit, maximum regret, and index value are calculated. The alternatives are ranked in Table 12 according to the proposed approach and EFQM criteria weights. By examining Condition 1 (acceptable advantage) and Condition 2 (acceptable stability in decision making) in the VIKOR method, it is determined that the institutions F, A, and B are similar according to Condition 1. Institutions A and B are alternatives to institution F in the ranking.

4. Validation of the proposed approach

Statistical analysis of criteria weights of EFQM model and the criteria weights obtained as a result of implementation has been conducted with a paired sample t-Test in SPSS Software. The paired sample t-Test includes dependent tests between two dependent groups. Dependent groups are related to each other. The criteria weights obtained from the implementation result and the criteria weights of the EFQM model and the results of the evaluation of the six institutions are analyzed by paired sample t-Test. As a result of the analysis, there are no statistically significant differences between these two groups. The H0 hypothesis is: "there is no statistically significant difference between the results of the institutions evaluated by the criteria weights of the EFQM model and the criteria weights

Table 9. Unweighted supermatrix.

	C1a	C1b	C1c	C1d	C1e	C2a	C2b	C2c	C2d	C3a	C3b	C3c	C3d	C3e	C4a	C4b	C4c	C4d	C4e	C5a	C5b	C5c	C5d	C5e	C6a	C6b	C7a	C7b	C8a	C8b	C9a	C9b
C1a	0.000	0.000	0.000	0.000	0.000	0.231	0.124	0.293	0.387	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.417	0.000
C1b	0.000	0.000	0.000	0.000	0.000	0.000	0.413	0.270	0.278	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.146	0.715
C1c	0.000	0.000	0.000	0.000	0.000	0.414	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.046	0.097
C1d	0.000	0.000	0.000	0.000	0.000	0.106	0.255	0.170	0.125	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.084	0.097
C1e	0.000	0.000	0.000	0.000	0.000	0.249	0.208	0.267	0.211	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.306	0.091
C2a	0.780	0.000	0.830	0.088	0.253	0.000	0.000	0.000	0.000	0.489	0.000	0.017	0.390	0.227	0.846	0.299	0.035	0.035	0.021	0.922	1.000	0.400	0.975	1.000	1.000	0.274	0.306	0.000	0.000	0.000	0.442	0.011
C2b	0.155	0.000	0.000	0.341	0.284	0.000	0.000	0.000	0.000	0.511	1.000	0.655	0.000	0.375	0.000	0.026	0.247	0.247	0.462	0.000	0.000	0.160	0.000	0.000	0.000	0.223	0.694	0.446	0.000	0.000	0.071	0.610
C2c	0.065	0.620	0.113	0.224	0.261	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.215	0.154	0.349	0.414	0.414	0.295	0.078	0.000	0.272	0.025	0.000	0.000	0.209	0.000	0.277	0.000	0.000	0.243	0.189
C2d	0.000	0.380	0.056	0.348	0.202	0.000	0.000	0.000	0.000	0.000	0.000	0.328	0.610	0.183	0.000	0.326	0.304	0.304	0.222	0.000	0.000	0.169	0.000	0.000	0.000	0.293	0.000	0.277	0.000	0.000	0.243	0.189
C3a	0.223	0.286	0.304	0.087	0.081	0.317	0.274	0.736	0.488	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.332	0.254	0.237	0.215	0.335	0.000	0.000	0.000	0.000	0.000	0.000	0.377	0.135
C3b	0.245	0.279	0.311	0.371	0.389	0.303	0.316	0.264	0.226	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.326	0.297	0.323	0.366	0.311	0.000	0.000	0.413	0.518	0.000	0.000	0.192	0.338
C3c	0.259	0.226	0.258	0.323	0.303	0.164	0.263	0.000	0.094	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.240	0.259	0.246	0.299	0.223	0.000	0.000	0.294	0.375	0.000	0.000	0.289	0.312
C3d	0.055	0.053	0.000	0.000	0.046	0.077	0.033	0.000	0.173	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.056	0.097	0.074	0.033	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
C3e	0.218	0.156	0.127	0.219	0.181	0.139	0.114	0.000	0.019	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.101	0.133	0.097	0.046	0.097	0.000	0.000	0.293	0.107	0.000	0.000	0.141	0.215
C4a	0.237	0.042	0.519	0.061	0.221	**0.381**	0.000	0.169	0.136	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.348	0.261	0.300	0.300	0.257	0.000	0.000	0.000	0.000	0.000	0.000	0.371	0.306
C4b	0.288	0.316	0.244	0.172	0.251	**0.244**	0.273	0.071	0.160	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.111	0.218	0.186	0.186	0.177	0.000	0.000	0.000	0.000	0.000	0.000	0.132	0.108
C4c	0.020	0.039	0.000	0.000	0.034	**0.000**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.024
C4d	0.167	0.290	0.098	0.132	0.219	**0.030**	0.073	0.219	0.187	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.235	0.227	0.228	0.228	0.251	0.000	0.000	0.000	0.000	0.000	0.000	0.219	0.210
C4e	0.288	0.313	0.139	0.636	0.275	**0.345**	0.654	0.541	0.517	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.306	0.295	0.286	0.286	0.315	0.000	0.000	0.000	0.000	0.000	0.000	0.279	0.353
C5a	0.432	0.542	0.530	0.355	0.383	0.691	0.430	0.510	0.310	0.729	0.729	0.438	0.438	0.438	0.701	0.541	0.435	0.507	0.417	0.000	0.000	0.000	0.000	0.000	0.169	0.000	1.000	1.000	0.000	0.000	0.435	0.311
C5b	0.317	0.231	0.348	0.266	0.353	0.309	0.329	0.232	0.206	0.206	0.206	0.245	0.245	0.245	0.096	0.271	0.346	0.303	0.309	0.000	0.000	0.000	0.000	0.000	0.292	0.323	0.000	0.000	0.000	0.000	0.198	0.236
C5c	0.011	0.000	0.000	0.082	0.000	0.000	0.044	0.029	0.103	0.000	0.000	0.103	0.103	0.103	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.270	0.000	0.000	0.000	0.000	0.054	0.000
C5d	0.023	0.061	0.000	0.082	0.114	0.000	0.043	0.114	0.232	0.000	0.000	0.049	0.049	0.049	0.183	0.088	0.172	0.145	0.130	0.000	0.000	0.000	0.000	0.000	0.203	0.394	0.000	0.000	0.000	0.000	0.313	0.283
C5e	0.218	0.166	0.122	0.215	0.149	0.000	0.154	0.114	0.149	0.065	0.065	0.165	0.165	0.165	0.020	0.101	0.047	0.046	0.143	0.000	0.000	0.000	0.000	0.000	0.337	0.013	0.000	0.000	0.000	0.000	0.000	0.170
C6a	1.000	0.000	1.000	1.000	0.569	0.569	0.110	0.565	0.565	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.298	0.000	0.110	0.000	0.431	0.431	0.431	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.110
C6b	0.000	1.000	0.000	0.000	0.431	0.431	0.890	0.435	0.435	0.000	0.000	0.000	0.000	0.000	1.000	1.000	0.702	1.000	0.890	1.000	0.569	0.569	0.569	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.890
C7a	1.000	0.000	1.000	1.000	0.641	1.000	0.565	0.500	0.890	0.641	0.000	0.890	1.000	1.000	0.000	0.000	0.000	0.000	0.000	0.298	0.298	0.300	0.300	0.300	0.000	0.000	0.000	0.000	0.000	0.000	0.435	0.110
C7b	0.000	1.000	0.000	0.000	0.359	0.000	0.435	0.500	0.110	0.359	1.000	0.110	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.702	0.702	0.700	0.700	0.700	0.000	0.000	0.000	0.000	0.000	0.000	0.565	0.890
C8a	1.000	0.000	0.431	0.000	0.000	0.569	0.110	0.359	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.565	0.702	0.435	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.435	0.110
C8b	0.000	1.000	0.569	1.000	1.000	0.431	0.890	0.641	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.435	0.298	0.565	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.565	0.890
C9a	1.000	0.500	0.000	0.500	0.500	0.500	0.500	0.500	0.500	1.000	0.298	0.702	0.500	0.298	1.000	0.435	0.000	0.500	0.700	1.000	1.000	0.000	0.298	0.000	0.702	0.000	0.500	0.000	0.702	0.298	0.000	0.000
C9b	0.000	0.500	1.000	0.500	0.500	0.500	0.500	0.500	0.500	0.000	0.702	0.298	0.500	0.702	0.000	0.565	1.000	0.500	0.300	0.000	0.00	0	1.000	0.702	1.000	0.298	1.000	0.500	1.000	0.298	0.702	0.000	0.000

Table 10. Limit supermatrix.

	C1a	C1b	C1c	C1d	C1e	C2a	C2b	C2c	C2d	C3a	C3b	C3c	C3d	C3e	C4a	C4b	C4c	C4d	C4e	C5a	C5b	C5c	C5d	C5e	C6a	C6b	C7a	C7b	C8a	C8b	C9a	C9b
C1a	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
C1b	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017
C1c	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005
C1d	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006
C1e	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010
C2a	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	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
C2b	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.051
C2c	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
C2d	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
C3a	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022
C3b	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
C3c	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026	0.026
C3d	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
C3e	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
C4a	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020	0.020
C4b	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
C4c	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
C4d	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014
C4e	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027
C5a	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072
C5b	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
C5c	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009
C5d	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024	0.024
C5e	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012
C6a	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019
C6b	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.073
C7a	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
C7b	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	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
C8a	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031	0.031
C8b	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	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
C9a	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100	0.100
C9b	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118	0.118

Table 11. Evaluation scores of enterprises according to sub-criteria.

	A	B	C	D	E	F	f_j^*	f_j^-
C1a	60	75	50	45	60	65	75	45
C1b	65	75	55	40	55	65	75	40
C1c	65	65	50	35	60	68	68	35
C1d	65	65	40	30	60	54	65	30
C1e	65	65	40	30	55	65	65	30
C2a	60	65	55	35	60	69	69	35
C2b	65	65	55	30	50	61	65	30
C2c	65	65	55	40	55	66	66	40
C2d	60	65	55	45	60	56	65	45
C3a	60	65	50	35	60	60	65	35
C3b	55	65	45	30	55	53	65	30
C3c	60	55	55	35	60	60	60	35
C3d	60	55	55	30	55	66	66	30
C3e	65	65	50	20	55	66	66	20
C4a	70	65	50	30	60	73	73	30
C4b	70	55	50	35	55	60	70	35
C4c	65	55	50	35	55	56	65	35
C4d	60	65	45	35	55	71	71	35
C4e	65	65	40	35	55	66	66	35
C5a	70	65	50	40	60	58	70	40
C5b	65	65	60	40	55	68	68	40
C5c	60	65	40	35	55	66	66	35
C5d	70	55	55	40	55	60	70	40
C5e	70	65	50	40	55	60	70	40
C6a	60	65	45	50	65	71	71	45
C6b	60	65	45	45	65	59	65	45
C7a	60	55	45	50	65	68	68	45
C7b	55	45	45	55	65	60	65	45
C8a	45	55	45	50	60	56	60	45
C8b	50	55	40	55	60	56	60	40
C9a	60	65	45	50	55	69	69	45
C9b	65	65	45	50	70	68	70	45

obtained as a result of the implementation". The H1 hypothesis is: "there is a statistically significant difference between the results of the institutions evaluated by the criteria weights of the EFQM model and the criteria weights obtained as a result of the implementation". According to both results at a 95% confidence level and a 99% confidence level, the test statistic value and the test significance are 1.24667 and 0.601, respectively. The H0 hypothesis is accepted because the significance value is greater than 0.001 for both confidence levels. It is concluded that there are no statistically significant differences between the results of the evaluation of the six institutions using the criteria weights of the EFQM model and the criteria weights obtained from the proposed implementation approach.

5. Results and discussions

In this study, the main criteria weights of the existing EFQM are analytically calculated via integrated MCDM methods. When the calculated weights are taken into consideration, weights of some criteria have decreased, namely leadership (from 10% to 5%), partnership and resources (from 10% to 7%), customer (from 15% to 9%), and society (from 10% to 7%). On the other hand, weights of some criteria have increased, namely strategy (from 10% to 15%), processes, products and services (from 10% to 15%), and business results (from 15% to 22%). Furthermore, the weights of people (10%) and people results (10%) criteria have not changed. Business Results, including key performance outcomes and indicators, have become the most essential criteria based on the proposed method. Consequently, the statistical validation process confirmed that determining criteria weights by fuzzy integrated MCDM methods showed no significant difference between the total scores of 6 public institutions calculated by the EFQM and the proposed model. Thus, the proposed approach could be used for evaluating the institutions during a real assessment process as an alternative to the original EFQM.

The excellence levels of institutions A, B, C, D, E, and F have been calculated according to EFQM's criterion weights of the proposed approach in Table 13. When enterprises' excellence level scores are compared, institutions A, B, E, and F deserve to receive the excellence award by getting 501 points and above. Institu-

Table 12. Comparison of the ranking alternatives according to the proposed approach and EFQM.

		S_i	Ranking	R_i	Ranking	Q_i	Ranking
Proposed approach		0.147	F	0.029	F	0	F
		0.200	B	0.053	A	0.110	A
		0.238	A	0.037	B	0.173	B
		0.244	E	0.058	E	0.232	E
		0.746	C	0.118	D	0.867	D
		0.874	D	0.094	C	0.912	C
EFQM		0.123	F	0.0133	F	0	F
		0.209	B	0.0424	B	0.204	B
		0.249	E	0.0438	E	0.238	E
		0.272	A	0.0500	A	0.285	A
		0.769	C	0.1125	D	0.891	D
		0.865	D	0.0909	C	0.936	C

Table 13. Organizational excellence levels according to the EFQM criteria and the proposed approach.

		A	B	C	D	E	F
EFQM	**C1a**	12.00	15.00	10.00	9.00	12.00	13.00
	C1b	13.00	15.00	11.00	8.00	11.00	13.00
	C1c	13.00	13.00	10.00	7.00	12.00	13.60
	C1d	13.00	13.00	8.00	6.00	12.00	10.80
	C1e	13.00	13.00	8.00	6.00	11.00	13.00
	C2a	15.00	16.25	13.75	8.75	15.00	17.25
	C2b	16.25	16.25	13.75	7.50	12.50	15.25
	C2c	16.25	16.25	13.75	10.00	13.75	16.50
	C2d	15.00	16.25	13.75	11.25	15.00	14.00
	C3a	12.00	13.00	10.00	7.00	12.00	12.00
	C3b	11.00	13.00	9.00	6.00	11.00	10.60
	C3c	12.00	11.00	11.00	7.00	12.00	12.00
	C3d	12.00	11.00	11.00	6.00	11.00	13.20
	C3e	13.00	13.00	10.00	4.00	11.00	13.20
	C4a	14.00	13.00	10.00	6.00	12.00	14.60
	C4b	14.00	11.00	10.00	7.00	11.00	12.00
	C4c	13.00	11.00	10.00	7.00	11.00	11.20
	C4d	12.00	13.00	9.00	7.00	11.00	14.20
	C4e	13.00	13.00	8.00	7.00	11.00	13.20
	C5a	14.00	13.00	10.00	8.00	12.00	11.60
	C5b	13.00	13.00	12.00	8.00	11.00	13.60
	C5c	12.00	13.00	8.00	7.00	11.00	13.20
	C5d	14.00	11.00	11.00	8.00	11.00	12.00
	C5e	14.00	13.00	10.00	8.00	11.00	12.00
	C6a	67.50	73.13	50.63	56.25	73.125	79.875
	C6b	22.50	24.38	16.88	16.88	24.375	22.125
	C7a	45.00	41.25	33.75	37.50	48.75	51.00
	C7b	13.75	11.25	11.25	13.75	16.25	15.00
	C8a	22.50	27.50	22.50	25.00	30.00	28.00
	C8b	25.00	27.50	20.00	27.50	30.00	28.00
	C9a	45.00	48.75	33.75	37.50	41.25	51.75
	C9b	48.75	48.75	33.75	37.50	52.50	51.00
	Total	**609.50**	**621.50**	**473.50**	**428.38**	**599.50**	**641.75**
Proposed approach	**C1a**	5.76	7.20	4.80	4.32	5.76	6.24
	C1b	10.80	12.47	9.14	6.65	9.14	10.80
	C1c	3.08	3.08	2.37	1.66	2.84	3.22
	C1d	3.69	3.69	2.27	1.70	3.41	3.07
	C1e	6.23	6.23	3.83	2.88	5.27	6.23
	C2a	31.74	34.38	29.09	18.51	31.74	36.50
	C2b	32.95	32.95	27.88	15.21	25.35	30.92
	C2c	15.46	15.46	13.08	9.52	13.08	15.70
	C2d	14.91	16.15	13.67	11.18	14.91	13.92
	C3a	13.00	14.08	10.83	7.58	13.00	13.00
	C3b	18.20	21.51	14.89	9.93	18.20	17.54
	C3c	15.86	14.54	14.54	9.25	15.86	15.86
	C3d	1.31	1.20	1.20	0.65	1.20	1.44
	C3e	9.41	9.41	7.24	2.90	7.96	9.55
	C4a	14.16	13.15	10.11	6.07	12.14	14.77
	C4b	8.53	6.70	6.09	4.26	6.70	7.31
	C4c	0.33	0.28	0.25	0.18	0.28	0.28
	C4d	8.35	9.04	6.26	4.87	7.65	9.88
	C4e	17.27	17.27	10.63	9.30	14.62	17.54
	C5a	50.73	47.10	36.23	28.99	43.48	42.03
	C5b	21.23	21.23	19.60	13.07	17.97	22.21
	C5c	5.45	5.90	3.63	3.18	5.00	5.99
	C5d	16.57	13.02	13.02	9.47	13.02	14.20
	C5e	8.37	7.77	5.98	4.78	6.58	7.18
	C6a	11.51	12.47	8.63	9.59	12.47	13.62
	C6b	43.54	47.16	32.65	32.65	47.16	42.81
	C7a	26.80	24.57	20.10	22.34	29.04	30.38
	C7b	29.25	23.93	23.93	29.25	34.57	31.91
	C8a	14.00	17.11	14.00	15.55	18.66	17.42
	C8b	21.15	23.26	16.92	23.26	25.38	23.68
	C9a	59.94	64.93	44.95	49.95	54.94	68.93
	C9b	76.42	76.42	52.91	58.79	82.30	79.95
	Total	**615.99**	**623.68**	**480.74**	**427.47**	**599.66**	**634.07**

tions C and D are entitled to receive the 4-Star Competency Certificate by scoring 401 points and above.

6. Conclusion

The literature clearly demonstrates that institutionalization is vital both in terms of achieving success and providing sustainability. The most important feature that distinguishes enterprises is their institutionalization level. A case study of six public organizations was investigated using the criteria of the EFQM excellence model. The fuzzy DEMATEL method was used to determine the interactions amongst the main criteria in the developed approach. Thus, relations amongst the criteria were determined via expert opinions. The criteria relations obtained by the Fuzzy DEMATEL method provided input to the Fuzzy ANP method. The most important criteria and weights for institutions to be considered institutionalized were determined. The business results criterion was thus considered the most important factor in institutionalization. The institutionalization levels of the 6 public institutions were ranked, and the levels of excellence were evaluated by means of VIKOR method. According to the developed and EFQM model, it was determined that institution F was the best institution. Institutions A and B may be considered alternatives to Institution F. The proposed approach was compared with the weights of the EFQM model, showing that there were no statistical differences between the EFQM weights and the criteria weights obtained as a result of implementation. Consequently, thanks to the proposed model, six public institutions were assessed and, then, the results were validated via comparison with the EFQM model.

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