Available online at www.qu.edu.iq/journalcm
JOURNAL OF AL-QADISIYAH FOR COMPUTER SCIENCE AND MATHEMATICS
ISSN:2521-3504(online) ISSN:2074-0204(print)

The application of fuzzy Logic in improving the Performance of the European Foundation for Quality Management(EFQM)

Miami Hamid Khalif [a], Kareem Radi Hassan[b]

[a b]University of Al Basra, Al Basra, Iraq, College of Computer Science and Information
[a] Email: itpq.miami.kleef@uobasrah.edu.iq,
[b] Email: karemradi@gmail.com.

ARTICLE INFO

Article history:
Received: 02 /08/2022
Rrevised form:27 /08/2022
Accepted : 31 /08/2022
Available online: 24 /09/2022

Keywords:

RADAR, EFQM, Fuzzy Logic

ABSTRACT

In today's tumultuous and competitive business environment, executives are more motivated than ever to demonstrate their teams' mettle by stellar results. The European Foundation for Quality Management (EFQM) has developed and verified the Excellence Model (EFQM) as the gold standard for measuring an organization's pursuit of excellence. An updated integrated strategy that incorporates fuzzy logic into the EFQM model is a powerful tool for boosting an organization's overall performance. This research utilizes the EFQM paradigm to suggest a novel and all-encompassing strategy for enhancing corporate performance. We looked at the specific situation of the Iraqi Oil Tanker Company to determine how doable the strategy actually is. With the use of the EFQM framework developed by the European Foundation for Quality Management, we have shown how useful this tool is for pinpointing both strengths and places for development. The RADAR Logical Method and Fuzzy-Based Strategy were utilized in this case study (EFQM). Matlab was used to apply the suggested technique for assessing the performance of the Iraqi Oil Tankers Company during a three-year period.

MSC..

https://doi.org/10.29304/jqcm.2022.14.3.1025

1. INTRODUCTION

Due to rapid breakthroughs in scientific-technical domains and continual economic-social difficulties, numerous companies may be found in today's competitive world. To generate goods and services of the highest possible quality, they are flexible, pure, and customer-oriented, leveraging current and new resources. By developing an efficient and consistent approach for evaluating their functions, companies can better understand the areas they can improve and compare them to their competitors. Then they'll be able to prioritize their tasks and keep an eye out for spots that can be recovered. As a result, they will be able to gradually elevate their position to one of transcendence within the business[1].

Many companies have implemented alternative quality management systems to achieve excellence and competitiveness. A consistent set of evaluation criteria is used in most of these approaches to evaluate an organization's Performance. The European Quality Award is one of the most well-known quality award systems (EQA), with awards such as Japan's Deming Prize and the Malcolm Baldrige National Quality Award [2]. A model of

∗Corresponding author

Email addresses:

Communicated by 'sub etitor'

European excellence developed by the European Foundation for Quality Management [3] is used in its implementation. Early in 1992, the EFQM Model was shown as part of the evaluation process for the European Quality Award. Customer and employee well-being and societal and corporate outcomes are at the heart of the excellence model (EFQM). [4] A quality management methodology is also highlighted in the approach.

On the other hand, businesses prefer the EFQM excellence model since it enables them to leverage Total Quality Management Principles to achieve excellence [5]. There are a variety of industries that can benefit from the EFQM excellence model, from manufacturing to service. This approach also helps to improve the quality of services and products [6]. As both a TQM application and management paradigm, many companies employ EFQM. Business competitiveness can be improved by adopting these model characteristics. To improve the company's Performance, the EFQM Excellence Model uses both financial and other metrics. As part of the EFQM model for excellence, employees at all levels of the organization participate in ongoing quality improvement efforts, which provide extensive analysis and improvement areas for every business process. An organization's activities and outputs are linked in the (EFQM), which focuses on the link. Duplication and weaknesses are also eliminated, which helps the organization better recognize its strengths [7]. EFQM excels at helping its clients obtain a competitive edge, which benefits everyone involved [8]. An excellent tool for self-evaluation is the excellence model EFQM. Even though the model is subjective, expert opinions sway it.

Ambiguous and imprecise data (linguistic variables) from expert and experimental research judgments cannot be converted into precise data by the model's score. The EFQM excellence model's language parameters are ambiguous, which raises doubts about the model's reliability. Complexity and uncertainty can be addressed with fuzzy Logic. As a result, this model incorporates fuzzy Logic. The model's verbal phrase can have multiple meanings thanks to fuzzy Logic [9]. When fuzzy Logic is incorporated into the EFQM model, it becomes more accurate and dependable. There are also standard EFQM ratings for implementation, which speed things up [10]. In the MATLAB fuzzy editor, an initial (FEFQM) model was built using RADAR scoring system data from the traditional excellence model of the EFQM theory of quality management. The FEFQM model was created using the base rule 'If-then.' Using the FEFQM model, the Iraqi Oil Tanker Company was compared to the traditional EFQM score

1.1. Literature review

According to the literature, there are two ways that the EFQM excellence model can be used. First, The EFQM is graded using linguistic variables in conjunction with fuzzy Logic. The EFQM excellence model criteria employ fuzzy multicriteria decision-making for the second time. Additionally, it demonstrates how the EFQM excellence model may be simplified by leveraging fuzzy Logic. This study explores whether the RADAR scoring technique employed in the standard excellence model (EFQM) offers sensitive business performance results. The study aims to see how well fuzzy models can represent the traditional EFQM model and create more sensitive assessments. The excellence model (EFQM) uses linguistic variables, so tackling it using fuzzy Logic should allow more precise computations. An attempt was made in this study to include fuzzy Logic into the EFQM excellence model to conduct self-evaluation even when things were not obvious. The names of Açikgöz Nilay and Kiraz Alper are in this article. [11] Use of fuzzy Logic to improve Performance This work offers the Fuzzy EFQM (FEFQM) model to reduce the expert opinion calculation deviation and more accurately quantify institutionalization. The models were tested on ten corporate institutions compared to the industry-standard EFQM and FEFQM models. The mean absolute percentage error for the FEFQM CN2/sum approach and the traditional excellence model (EFQM) was 2.33 percent. Experimentation has shown that EFQM assessors and policymakers can use the model. Antonio Abreu and others [12] Improve R&D Quality Management through a Fuzzy Logic Model. Fuzzy Logic is a novel integrated strategy for improving an organization's overall Performance. The proposed method can be used in an R&D project based on RADAR's Logic methodology. Fuzzy Logic is then utilized to assess the EFQM framework's strengths and weaknesses. Then the most urgent improvement projects are selected. Aydin Serhat and associates [13] Uncertainty in multicriteria decision-making In this study, a new analytical hierarchy process and the EFQM Model for assessing company performance excellence are combined to provide a new integrated approach. The EFQM Excellence Award rating system allows professionals to utilize fuzzy scales to evaluate enterprises. According to Khosravi Alireza et al. [14], an EFQM-Fuzzy Network Data Envelopment Analysis Model for Organizational Efficiency Assessment in Companies has been established. According to the suggestive model, the efficiency of a company can be gauged by using the EFQM and Fuzzy Network Data Envelopment Analysis (FNDEA) organizational excellence models. Uygun and co-workers [15] EFQM's institutionalization has been driven by an integrated fuzzy multicriteria decision-making strategy. When evaluating EFQM criteria, fuzzy multicriteria decision-making approaches such as the fuzzy DEMATEL approach and the fuzzy analytic network are employed. Jamal Hosseini and others [16] An integrated strategy based on the EFQM model

may be offered to improve Business evaluation and identification of improvement projects using the Fuzzy logic and operations research (OR) methodologies and the Analytical Hierarchy Process (AHP). Javad, Dodge, and others.[17] The current EFQM approach contains faults and problems in identifying the most critical areas for improvement (AFI). Some indices and guidelines should govern prioritizing and selecting AFIs for organizations with limited time, money, and resources. You can identify AFIs by using an AFI model. EFQM's AFIs will be assessed, appraised, and calculated with its help. Daniel Jay and other members of the group [18] Accept erroneous data, and different assessment experiences are made possible by fuzzy reasoning systems (FISs). A new fuzzy multilayer assessment approach in the EFQM paradigm. An electric utility in the area used the process to test and verify it. Yousef The same goes for everyone else. [19] The purpose is to implement a new technique for deploying the new product by selecting practical management tools for putting up an EFQM model utilizing a quality function deployment (QFD) strategy. The study focuses on using firm satisfaction with excellence can be improved by a better selection of management tools athletic satisfaction excellence can be enhanced by a better choice of management tools attainment. To deal with the ambiguity of qualitative language evaluations, the suggested HOQ employs fuzzy Logic.

As can be seen from the above literature, EFQM has been used in many other sectors, including but not limited to: industry, hotels, healthcare sector and many more. In all of these studies, fuzzy logic served as the basis for the research methodology and application of the technique. Specifically, we proposed two models: one that integrates the requirements of the European Foundation for Quality Management in fuzzy logic, and the other that uses parts of radar logic to enhance the predictive power of fuzzy logic. Implementation of EFQM standards in all sections of the Iraqi Oil Tanker Company instead of only one section (Human Resources, Finance, Research and Development, etc.)

A. ***Excellence Model(EFQM)***

This non-prescriptive quality management model is the Excellence Model (EFQM) [20]. Extensive quality management (EFQM) incorporates strategic, managerial, and operational aspects [21]. In 1988, fourteen major European corporations outlined this strategy. By fostering excellence, they hope to improve the worldwide competitiveness of European businesses [22]. There are three interrelated sets of components that help significant firms function well and meet the expectations of all of their stakeholders

1) The fundamental concepts of excellence, every business must understand eight basic concepts regarding excellence. An organization's culture can be described using these notions as a starting point for top management to communicate in the same way. To achieve greatness, you must focus on the end product, put your clients first, be consistent, manage procedures, develop and include your employees, make alliances, and constantly improve [23].

2) The criteria EFQM's nine-criteria excellence model is depicted in two sections. In line with the organization's objectives, guided by a clear vision and plan. Customer, employee, and societal outcomes are the most critical performance metrics. For example, a firm's enablement criteria indicate how things are done, while its outcomes criteria show what the company has accomplished [24]. Questionnaires, matrix diagrams, workshops, preforms, and award simulations are included in EFQM's self-assessment procedures. The Results and Enablers score in the EFQM model is 1000 points. Leadership leads relationships, people, policy and strategy, processes, and resources for exceptional Performance for customers and society. According to the model, There are a variety of ways to achieve high levels of performance., according to the model. Based on this, "Excellent results to performance, people and customers are accomplished by leadership driving policy and strategy, implemented through people, processes, and partnership resources," it is stated. In the EFQM Arrows, dynamic nature has highlighted the models. Enablers and outcomes are enhanced by innovation and learning. The model's nine checkboxes indicate an excellent standard. This can be seen in (Figure 1). Every one of the nine criteria has a high-level definition [25].

1- Leadership: These leaders can influence the work of the organization and make others follow them. They keep the company focused on its mission even as it changes.
2- People When employees feel appreciated and cared for, they are more likely to contribute to the firm.
3- Policy & Strategy: Excellent companies implement stakeholder-focused strategies that take the market and industry as a whole into account. The method's implementation is guided by policies, plans, goals, and procedures.
4- Resources and Partnerships: External alliances, suppliers, and internal resources are all well-managed by excellent organizations to support their goals.

5- Processes: An organization's success depends on managing and improving its operations to provide and enhance customer value.
6- People results: Great firms use their employees to track and fulfill their goals.
7- Customer results: A company's ability to satisfy its customers is crucial for its success.
8- Society results: Organizational excellence is measured and achieved by excellent organizations.
9- Key performance results: Exceptional organizations track and report on their policy and strategy's progress and outcomes.

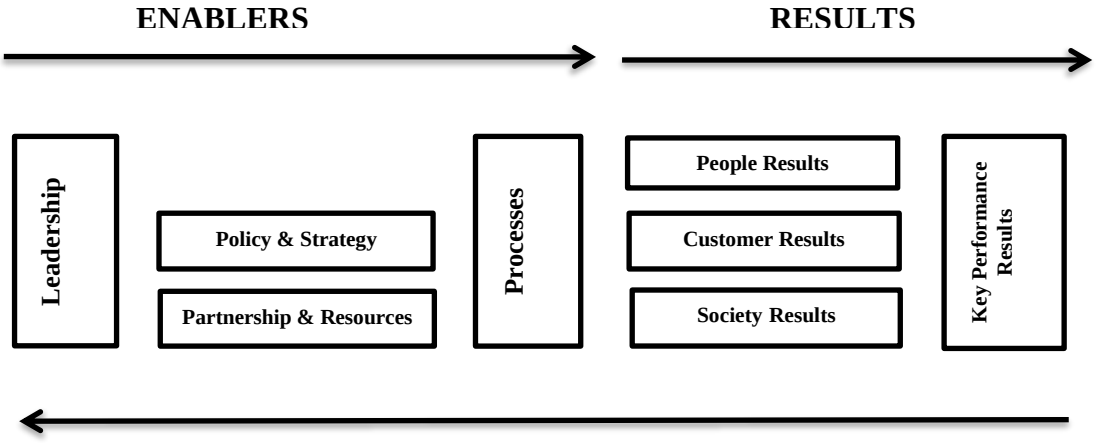

Fig. 1 - EFQM Model

3) The radar logic An EFQM-based self-assessment scheme provides the basis for this reasoning. the organization can be shown how it works through deployment, assessment, and refinement.[26]. A non-deterministic framework for evaluating the relationship between an organization's activities (enabler criteria) and its ability to achieve results is the EFQM excellence model. Customers, employees, society, and other critical outcomes anticipate that there are various ways to achieve the same level of success. Organizational processes can be managed more effectively without assigning tasks a higher priority when using the EFQM excellence model. Using the complete quality principles helps firms transform and achieve continuous improvement. Managers can improve their abilities to lead and make decisions and increase the satisfaction of those who benefit from the organization as a whole. In other words, the EFQM excellence model helps companies evaluate their existing situation and apply continuous improvement flow modeling and advice through evaluation .

B. Fuzzy Logic System

Fuzzy Logic (FL) was developed in 1965 by Lotfi Zadeh to deal with uncertain, imprecise, or qualitative decisions [27]. Fuzzy sets, Logic, algorithms, and control are all included in what we call "Fuzzy Systems.". In all "fuzzy domains," fuzziness is employed in some way—an easy and steady transition from 0 to 1 rather than a sudden change. Traditional set theory and Logic are solely concerned with discrete values. The membership of regular sets (crisp sets) is binary. Factual (represented by 1) logic assertions are not valid (0). By introducing partial veracity, fuzzy systems open up a more comprehensive range of study areas. Especially in isolated pastures, fog is a constant presence [28][29]. Many difficulties can be addressed using FL, from microcontrollers to PC or workstation data collecting. Because of this approach, there's no need to worry about input data that are confusing, wrong, noisy, or missing. IF X AND Y, THEN the Z rule is utilized instead of mathematical modeling. This mapping transforms the data coming into the output. FL consists of fuzziness, rule base, inference engine, and defuzzification[30][31].

2. METHOD

As long as the percentage changes are small, the score can go from 0% to 100% (out of 20 possible possibilities for each sub-criteria). Because no two consultants will use the same set of sub-criteria, the scores may fall into a tight range. I opted to use RADAR's method to divide the scoring into five levels. Because there are only five fuzzy options, there is no hesitancy when selecting the correct score. With this method, plus the fact that consultant scores aren't always specific (though they're generally closed), you'll get more accurate scores. An initial step was to specify what the associated membership functions should be using triangle functions, which indicate the relationship's midpoint by having three parameters [α, β, γ]. As a result, a Fuzzy triangular number is generated, from which consultants can select one of five Fuzzy sets to assign a score to the sub-criteria elements. As shown in the table(1)

Table 1 -. Fuzzy sets and membership functions

Ne.	Scoring.	Fuzzy Set	Membership Function [α, β, γ]
1	0	(“Very Bad”) no evidence/a small segment of regions	(0,0,25)
2	25	(“Bad”) limited evidence/≈ 1/4of regions	(0,25,50)
3	50	(“Medium”) remarkable evidence/ ≈ 1/2 of regions	(25,50,75)
4	75	(“Good”) high evidence/≈ 3/4 of regions	(50,75,100)
5	100	(“Very Good”) complete evidence/≈ entire region	(75,100,100)

Fuzzy numbers were employed for "Results," "Approach," "Deployment", "Assessment" scores in EFQM logic of RADAR, as well as "Refine" scores. This conclusion was made by taking into account each subcriterion, criterion, and the total score. Denazified the scores using the centroid method, resulting in a precise value that can be measured. For the model implementation, I settled on using MATLAB. An example of the Enablers criteria is shown in Figure 2. It's the same story when it comes to the "Results" measure: tables 2 and 3 display the scores for both the "Enablers" and "Results" criteria. EFQM's RADAR approach analyzed each sub-criteria item using the same table for each enabler. After picking one of five possibilities for the quantity of verification that had been received, these procedures were carried out ("Very Bad," " Bad," " Medium," "Good," and "Very Good."). "Results" was approached in the same fashion as "Methods." Each sub-evaluation criterion in this study was based on Performance, relevance, and usability.

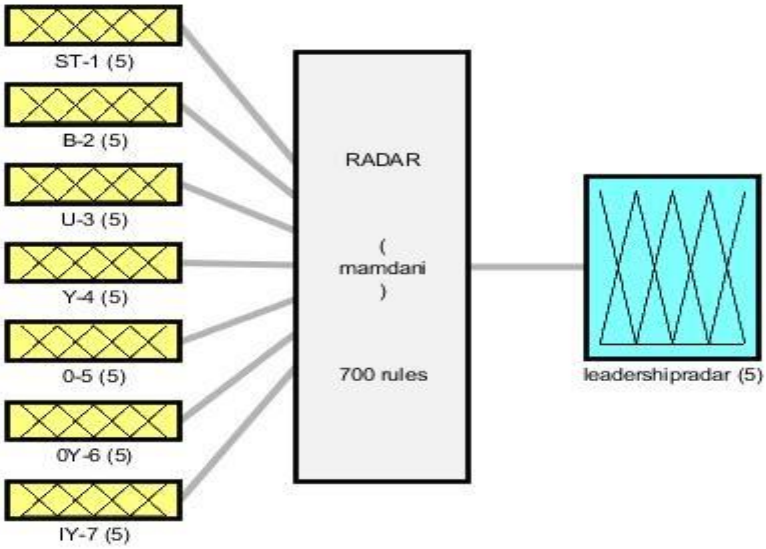

Fig. 2 - EFQM model Matlab

Table 2 - Proposed scoring of enablers

Elements	Attribute	Very Bad	Bad	Medium	Good	Very Good
Approach	Sound	No evidence	Some evidence	Remarkable evidence	Precise &clear evidence	Complete & comprehensive evidence
	Integrated	No evidence	Some evidence	Remarkable evidence	Precise &clear evidence	Complete & comprehensive evidence
Deploy	Implemented	No evidence	Implemented in 1/4 of relevant areas	Implemented in 1/2 of relevant areas	Implemented in 3/4 of relevant areas	Implemented in all relevant areas
	Systematic	No evidence	Some evidence	Remarkable evidence	Precise &clear evidence	Complete & comprehensive evidence
Asses & Refine	Measurement	No evidence	Some evidence	Remarkable evidence	Precise &clear evidence	Complete & comprehensive evidence
	Creativity & Learning	No evidence	Some evidence	Remarkable evidence	Precise &clear evidence	Complete & comprehensive evidence
	Improvement	No	Some	Remarkable	Precise &clear	Complete & comprehensive

	& Innovation	evidence	evidence	evidence	evidence	evidence

Table 3 - Proposed scoring of results

Elements	Attribute	Very Bad	Bad	Medium	Good	Very Good
Performance	Trends	No results	about 1/4 of the results have shown a positive trend in at least three years.	Positive direction and sustained about 1/2 impact over at least three years	Positive trend for about 3/4 of results over at least three years	Positive trend for all effects over at least three years
	Targets	No results	Set appropriate & achieved for about 1/4 of critical results	Set appropriate & earned for about 1/2 of essential results	Set appropriate & earned for about 3/4 of critical results	Set appropriate & performed for all key results
	Comparison	No results	Established favorable for about 1/4 results	Based suitable for about 1/2 results	Based suitable for about 3/4 of results	Based suitable for all results
	Causes	No results	Enabling effect visible for about 1/4 of results	Boosting effect visual for about 1/2 results	Boosting effect visual for about 3/4 of results	Boosting effect visual for all results
Relevance & usability	Scope	No results	Results presented & relevance established for about 1/4 of areas involved	Results suggested & bearing set for about 1/2 of areas involved	Results suggested & relevance set for about 3/4 of areas involved	Results suggested & relevance set for all areas involved

3. RESULTS AND DISCUSSION

The company's efficiency was scrutinized from the inside out. In order to determine each sub-criterion and the ultimate score, a scoring table was used, as shown in Table 1. The EFQM award simulation method was used to evaluate the Iraqi Oil Tanker Company. A self-evaluation report was submitted in the beginning. The sub-criteria scores and the total score of the organization are then determined in accordance with the scoring table. The EFQM 9 criteria (sub-criteria) and the EFQM RADAR were used to score the Iraqi Oil Tanker Company's organizational behavior; the results are shown in table 4. Instead of relying on an EFQM consultant to examine organizational behavior for the Iraqi Oil Tanker Company, we used the Fuzzy approach. Table 5 displays the results based on the main criteria, sub-criteria, and overall score.

Table 4 - Evaluation of Iraqi Oil Tanker Company by considering RADAR's approach

Enablers	1-leadership		2- Policy & Strategy		3-people		4-partnerships & resources		5-processes	
	1a	10.8	2a	18.5	3a	21	4a	17.3	5a	20

	1b	18.4	2b	21	3b	13.9	4b	19.5	5b	16.7
	1c	14.5	2c	17.9	3c	16	4c	16.8	5c	15
	1d	20	2e	19.3	3d	18.2	4d	20	5d	18.3
	1e	17			3e	14.6	4e	21	5e	14
	Total	80.7%	Total	76.7%	Total	83.7%	Total	94.6%	Total	84%
	mean	16.14	mean	19.2	mean	17.74	mean	18.9	mean	16.8

Result	**6-people**				**7-customers**				**8-society**				**9-Key Performance**				**Final score**
	6a	72	*0.75	54	7a	61	*0.75	45.75	8a	67	*0.5	33.5	9a	79	*0.5	39.5	
	6b	70	*0.25	17.5	7b	64	*0.25	16	8b	66	*0.5	33	9b	83	*0.5	41.5	
	Total		71.5%		Total		61.75%		Total		66.5%		Total		81%		700.45%

Table 5 - Evaluation of Iraqi Oil Tanker Company by using Fuzzy approach

Enablers	**1-leadership**		**2- Policy & Strategy**		**3-people**		**4-partnerships & resources**		**5-processes**	
	1a	12.5	2a	20	3a	19	4a	16.5	5a	18
	1b	24	2b	16	3b	25	4b	21	5b	14.5
	1c	19	2c	15.9	3c	18	4c	18.4	5c	17.3
	1d	16.8	2e	20	3d	15.7	4d	23	5d	21
	1e	18.4			3e	17.3	4e	14.8	5e	13.8
	Total	90.7%	Total	71.9%	Total	95%	Total	93.7%	Total	84.7%

	mean	18.14	mean	18	mean	19	mean	18.74	mean	16.94

Result	6-people				7-customers				8-society				9-Key Performance				Final score
	6a	72	*0.75	54	7a	63	*0.75	47.25	8a	70	*0.5	35	9a	80	*0.5	40	
	6b	73	*0.25	18.25	7b	67	*0.25	16.75	8b	68	*0.5	34	9b	85	*0.5	42.5	
	Total		72.25%		Total		64%		Total		69%		Total		82.5%		723.75%

According to EFQM standards, the "enabling factor" and "outcomes" parts should be interpreted in the same way. The two methods of scoring are contrasted in Figure 3. The overall score takes into account all of the criteria and sub-criteria. The differences between the two techniques appear insignificant, as illustrated in Fig. 3. With both methods compared, you'll be able to observe the difference even more clearly (Tables 5 and 6, respectively). A relative difference of approximate points exists between the two values corresponding to each approach and sub-criteria in terms of the computed scores (Fig. 3). As a result, the distinction between the two strategies is essentially non-existent

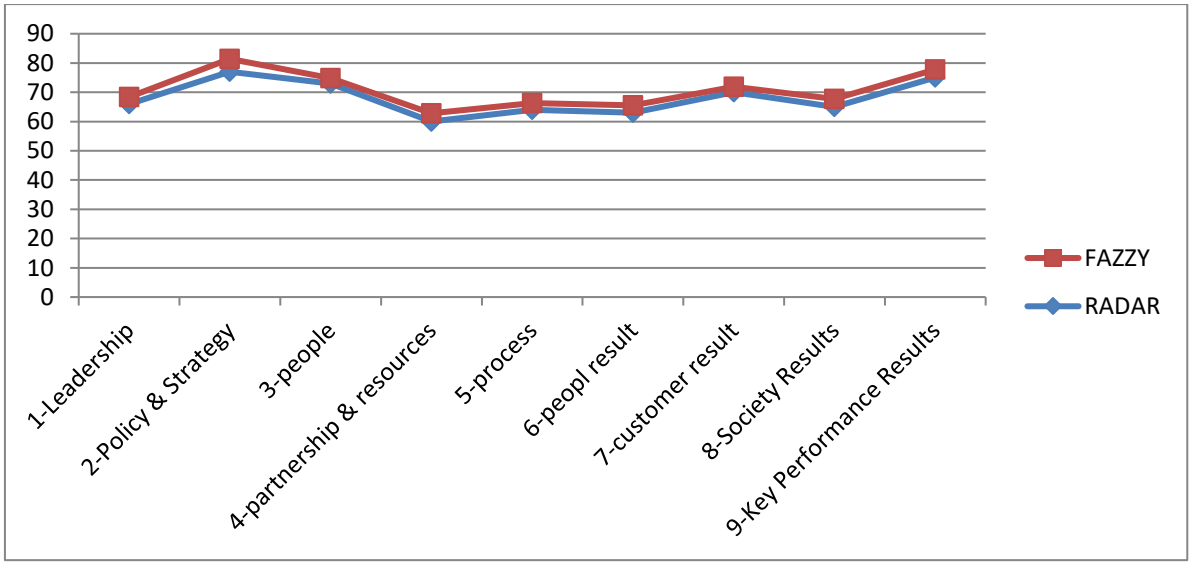

Fig. 3 - Results from the two approaches used to evaluate the Iraqi oil tanker company, according to the EFQM

4. CONCALUSION

Using a decision-making process built on Fuzzy Logic, an integrated technology has been developed to improve the entire performance of the Iraqi Oil Tanker Company. As part of the EFQM implementation, I chose to log subcriteria

using RADAR (Logic) and Fuzzy Logic (Algorithm) approaches. After evaluating the strengths and defects in the organization, improvement measures are developed through the sub-standards of the European Foundation for Quality Management by distributing forms to obtain some opinions and there was cooperation by the company's departments and its employees from the leadership, management office and others. After designing and implementing improvement measures, we developed action plans for each field as follows (increasing training courses and increasing working hours in unfinished projects with giving low and moral incentives such as thank you letters and others, reducing production costs, increasing production and increasing mutual exchange with foreign companies such as the Kuwaiti company). Use the EFQM Excellence Model as a practical tool that can be used to conduct a self-assessment In Iraqi oil tanker companies and other oil companies to improve their overall performance. As an example for further development, the proposed approach can be improved in this case, by combining a combination of fuzzy logic and multi-criteria techniques (such as AHP, (OR), DEMATEL, ELECTRE, TOPSIS), to prioritize areas for improvement, as well as their actions.

References

[1] D. Xu and J. Yang, "Intelligent decision system for self‐assessment," J. Multi‐Criteria Decis. Anal., vol. 12, no. 1, pp. 43‐60, 2003.

[2] A. Calvo‐Mora, A. Leal, and J. L. Roldán, "Using enablers of the EFQM model to manage institutions of higher education," Qual. Assur. Educ., 2006.

[3] S. D. Anastasiadou and P. A. Zirinoglou, "EFQM dimensions in greek primary education system," Procedia Econ. Finance., vol. 33, pp. 411–431, 2015.

[4] V. Belvedere, A. Grando, and H. Legenvre, "Testing the EFQM model as a framework to measure a company's procurement performance," Total Qual. Manag. Bus. Excell., vol. 29, no. 5–6, pp. 633–651, 2018.

[5] E. Suárez, A. Calvo-Mora, J. L. Roldán, and R. Periánez-Cristóbal, "Quantitative research on the EFQM excellence model: A systematic literature review (1991–2015)," Eur. Res. Manag. Bus. Econ., vol. 23, no. 3, pp. 147–156, 2017.

[6] J. Dobrovič, Ľ. Kemco, P. Gallo, and P. Gallo jr, "Implications of the Model EFQM as a Strategic Management Tool in Practice: A Case of Slovak Tourism Sector: Dobrovič, J., Kmeco, L., Gallo, P., Gallo jr., P.(2019). Implications of the Model EFQM as a Strategic Management Tool in Practice: A Case of Slova," J. Tour. Serv., vol. 10, no. 18, pp. 47–62, 2019.

[7] B. Al-Majali and M. Almhirat, "The role of European Foundation for Quality Management (EFQM) in improving public sector efficiency and its impacts on customer satisfaction employees results and corporate image," Int. J. Qual. Res., vol. 12, no. 3, p. 593, 2018.

[8] V. C. Nguyen and N. T. Chau, "Research framework for the impact of total quality management on competitive advantage," Rev. Int. Bus. Strategy., vol. 27, no. 3, pp. 335–351, Jan. 2017, DOI: 10.1108/RIBS-02-2017-0016.

[9] F. Bagheri, R. Noorossana, and M. Najmi, "The extent of EFQM effectiveness in routine and non-routine organizations based on multivariate techniques: an empirical study," Oper. Res., vol. 19, no. 1, pp. 237–267, 2019.

[10] J. Dodangeh, R. M. Yusuff, and J. Jassbi, "Assessment system based on fuzzy scoring in European Foundation for Quality Management (EFQM) business excellence model," African J. Bus. Manag., vol. 5, no. 15, pp. 6209–6220, 2011.

[11] A. Kiraz and N. Açikgöz, "A fuzzy-logic-based approach to the EFQM model for performance enhancement," Sādhanā, vol. 46, no. 1, pp. 1–15, 2021.

[12] A. Abreu, R. Santos, J. M. F. Calado, and J. Requeijo, "A Fuzzy Logic Model to Enhance Quality Management on R&D Units," KnE Eng., pp. 285–298, 2020.

[13] S. Aydin, C. Kahraman, and İh. Kaya, "A new fuzzy multicriteria decision-making approach: An application for European Quality Award assessment," Knowledge-Based Syst., vol. 32, pp. 37–46, 2012.

[14] A. Khosravi, M. Fallah, and S. E. Najafi, "An EFQM-fuzzy network data envelopment analysis model for efficiency assessment in organizations," J. Math., vol. 2021, 2021.

[15] O. Uygun, S. Yalcin, A. Kiraz, and E. F. Erkan, "A novel assessment approach to EFQM driven institutionalization using integrated fuzzy multicriteria decision-making methods," 2020.

[16] J. H. Ezzabadi, M. D. Saryazdi, and A. Mostafaeipour, "Implementing Fuzzy Logic and AHP into the EFQM model for performance improvement: A case study," Appl. Soft Comput., vol. 36, pp. 165–176, 2015.

[17] J. Dodangeh, R. M. Yusuff, N. Ismail, M. Y. Ismail, M. R. B. Zadeh, and J. Jassbi, "Designing fuzzy multi criteria decision making model for best selection of areas for improvement in European Foundation for Quality Management (EFQM) model," African J. Bus. Manag., vol. 5, no. 12, pp. 5010–5021, 2011.

[18] J. Daniel, M. Naderpour, and C.-T. Lin, "A fuzzy multilayer assessment method for EFQM," IEEE Trans. Fuzzy Syst., vol. 27, no. 6, pp. 1252–1262, 2018.

[19] S. Yousefie, M. Mohammadi, and J. H. Monfared, "Selection effective management tools on setting European Foundation for Quality Management (EFQM) model by a quality function deployment (QFD) approach," Expert Syst. Appl., vol. 38, no. 8, pp. 9633–9647, 2011.

[20] U. Nabitz, N. Klazinga, and J. A. N. Walburg, "The EFQM excellence model: European and Dutch experiences with the EFQM approach in health care," Int. J. Qual. Heal. Care, vol. 12, no. 3, pp. 191–202, 2000.

[21] D. Kafetzopoulos, K. Gotzamani, and D. Skalkos, "The relationship between EFQM enablers and business performance: The mediating role of innovation," J. Manuf. Technol. Manag., 2019..

[22] L. Para-González, D. Jiménez-Jiménez, and A. R. Martínez-Lorente, "The link between people and performance under the EFQM excellence model umbrella," Total Qual. Manag. Bus. Excell., vol. 32, no. 3–4, pp. 410–430, 2021.
[23] A. Calvo-Mora, A. Navarro-García, and R. Periañez-Cristobal, "Project to improve knowledge management and key business results through the EFQM excellence model," Int. J. Proj. Manag., vol. 33, no. 8, pp. 1638–1651, 2015.
[24] J. Zhang et al., "Development of a market-oriented EFQM excellence model for analyzing the implementation of quality management in developing countries," Int. J. Constr. Manag., vol. 21, no. 9, pp. 884–909, 2021.
[25] S. Verner, U. Nabitz, G. Bragonzi, A. Rebelli, and R. Molinari, "A two‐level EFQM self‐assessment in an Italian hospital," Int. J. Health Care Qual. Assur., 2007.
[26] A. Calvo-Mora, M. Domínguez-CC, and F. Criado, "Assessment and improvement of organizational social impact through the EFQM Excellence Model," Total Qual. Manag. Bus. Excell., vol. 29, no. 11–12, pp. 1259–1278, 2018.
[27] L. C. d. Barros, R. C. Bassanezi, and W. A. Lodwick, "The first course in fuzzy logic, fuzzy dynamical systems, and biomathematics: theory and applications," ed: Springer, 2017.
[28] T. Munakata, Fundamentals of the n*ew artificial intelligence*, vol. 2. Springer, 1998.
[29] Z. T. Allawi and T. Y. Abdalla, "An optimal defuzzification method for interval type-2 fuzzy logic control scheme," in 2015 Science and Information Conference (SAI), 2015, pp. 619–627.
[30] T. Y. Abdalla, H. A. Hairik, and A. M. Dakhil, "Direct torque control system for a three phase induction motor with fuzzy logic based speed controller," in 2010 1st International Conference on Energy, Power and Control (EPC-IQ), 2010, pp. 131–138.
[31] S. A. Abbas, A. A. Hassan, and W. S. Al-Rekabi, "Estimation of MeanReference Evapotranspiration in Basrah City, South of Iraq Using Fuzzy Logic," J. Univ. Babylon, vol. 25, no. 1, 2017.