Hindawi
Mathematical Problems in Engineering
Volume 2022, Article ID 6358562, 18 pages
https://doi.org/10.1155/2022/6358562

Research Article

A Decision Support System for Evaluating Success Factors of Projects in the Oil and Gas Industry

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Received 27 February 2022; Revised 12 October 2022; Accepted 15 October 2022; Published 4 November 2022

Academic Editor: Mijanur Rahaman Seikh

Oil and gas (O&G) projects have a high social and economic impact in many countries. This study aims to identify the success factors in the O&G industry and to present a framework for evaluating the projects in an uncertain environment. In this study, 197 indicators are identified from a literature review and summarized to 34 indicators. Exploratory factor analysis (EFA) was performed, and seven main factors have been identified as success factors of O&G projects. Confirmatory factor analysis (CFA) confirmed the validity of the measurement model. A two-step fuzzy inference system is proposed to present an evaluation framework for assessing the performance of O&G projects. The hybrid framework was applied for the assessment of five Iranian O&G projects.

1. Introduction

Energy supply is one of the main concerns of governments. The oil and gas industry has the largest share in world energy supply. Oil and gas resources play an important role in the economies of many countries. Therefore, the efficient and effective implementation of projects related to the exploration and extraction of these valuable resources is always one of the main priorities of many governments. To illustrate the importance of these resources, the oil and gas industry of Saudi Arabia contributes 42% of the GDP and accounts for 87% of the country's budget [1, 2].

The oil industry has a very ancient history. May 1908 is the beginning of the oil era in Iran and marked the beginning of the industrial exploitation of the "black gold." A review of the history of Iran over the past 100 years makes it clear that the political, social, economic, and cultural development of Iran has been strongly affected by oil. Considering the importance of the supply chain is a key factor for the success related projects. In order to prevent undesirable performance of a project, issues such as increased costs and delays need special attention [3, 4]. Kaviani et al. [5] point out that the supply chain in the oil and gas sector, especially in the upstream field, is based on a large number of medium and small enterprises. These firms provide services and technologies needed by the oil companies. The management and supervision of these service providers as a part of the whole supply chain of large companies are important for the effectiveness of the oil and gas supply chain.

Kaviani et al. [5], Raut et al. [6], and Kumar and Garg [7] consider a sustainable supply chain in the oil and gas industry suitable for economic development with environmental and social improvement. This suggests that the development of oil and gas projects should address issues such as economic development, environmental issues, improving economic conditions, and other economic effects. Also, two issues of organization agility and supply chain performance play a crucial role in the supply chain's competitiveness. The more oil companies outsource their supply processes; the more important are the integration and use of supply chain management capabilities [5, 8, 9].

According to Bogdanov et al. [10] and Burandt et al. [11], the oil and gas industry plays a major role in modern societies in meeting heat, power, and transportation needs. Since the discovery and exploitation of oil and gas resources began, there have been concerns about the sustainability of this industry. Despite the importance of the oil and gas industry for social and economic activities, supply chain management has been less attentive to the industry challenges.

This study aims to identify success factors in oil and gas (O&G) projects and proposes a framework for evaluating the projects. Iran has many O&G fields but faces many restrictions, e.g., regarding equipment and human resources. Therefore, finding the critical success factors (CSFs) for evaluating O&G projects is crucial. The evaluation of O&G projects is one of the popular subjects among researchers, and many methods have been applied in diverse countries. Many of these methods can be characterized as multicriteria decision making (MCDM) methods and other methods for dealing with uncertainty. The novelty of this study is the combination of statistics and mathematics methods in an uncertain environment to design a robust model for evaluating O&G projects using exploratory factor analysis (EFA) for developing the decision support system (DSS) in uncertain situations. The customized factors are prioritized using a fuzzy inference system (FIS), which offers advantages over triangular and trapezoidal fuzzy numbers.

The remaining study is structured as follows. A literature review is provided in Section 2. Section 3 deals with the methodology and data analysis of the research. Section 4 is open for results and discussion. Section 5 presents the conclusions and managerial implications.

2. Literature Review

In this section, we review papers that discuss success factors in O&G projects. After this review, the identified indicators are used as input for the EFA. Many studies have been conducted to determine the success factors in the supply chain.

2.1. Research on Success Indicators. Rane et al. [12] mentioned that agility, outputs of projects, and competition were introduced as the main factors of the success of oil and gas projects (see also [13]). Mokni [14] analyzed the impact of oil price shocks on the real return on capital in the United States and thirteen European countries between 1986 and 2005. This study shows the impact of oil price shocks on decisions regarding projects in the oil and gas industry. Increased demand for energy resources, lack of skilled labor, increased environmental risks, the impact of renewable energies, the behavior of existing competitors, the behavior of new competitors, the bargaining power of suppliers, and the bargaining power of customers are some indicators that researchers introduce as general conditions of competition by researchers.

According to Cushing et al. [15], the activities of the oil and gas industry related to safety and social welfare entail high costs. Some incidents occurred due to insufficient safety, health, and environmental laws. In recent decades, oil and gas companies have developed project management methods to balance demand with market expectations for the extraction of reserves [16]. Knowledge management, flexibility in critical paths, project completion at due date, project completion at specified cost, completion of the project with expected quality, and rate of return are indicators which are mentioned in the literature for assessing project performance. Project delays, cost increases, multiple stakeholders, and high uncertainties are some of the characteristics of government projects that complicate their planning, implementation, and management [17]. According to Zaman et al. [18], an accurate understanding of customer needs, the proper breakdown of the project, and good project management lead to better project performance. Guerin [19] pointed out that many construction projects do not meet the expectations of customers. Time, cost, and quality are usually used for project performance measurement.

Gunduz and Abdi [20] suggested that the best way of communication between the customer and the contractor is to align interests and develop collaboration between both parties. In such a situation, conflicts are resolved, knowledge sharing is easy to achieve, and each party would be able to integrate and coordinate with the other party to successfully complete the project. Project compliance with scheduling, cost control, customer satisfaction, knowledge exchange, interaction with the customer to resolve disputes, quality, organizational culture, senior management commitment, and coping with critical accidents are some indicators related to contractor performance assessment researchers discussed. The criteria considered for contractor performance are related to regulations, accountability of managers, training and customer competence, environmental protection, preparation for critical situations, and accident analysis [21].

de Jesus et al. [22] used the analytic network process (ANP) to rank O&G contracts. They considered the contracting process, the contract type, the organizational structure, and project characteristics as the main categories for evaluating contracts, considering some subcriteria. The results pointed out which of these factors should be selected in the context of contracts.

Yazdi et al. [23] pointed out how to select oil projects by using the best-worst method (BWM) and the weighted aggregated sum product assessment (WASPAS) with Z-numbers. In this research, the factors considered for oil project selection are the length of operations, costs, technology, location, budget, production capacity, revenue, quality, delay, and logistics. The result showed which of the considered 14 projects should be selected.

Karbassi Yazdi et al. [24] demonstrated how to choose LNG contracts with a combination of the linear-programming technique for multidimensional analysis of preference (LINMAP) and mixed-integer linear programming (MILP). They considered cost, quality, and the evaporation rate factors in evaluating LNG contracts. The results show which LNG contract from a given set should be selected.

Based on this literature review, 197 indicators were identified in total. Table 1 presents an overview of the success factors found.

2.2. Research Gap. Various success factors in different industries are discussed in the literature. Identifying success factors in O&G projects would help experts to boost their performance. Extracting the success factors through a statistical procedure helps us enormously design a decision support system that could efficiently measure the performance of a respective project.

The multiple studies used different strategies to cope with uncertainty in the decision-making problem. Some studies used both multicriteria decision-making (MCDM) and fuzzy methods for ranking suppliers. Some others combined MCDM methods with other approaches dealing with uncertainty. Table 2 summarizes some related papers together with the applied methods.

Most studies lack scientific methods for determining the success factors and rely mainly on the factors mentioned in some published papers.

Our study analyzed 69 papers from various countries to determine critical success factors (CSFs) in the O&G industry from 2010. Figure 1 shows the variety of these studies from different global regions.

The comprehensive investigation of published papers that considered success factors in supply chains, especially regarding O&G projects, is one of the contributions of our study. As a result, a total of 197 indices were identified and presented to experts. This work allows decision makers (DMs) to take into account all indices that can be used for evaluating O&G projects. In addition, EFA is used to determine the most crucial success factors, which are the inputs of the developed decision support system. Since these factors have been extracted from numerous studies in diverse countries, they need to be customized to Iran as the situation is unique. Therefore, EFA is one of the powerful tools to customize CSFs.

Another novelty of this study and gap in current research is the application of an FIS to rank these CSFs. Most papers in this field ranked the considered CSFs with MCDM methods and combined them with various methods dealing with uncertainty. An FIS has not been used in this field so far.

3. Research Methodology

3.1. Fuzzy Sets. The theory of fuzzy sets [57] is used to model decision-making processes based on obscure and inaccurate information. A fuzzy set is the generalization of a classical set that allows the function of the membership of any value in the interval [0, 1]. In other words, a classical set could only have two values of 0 and 1, whereas the function of membership to a fuzzy set is continuous in the range [0, 1].

Fuzzy sets are one of the essential methods used in uncertain environments. Their merits are that they can be easily used in modeling and represent a logic that is close to human thinking.

3.2. Fuzzy Triangular and Trapezoidal Membership Functions. A triangular membership function with the specified parameters (l, m, u) is defined as follows.

l is a lower number, m is a middle number, and u is an upper number used as parameters for the membership function, and x is a variable to determine the membership degree of the fuzzy set:

$$\mu_A(x) = \begin{cases} \dfrac{x-l}{m-l}, & l \le x \le m, \\ \dfrac{u-x}{u-m}, & m \le x \le u, \\ 0, & \text{otherwise}. \end{cases} \tag{1}$$

Each trapezoidal membership function is defined with four parameters (a, b, c, d), which represent the coordinates of the four-headed trapezoid as (2). a is the lower number, m is the first middle number, c is the second middle number, and d is the upper number:

$$\mu_f(x) = \begin{cases} \dfrac{x-a}{b-a}, & a \le x \le b, \\ 1, & b \le x \le c, \\ \dfrac{d-x}{d-c}, & c \le x \le d, \\ 0, & \text{otherwise}. \end{cases} \tag{2}$$

3.3. T-Norm and S-Norm. A t-norm is an operation that satisfies the commutativity (3), associativity (4), monotonicity (5), and boundary conditions (6) [58]. *a, b,* and *c* are fuzzy numbers in the following equations:

$$a\,t\,b = b\,t\,a, \tag{3}$$

$$a\,t\,(b\,t\,c) = (a\,t\,b)\,t\,c, \tag{4}$$

$$\text{if } b \le c, \quad \text{then } a\,t\,b \le a\,t\,c, \tag{5}$$

$$\begin{aligned} a\,t\,1 &= a, \\ a\,t\,0 &= 0. \end{aligned} \tag{6}$$

An s-norm is similar to a t-norm, but the boundary condition is the same as in

$$\begin{aligned} a\,s\,0 &= 0, \\ a\,s\,1 &= 1. \end{aligned} \tag{7}$$

Table 1: Some papers published considering success factors in O&G projects.

References	Indices
[22]	Market sensitivity, speed of delivery, data accuracy, new product development, trust, improvement of service level, cost reduction, customer satisfaction, quality improvement, minimizing unreliability collaborative planning, process integration, technology application, lead time reduction, and reducing change resistance
[25, 26]	Market sensitivity, IT application, process integration, and networking
[13, 27]	Project plan updating time, decision time, delivery frequency, customer validation, and customer and team interaction
[28, 29]	Responsiveness, speed, and flexibility
[4]	Well-recognized need for agility, integration of agility into the strategic context of the supply chain, management commitment and support, information flow within the supply chain, continuous monitoring of the supply chain and business environment, use of agile-enabling technologies, intraorganizational collaboration, the collaboration between supply chain partners, management competence, and the competence of employees
[30]	Company's internal capability, human resources, rapid changes in the production line, motivation and educated, management, and communication technology
[31]	Environmental changes, environmental opportunities, environmental threats, supplier information, customer information, decision making, sustainable decisions, capacity increase, and flexibility
[32]	Political situation
[33]	Currency exchange and national currency strength
[34]	Rate of return
[35]	Increased demand for energy resources, lack of skilled labor, increased environmental risks, bargaining power of suppliers, impact of renewable energies, existing competitor behavior, behavior of new competitors, and bargaining power of customers
[36]	Oil price fluctuation, environmental instability, and geographical position of the company
[37]	Political stability, economic stability, stakeholders force, laws and regulations, alternative energies, and competition in the O&G industry
[38]	Cost deviation, time deviation, and project quality
[39]	An accurate understanding of customer needs, proper breakdown of the project, and good project management
[40]	Knowledge management, flexibility in the critical path, completion of the project with expected quality project completion at the due date, project completion at specified cost, and rate of return
[41]	Completion of the project with expected quality, project completion at the due date, and project completion at the specified cost
[42]	Completion of the project with expected quality, project completion at the due date, and project completion at the specified cost
[43]	Technological performance, HSE performance, and social responsibilities
[44]	Innovation, shortening project time, and joint venture
[45]	Price, reliability, availability, and service level
[46]	Customer fulfillment, contract implementation, product/service quality, technical capability, minimization of waste, product compliance with safety and environmental regulations, and reliability
[47]	HSE performance
[48]	Financial potential, professional behavior, local supply, reliability, risk management, communication, computer-integration, supplier's communication, engineering expertise, HSE, ability in logistics, supply chain management, resource availability, and innovation
[49]	Scheduling, safety, cost, and quality
[50]	Training, the performance of project manager, cost control, key personnel availability, quality, HSE, and schedule control
[51]	Project compliance with scheduling, cost control, organization culture, customer satisfaction, knowledge exchange, senior management commitment, interaction with customers, quality, and coping critical accidents
[52]	Relationship with suppliers, problem-solving, on-time informing of problems, supplying long lead time items, consistency, innovation, HSE performance, project compliance with scheduling, competitive price, and local supply
[53]	Healthy regulations, training, applying international standards, energy consumption, environmental issues, respect for culture, tax obligations, fair division of job positions, and renewal of contracts
[21]	Respect to regulations, the responsibility of managers, training, readiness for critical situations environmental issues, and accident analysis

Table 2: Some studies for considering uncertainty in DSS.

Author/authors	Methods
[25]	DEMATEL
[54]	FANP and VIKOR
[55]	AHP and Delphi
[5]	Grey-SWARA and Grey-EDAS
[56]	Fuzzy TOPSIS
Current research	Fuzzy inference system and EFA method

3.4. Fuzzy Inference System. The fuzzy inference system (FIS) [59] is a process for mapping inputs to outputs using fuzzy logic. Depending on the mapping, a decision is made or a pattern is detected.

Each FIS consists of 6 steps as follows. (a) The membership functions of input and output are defined. (b) "If–then" rules are defined. (c) The product t-norm for the logic operator "and" as defined in (8) is used, while, for the logic operator "or," the s-norm (maximum) is adopted as (9) [60]. In the following equations, $\mu_A(x)$ is the membership

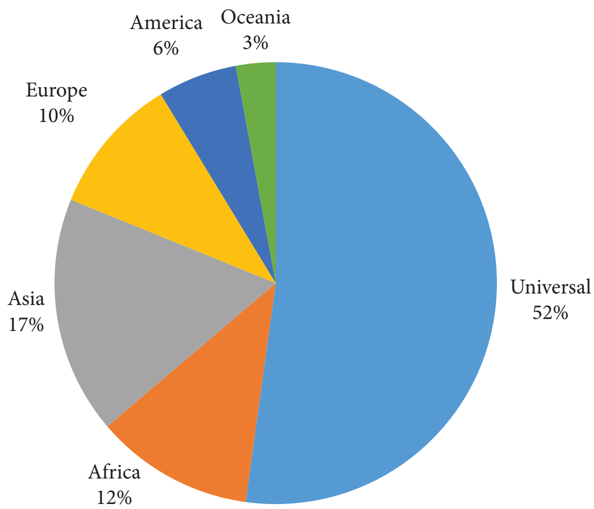

Figure 1: Global distribution of studies about CSFs.

function of element x to the fuzzy set A and $\mu_B(y)$ is membership function of element, y:

$$\mu_A(x) \text{ AND } \mu_B(y) = \{\mu_A(x) * \mu_B(y)\}, \quad (8)$$

$$\mu_A(x) \text{ OR } \mu_B(y) = \text{Max} \quad \{\mu_A(x), \mu_B(y)\}. \quad (9)$$

(d) The inference engine applies an implication relation $(\mu_R(x, y))$ for which we used "min" operator (10). (e) The output of a fuzzy number $(S \circ R(x, z))$ is aggregated by the "max" operator (11). (f) The defuzzification method which we used is "centroid" as in (12) uses the COA (Center Of Area) concept to convert fuzzy values to crisp values:

$$\mu_R(x, y) = \text{Min} \quad \{\mu_A(x), \mu_B(y)\}, \quad (10)$$

$$S \circ R(x, z) = \text{Max} \quad \{\mu_S(x, y), \mu_R(y, z)\}, \quad (11)$$

$$\text{COA} = \frac{\sum_{k=1}^{n} \mu_A(x_k) * x_k}{\sum_{k=1}^{n} \mu_A(x_k)}. \quad (12)$$

3.5. Research Procedure. In this study, we aim to identify the factors influencing the success of oil and gas projects. The study is organized into five phases. Figure 2 presents the framework of the study.

3.5.1. Phase 1: Data Screening Prior to Exploratory Factor Analysis (EFA). Since we want to investigate success factors in the O&G industry in Iran, the statistical population of this study are experts and specialists who mostly had five years' experience in the oil and gas projects of the country. Table 3 shows the sample's descriptive statistics, including gender, age, experience, and education of study participants. 79% of the participants are male whereas 21% are female. 50% of them have a master's degree and 50% a bachelor degree as highest education degrees.

Table 4 presents the steps of the screening data for EFA and briefly the results of each step.

Of the 197 indices collected for this study, the following steps were taken to decrease the relevant number of indices:

Step 1: during two meetings (6 hours each) with experts from the O&G industry, all indices were presented and described for better understanding.

Step 2: using the fuzzy Delphi technique and experts' opinions, the total number of indices to be considered in this study was decreased to 106.

Step 3: in order to evaluate the score of each of the 106 remaining indices, the following criteria were prepared for evaluating the indices: (1) adoptability in the O&G industry of Iran, (2) ease of understanding, (3) effects in performance evaluation, (4) universality of the index, and (5) measurability of the index.

Step 4: the team of experts was asked to evaluate the indices based on a five-point Likert scale.

Step 5: the simple additive weighting (SAW) method was used to evaluate the indices. The score was used to rank the indices in descending order. An aggregate score of 70% was considered a minimum requirement. Finally, 34 indices were selected to continue the study.

3.5.2. Phase 2: Preparation of Data for the Exploratory Factor Analysis (EFA). The data for the factor analysis should contain meaningful information. We need to ensure that there is a possibility to perform the EFA. The necessary steps and results are briefly reported in Table 6.

3.5.3. Phase 3: Exploratory Factor Analysis. Kline states that the goal of most factor analysis studies is to summarize the correlation matrix in a way that can be explained in terms of main factors. To perform a factor analysis, computer programs are used in which the matrix algebra and principal component analysis (PCA) are used. Table 7 summarizes the steps and results of EFA. A questionnaire was designed for screening factors using EFA on a 9-point Likert scale. Then, these questionnaires were distributed among the DMs. The DMs are a group of nine people who have more than 25 years of O&G experience and either a higher education degree or more than 150 hours of coursework on diverse O&G subjects.

A scree plot is depicted in Figure 3. It is obvious that the slope of the curve only has slight changes after the tenth factor [63, 64]. It means that considering 10 main factors for analysis of the results appears appropriate.

After identifying the factors that are empirically related, we need to assign the factors a name by considering the related variables. According to the concepts derived from the literature review and the consultation with the experts, the considered factors are specified in Table 8. The relationships between observed and latent variables are shown in Table 9.

3.5.4. Phase 4. Confirmatory Factor Analysis (CFA). The measurement model represents the factor loads of the

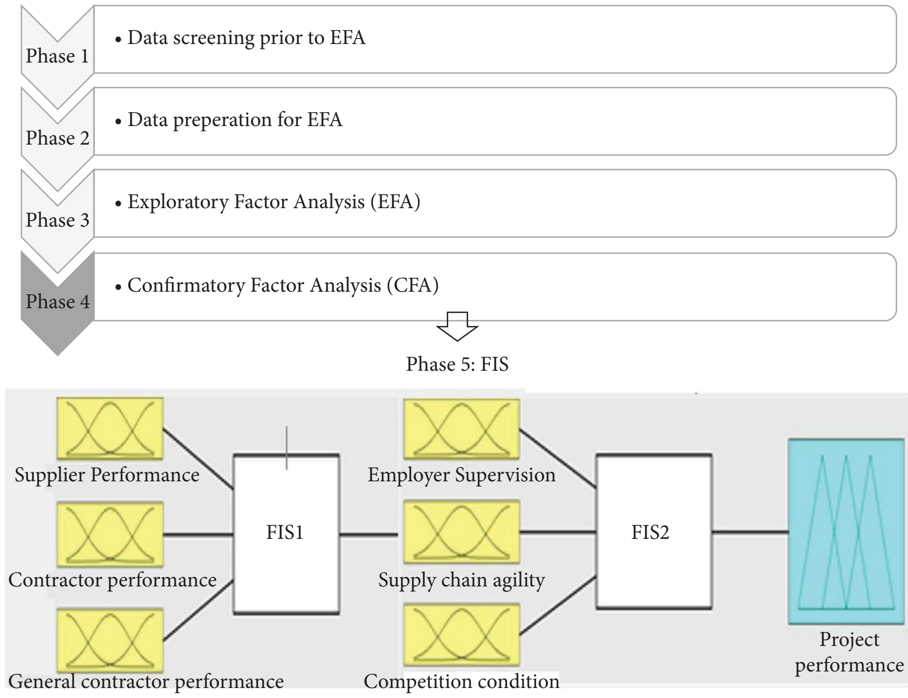

Figure 2: Framework of the study.

Table 3: Descriptive data of the sample.

	Gender		Age (years)				Experience (years)				Education degree		
	Female	Male	<30	30–40	40–50	>50	<3	3–5	5–10	>10	Associate	Bachelor	Master
Frequency	37	140	25	95	44	13	2	26	31	118	2	87	88
Percentage	21	79	14	54	25	7	1	15	17	67	1	50	50

Table 4: Steps for screening data before EFA.

Step no.	Description	Results
Step 1	Questionnaire preparation	Initially, 197 indicators were identified and after screening 34 questions were selected (Table 5)
Step 2	No missing data	Initially, 280 questionnaires were distributed among experts, while 178 were completed
Step 3	Adequate sample	Since 34 questions were considered in the study, an adequate sample size is at least 170
Step 4	No multivariate outliers	Using the Mahalanobis test and the chi-square test with threshold in 99.5%, four outliers detected and removed from the study; so, the reduced sample size is 174
Step 5	Normalization of data	Q22 and Q34 resulted skewness of −1.44 and −1.013; variable change is performed; NewQ22 and NewQ34 with skewness −0.78 and −0.038 remained in the study
Step 6	Linearity of data	Scatter plot confirmed that linearity hypothesis is satisfied

observed variables for each latent variable. The load factor has a value between zero and one. Table 10 presents the steps taken to perform CFA [65, 66]. The mentioned steps were done for each of the seven accepted factors.

3.5.5. Phase 5: Using FIS to Determine the Project Performance. In the previous steps, seven key factors which have an effect on the success of O&G projects were identified. Now, we aim to present a decision framework which enables us to evaluate the project performance. In the judgement regarding project performance, managers mostly consider verbal evaluation. Such a situation encouraged us to use FIS for a more reliable analysis of the experts' opinion regarding different projects. Using FIS, one can comment on several inputs as fuzzy, and by defining a rule, a set of fuzzy rules can be created that obtains a definite result for decision making using the implication method and ultimately the aggregation of the rules.

Our framework for decision making consists of two FIS modules. In the first module, supplier performance, contractor performance, and general contractor are considered

Table 5: Criteria of the study.

Question number	Definition of the criteria	No	Min	Max	Skewness		Kurtosis	
					Ave	STD	Ave	STD
Q1	Expertise in design & engineering	177	3	9	−0.315	0.183	−0.288	0.363
Q2	Desired quality of product	177	3	9	−0.703	0.183	0.665	0.363
Q3	Technical capability	177	3	9	−0.569	0.183	−0.092	0.363
Q4	Customer satisfaction	177	3	9	−0.648	0.183	0.256	0.363
Q5	Previous successful performance	177	3	9	−0.255	0.183	−0.585	0.363
Q6	Obligations fulfillment of contractual	177	3	9	−0.678	0.183	0.29	0.363
Q7	Successful management of supply chain	177	1	9	−0.787	0.183	1.134	0.363
Q8	Economic stability	177	3	9	−0.751	0.183	0.622	0.363
Q9	National currency strength	177	1	9	−0.45	0.183	0.171	0.363
Q10	Political stability	177	3	9	−0.696	0.183	−0.191	0.363
Q11	International competition in O&G industry	177	1	9	−0.551	0.183	0.525	0.363
Q12	Rate of return	177	3	9	−0.686	0.183	−0.178	0.363
Q13	Qualified labor	177	3	9	−0.556	0.183	−0.293	0.363
Q14	Accuracy of data	177	3	9	−0.278	0.183	0.249	0.363
Q15	Management commitment	177	1	9	−0.859	0.183	1.245	0.363
Q16	On-time decision making	177	1	9	−0.38	0.183	−0.234	0.363
Q17	On-time reply to customer demand	177	3	9	−0.515	0.183	−0.247	0.363
Q18	Long-term cooperation with suppliers	177	3	9	−0.05	0.183	−0.567	0.363
Q19	Long-term cooperation with customers	177	3	9	−0.035	0.183	−0.632	0.363
Q20	Inter-organizational relationship	177	3	9	−0.474	0.183	0.303	0.363
Q21	Information accuracy inside organization	177	3	9	−0.505	0.183	−0.01	0.363
Q22	Completion of the project with planned budget	177	1	9	−1.488	0.183	2.159	0.363
Q23	Completion of the project with planned time	177	3	9	−0.891	0.183	0.109	0.363
Q24	Investment profit	177	3	9	−0.738	0.183	0.531	0.363
Q25	Meeting the customer expectations	177	3	9	−0.671	0.183	0.503	0.363
Q26	Desired deliverables quality	177	3	9	−0.651	0.183	0.348	0.363
Q27	Knowledge management	177	1	9	−0.668	0.183	0.598	0.363
Q28	Proper execution of scheduled projects	177	1	9	−0.893	0.183	1.575	0.363
Q29	Cost control	177	3	9	−0.593	0.183	0.391	0.363
Q30	Desired quality of work	177	3	9	−0.845	0.183	0.793	0.363
Q31	Eradicate corruption	177	1	9	−0.73	0.183	0.084	0.363
Q32	Customer satisfaction	177	1	9	−0.78	0.183	0.704	0.363
Q33	Compliance with domestic and international laws and standards	177	1	9	−0.698	0.183	0.316	0.363
Q34	Senior contractor commitment	177	1	9	−1.008	0.183	2.86	0.363

Table 6: Steps for preparation of data for EFA.

Step no	Description	Results
Step 1	Factorability of the correlation matrix	KMO is 0.799 which means the sample size is adequate; Bartlett's test significance value is 0.000, which implies that at least two questions have a correlation to each other, and we can apply EFA
Step 2	Communalities	Using principal component analysis (PCA), Q15 with extraction the communality of 0.457 was removed and the number of questions reduced to 33 factors
Step 3	Reliability test	Using SPSS, Cronbach's alpha was 0.598 which indicates that reliability of the questionnaire is acceptable
Step 4	Measuring sample adequacy (MSA)	KMO value for each question checked by anti-image matrix and the sample size for all questions was adequate

as inputs of the FIS1, while the output is the score of the supply chain agility. Likewise, FIS2 considers supply chain agility, competition condition, and customer supervision scores as the inputs. The output of FIS2 is the project performance score. Figure 4 presents the decision framework.

According to the FIS method, linguistic variables were designed for the questionnaire. DMs provide responses to the questions with verbal specification instead of using crisp

Table 7: Steps of EFA.

Step no	Description	Results
Step 1	Initial extraction	Initially 10 factors were detected which explained 63% of the cumulative variance
Step 2	Rotated component matrix	Varimax rotation methods used to detect the loading of each question on each factor
Step 3	Assigning questions to factors	Since some factors loaded with less than 2 questions, finally 7 factors were detected
Step 4	Naming the factors	Considering the literature review and expert's opinion 7 factors were named

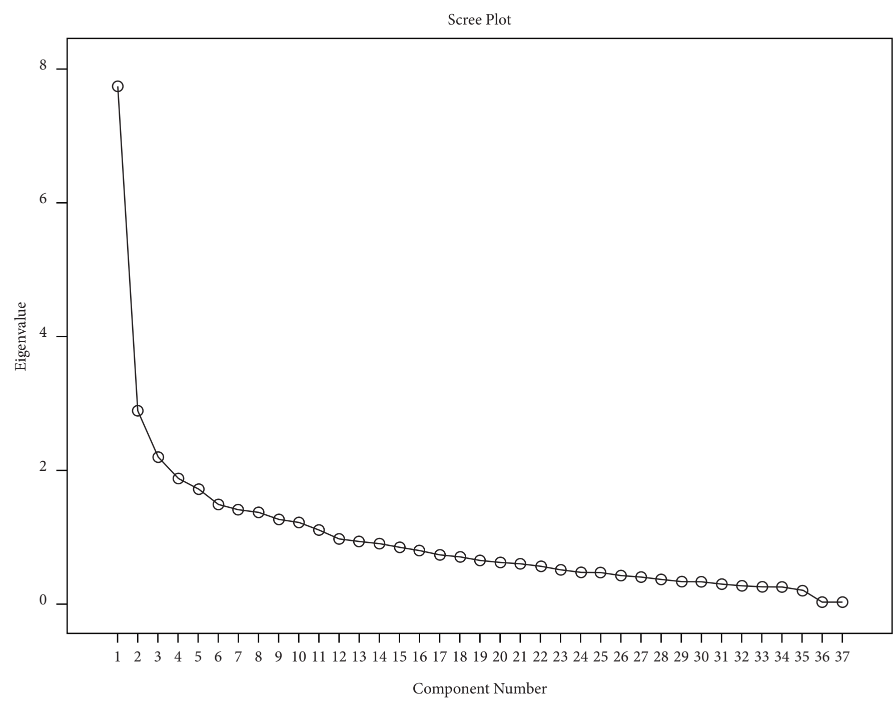

Figure 3: Scree plot.

Table 8: Considered factors.

Factor no	Name of the factor	Questions	Factor no	Name of the factor	Questions
1	Customer supervision (cus sup)	NQ22, Q29, Q28, Q23	6	Competition conditions (compete)	Q10, Q11, Q12
2	Project performance (prj per)	Q24, Q25, Q26, Q31	7	Supplier performance (sup per)	Q4, Q5, Q6, Q7
3	Contractor performance (contr per)	NQ34, Q30, Q32, Q33	8	Not accepted	Q8, Q9
4	Supply chain agility (SC agility)	Q13, Q14, Q20, Q21, Q27	9	Not accepted	Q18, Q19
5	General contractor performance (GC per)	Q1, Q2, Q3	10	Not accepted	Q16, Q17

numbers. These verbal expressions comprise "low," "middle," and "high" or "low," "middle 1," "middle 2," and "high." In the other words, these linguistic variables relate to a fuzzy membership function.

Table 11 shows the membership functions related to each factor.

Figures 5 and 6 show the membership functions of FIS1 and FIS2.

In the definition of the membership functions, the input and output variables of the triangular membership function are used as needed to optimally reflect the decision-making conditions. In order to extract the rules, a group of three experts was chosen. After explaining the process of decision-making and further discussion among the group of experts, they agreed upon the final inference engines (rule tables) for FIS1 and FIS2 as illustrated in Tables 12 and 13.

The suggested fuzzy inference system helps managers decide on the performance of different projects. Figure 9 shows the schematic rule viewer of the MATLAB Software for the FIS2. The inputs for FIS1 are supplier performance = 8, contractor performance = 6.5, and general contractor performance = 4. The output of the FIS1 is calculated as 6.08. Considering completion condition = 7 and customer supervision = 5 with the value attained from FIS1, the project performance is calculated as 8.87.

Table 9: Relationships between observed and latent variables.

Observed variable		Latent variable	Estimate	Observed variable		Latent variable	Estimate
Q30	<---	Contractor.perf	0.711	Q24	<---	Project.perf	0.515
Q32	<---	Contractor.perf	0.616	Q25	<---	Project.perf	0.705
Q33	<---	Contractor.perf	0.723	Q26	<---	Project.perf	0.551
NQ34	<---	Contractor.perf	0.655	Q31	<---	Project.perf	0.541
Q4	<---	Supplier.perf	0.423	NQ22	<---	employer.supervision	0.662
Q6	<---	Supplier.perf	0.634	Q23	<---	employer.supervision	0.924
Q5	<---	Supplier.perf	0.412	Q28	<---	employer.supervision	0.616
Q7	<---	Supplier.perf	0.604	Q29	<---	employer.supervision	0.485
Q10	<---	competition.condition	0.497	Q1	<---	General.contractor.perf	0.7
Q11	<---	competition.condition	0.704	Q3	<---	General.contractor.perf	0.676
Q12	<---	competition.condition	0.645	Q2	<---	General.contractor.perf	0.539
Q13	<---	SCagility	0.67	Q20	<---	SCagility	0.635
Q14	<---	SCagility	0.453	Q21	<---	SCagility	0.613
				Q27	<---	SCagility	0.462

Table 10: Steps of CFA.

Step no	Description	Results
Step 1	Normality test	Questions corresponding to one factor should have a multivariate normal distribution; outliers shall be omitted; using the mahalonobis test, outliers were detected and removed from the study
Step 2	Bootstrapping	If normality could not be attained, bootstrapping is used for the reliability of the estimates
Step 3	Degree of freedom	It identifies the number of free parameters which could be used to fit the model
Step 4	Model fitness	Some indices are checked to ensure goodness of fit
Step 5	Modifications	To attain high goodness of fit, some modifications can be made to the model

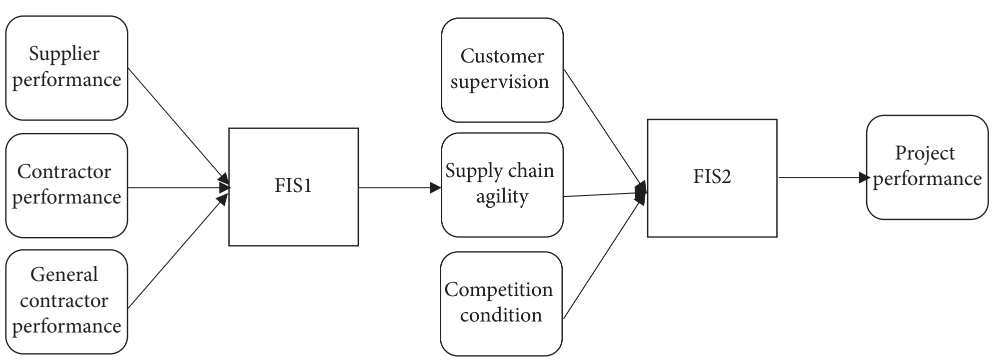

Figure 4: Decision framework.

Table 11: Membership functions.

Input	Low (triangular)	Normal (triangular)	Good (triangular)
Supplier performance	(0, 0, 5)	(4.5, 6, 9)	(7.5, 10, 10)
Contractor performance	(0, 0, 4)	(1, 5, 9)	(6, 10, 10)
General contractor performance	(0, 0, 5.7)	(5, 6.5, 7.5)	(7, 10, 10)
Supply chain agility	(0, 0, 5.5)	(4.5, 6.2, 7.5)	(7, 10, 10)
Customer supervision	(0, 0, 5)	(4.5, 5.5, 7)	(6.5, 10, 10)
Competition condition	(0, 0, 5.5)	(5, 6, 7)	(6.5, 10, 10)
Project performance	(0, 0, 6)	(5.5, 6.5, 8)	(7.5, 10, 10)

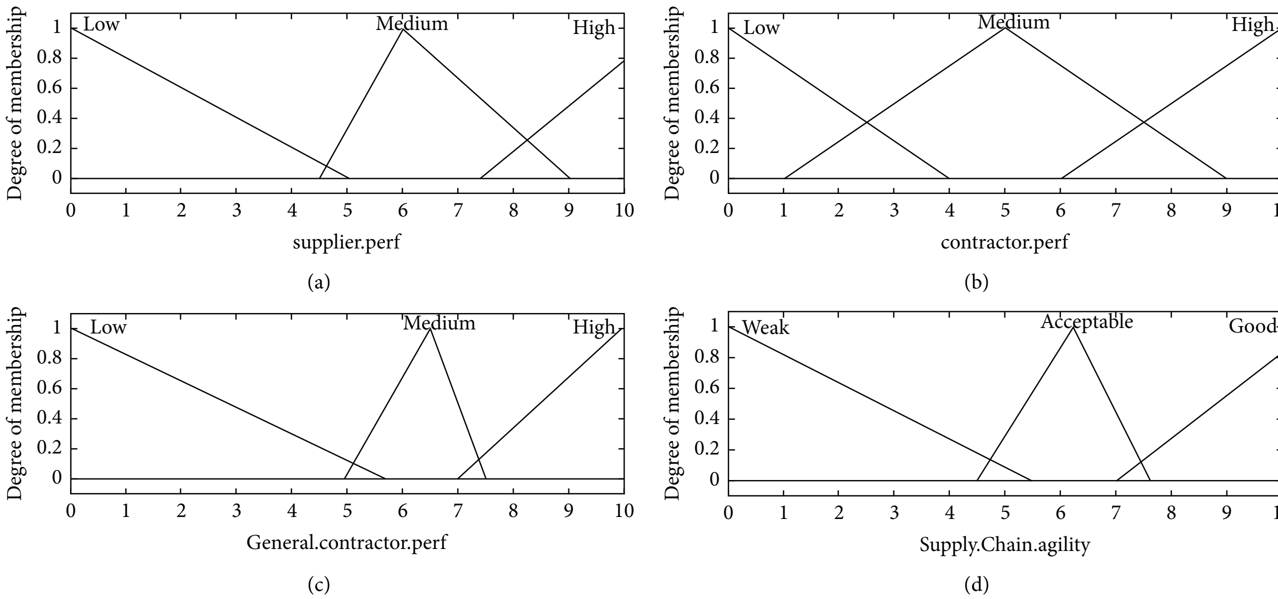

Figure 5: (a) Membership function of supplier performance, (b) membership function of contractor performance, (c) membership function of general contractor performance, and (d) membership function of supply chain agility.

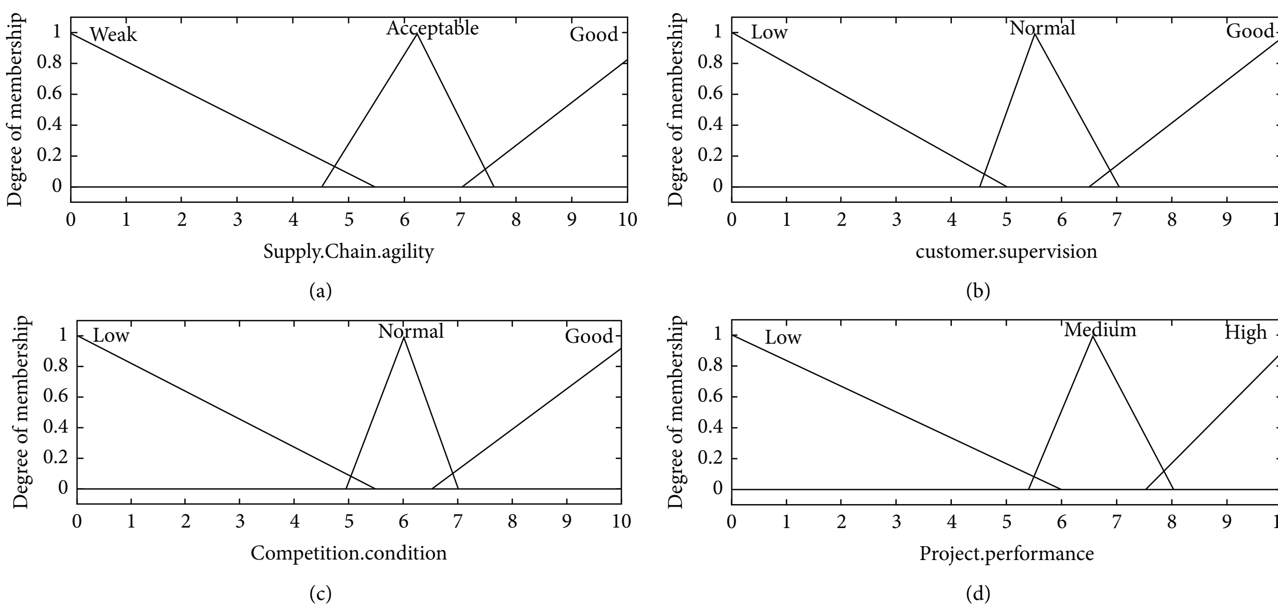

Figure 6: (a) Membership function of supply chain agility, (b) membership function of customer supervision, (c) membership function of competition condition, and (d) membership function of project performance.

Here, we applied the proposed model for deciding on five oil and gas projects which were running in Iran. A group of six experts which were fully involved in project planning and control of the mentioned projects was nominated. Since the key factors involved in evaluating the project performance had been previously identified, the experts could easily express their score for each of the factors. Table 14 summarizes the average scores of the experts for each factor regarding the five projects.

4. Results and Discussion

As is often pointed out, the search for suitable suppliers may lead to significant increases in the performance of companies. In this research, related success factors are customized using statistical methods and ranked based on a FIS. A careful investigation of the questions about the individual factors helps us understand them more precisely.

In short, the factors which guarantee the success of the oil and gas projects fall into two categories, namely, internal

Table 12: Inference engine for FIS1.

				GC		
				L	M	H
			L	W	W	AC
	L		**M**	W	AC	G
			H	W	AC	G
			L	W	AC	G
SP	**M**	**CP**	**M**	AC	AC	G
			H	AC	G	G
			L	AC	AC	G
	H		**M**	AC	G	G
			H	AC	G	G

SP, supplier performance; W, weak; CP, contractor performance; AC, acceptable; GC, general contractor; G, good.

Table 13: Inference engine for FIS2.

				CC		
				L	N	G
			L	L	L	M
	L		N	L	M	H
			G	L	M	H
			L	L	M	H
SCA	N	ES	N	L	M	H
			G	L	M	H
			L	L	M	H
	G		N	L	M	H
			G	M	M	H

SCA, supply chain agility; L, low; ES, employer supervision; M, medium; CC, completion condition; H, high.

and external factors. Internal factors include supplier performance, contractor performance, and general contractor performance. Internal factors directly influence the supply chain agility. External factors such as competitive conditions and supervision of project drivers together with agile supply chain aspects constitute the performance of the project.

Referring to Table 5, factor 1 includes the main aspects of project control, that is, time and cost. The questions related to the second factor mostly focus on project deliverables such as profit of the project and stakeholder expectations from the project. Commitment of the contractor and their compliance with domestic and international laws and standards are the main elements considered in the third factor. The questions related to the fourth factor deal with the main agility aspects of each organization. Agility dimensions which are important in O&G projects as revealed in this study are interorganizational relationships and a smooth data and knowledge management flow. Another important pillar in running the projects is the expertise of the general contractor in the design and engineering of the project which is defined by the questions related to the fifth factor.

The political stability of the country and the international competition of the O&G industry are considered a competitive condition. Based on the current study, the fulfillment of the contractual obligations is highly affecting (0.634) supplier performance. Compliance with domestic and international laws and standards plays a key role (0.723) in improving contractor performance. Improvements in general contractor performance are mainly due to high expertise in design and engineering with the severity of 0.7. Qualified labor is known as the most effective variable (0.67) in designing an agile supply chain in the Iranian O&G industry.

The most important variable in customer supervision is the completion of the project in the scheduled time with the estimated value of 0.924. International competition in the O&G industry is the most impactful variable for the competitive condition. When evaluating the project performance, meeting customer expectations has the highest effect with an estimate of 0.704.

As a main result of our research, it is demonstrated how suppliers can be selected in the O&G industry of Iran based on these factors. This "road map," for finding and selecting better suppliers, is illustrated for five O&G projects. Table 12 presents the respective results regarding the project performance of the considered projects P1, . . ., P5.

Comparing the project performance of P1 and P2 reveals that both have almost the same score, but the supply chain agility of P2 is higher than of P1 which means that players of the supply chain of P2 are more agile than those of P1. Despite the high supply chain score of P3 (7.37), the final score of FIS2 is very low. This is due to low competitive condition score, while other input variables achieved average

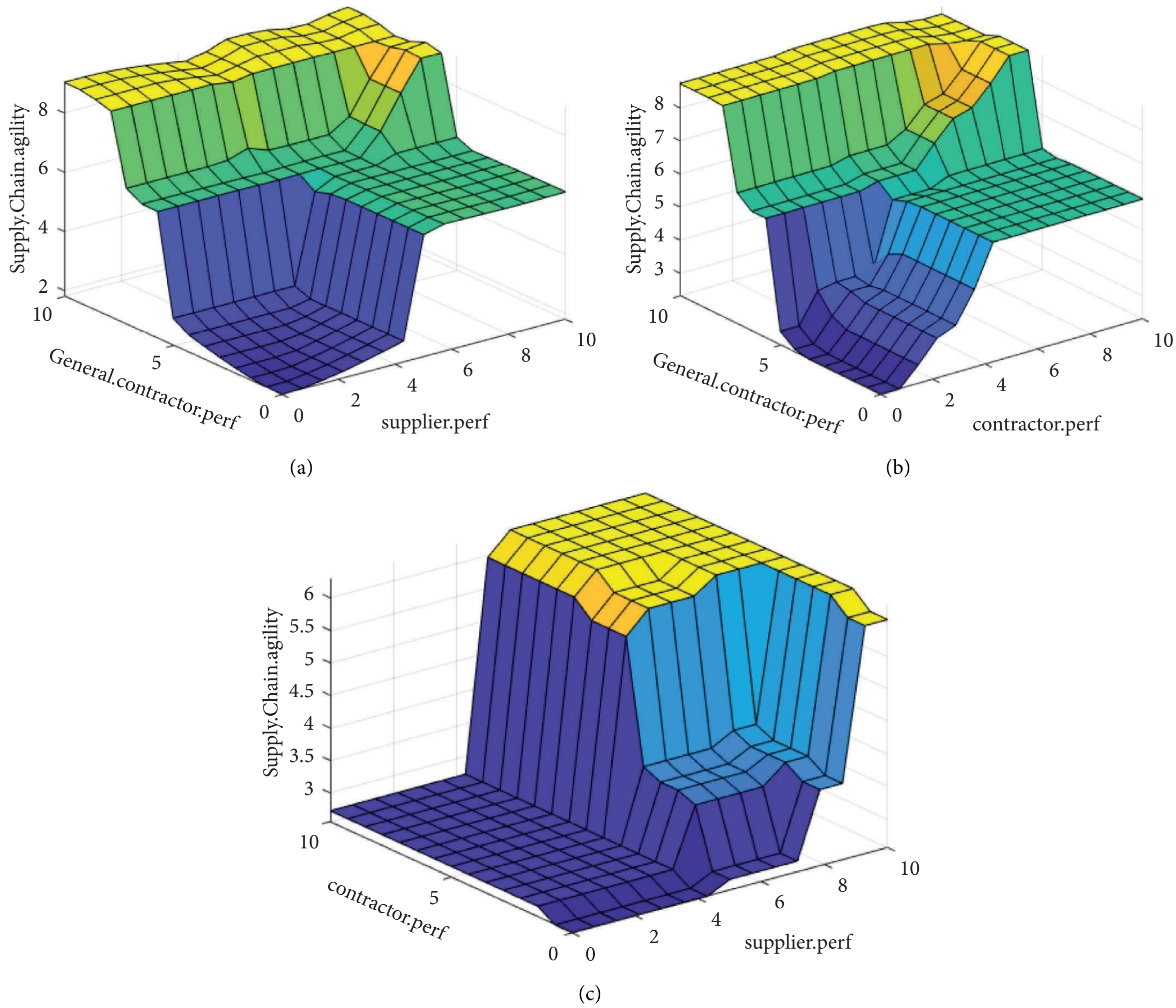

Figure 7: Output surface of FIS1: (a) effect of general contractor and supplier contractor performance on supply chain agility, (b) effect of general contractor and contractor effect on supply chain agility, and (c) effect of supplier and contractor effect on supply chain agility.

scores in FIS1 and FIS2. P4 has high scores regarding contractor performance, general contractor performance, and supply chain agility, but supplier performance is on an average level. High supply chain agility cannot guarantee a high project performance score due to an average score of customer supervision and in relation to the competitive condition. Most of the inputs of P5 are on average levels (using the Mahalanobis test and the chi-square test with 99.5%). Thus, the project performance of P5 is also calculated as average.

The most important result is that good supplier, contractor, and general contractor performance would increase the agility of the supply chain. Moreover, a high level of customer supervision and a focus on the competitive condition would help the projects achieve high performance.

To study the effect of the general contractor on the agility of the supply chain, we corrected the input data for other factors (contractor performance and supplier performance) in FIS1. Figure 10(a) shows that, by increasing the general contractor score, the supply chain agility increases. An increased general contractor score of more than 7 would significantly increase the agility of the supply chain. The maximum score of the agility of the supply chain is 7.42.

Likewise, general contractor performance and contractor performance scores were considered fixed. Figure 10(b) reveals that an increase in supplier performance slowly leads to an increase in the agility of the supply chain. In this case, the maximum attainable agility of the supply chain is 6.09.

Also, supplier performance and general contractor performance are fixed to investigate the effect of contractor performance on the agility of the supply chain. Figure 10(c) reveals that by an increase in contractor performance the agility of the supply chain does not change but remains stable.

Figure 10(d) shows that increasing all three inputs simultaneously results in an increase in supply chain agility. It is notable that by simultaneously increasing all three inputs above 4.5, the agility of the supply chain undergoes a major change. It proves that it is irrefutable that general contractor, contractor, and supplier need to be coordinated to make the supply chain agile.

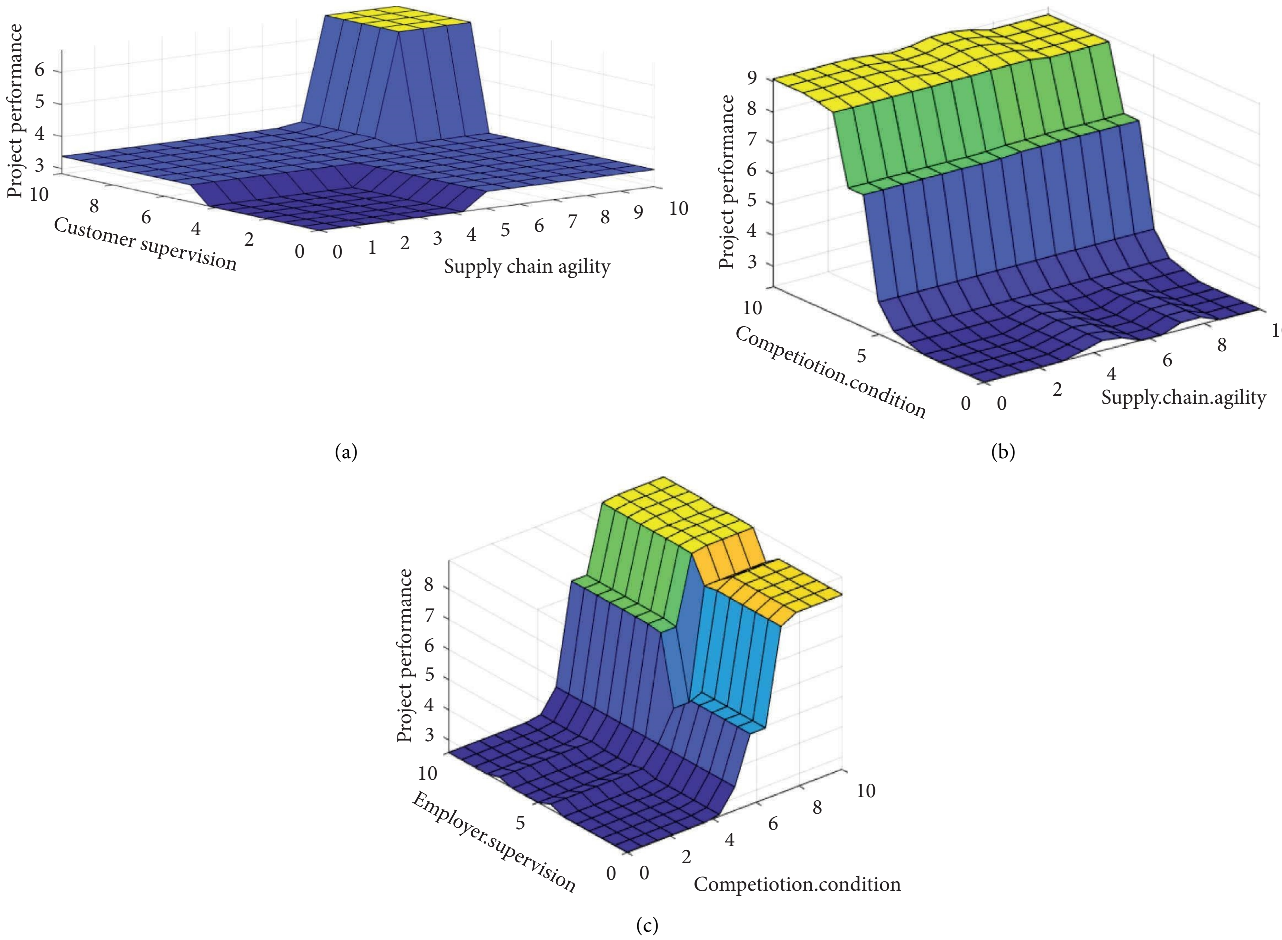

Figure 8: Output surface of FIS2: (a) effect of customer supervision and supply chain agility on project performance, (b) completion condition and supply chain agility on project performance, and (c) effect of completion condition and customer supervision on project performance.

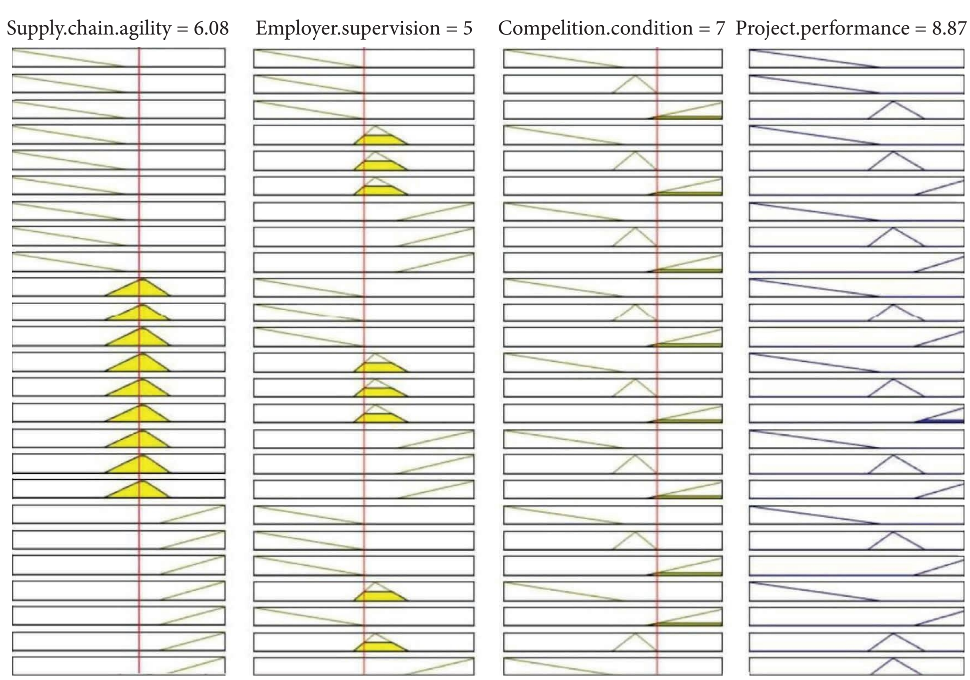

Figure 9: Rule viewer of FIS2.

Table 14: Average scores of the experts.

Input	P1	P2	P3	P4	P5
Supplier performance	3.68	6.85	8.24	5.64	6.28
Contractor performance	7.32	8.36	5.21	7.25	5.37
General contractor performance	6.82	6.45	5.3	7.68	6.48
Supply chain agility	6.08	8.17	7.37	8.73	6.11
Customer supervision	4.23	3.26	6.2	5.27	3.78
Competition condition	5.65	5.46	3.2	6.23	5.23
Project performance	6.7	6.49	2.79	6.68	5.39

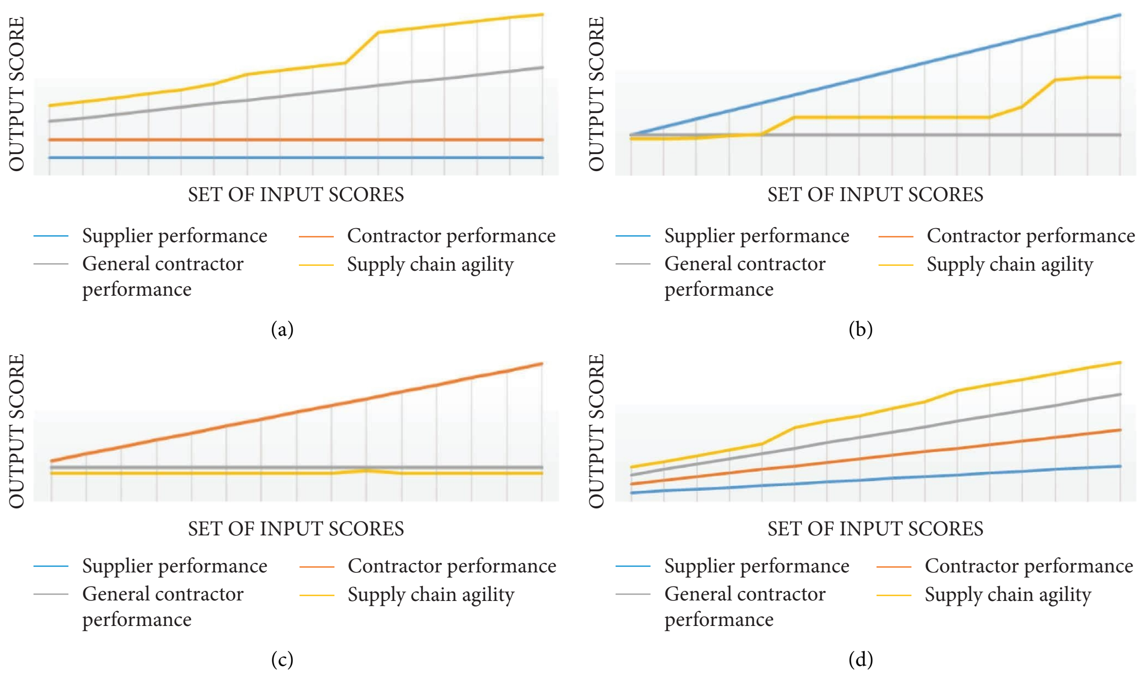

Figure 10: Simultaneous effects of inputs and output of FIS1.

To investigate the effects of an increase in the competition condition on project performance, we fixed other inputs (supply chain agility and customer supervision) in FIS2. Figure 11(a) reveals that an increase in the competition condition does not have a meaningful effect on the project performance excellence (until threshold 6.5; using the Mahalanobis test and chi-square this threshold corresponds to 99.5% significance). This slowly helps increase project performance. For values above 6.5, a huge change in project performance occurs, and more than the mentioned completion condition score, project performance remains stable.

In Figure 11(b), the values for supply chain agility and competitive condition scores are fixed values, while increases in customer supervision scores are investigated for project performance. By increasing the customer supervision score, the project performance stays stable and no notable changes occur. Figure 11(c) investigates the effect of an increase in the agility of the supply chain on project performance which reveals that supply chain agility alone is not enough to increase the project performance and therefore other drivers are needed.

Figure 11(d) presents the simultaneous effects of three inputs (customer supervision, supply chain agility and competitive condition) on project performance. It is obvious that by synchronizing the increase of the inputs, the project performance yields better results. An important point is that by reaching the input scores to threshold 5 (it means that the inputs reach average performance levels), a huge improvement in project performance is attainable. If the main players of the supply chain (supplier, general contractor, and contractor) all work well and show acceptable performance, with powerful customer supervision and considering the competitive condition, one can guarantee that the project would achieve perfect results.

Our results confirm the findings of Yazdi et al. [9] regarding the factor of quality. Both papers focus on an uncertain environment in general. However, in this paper, all factors and methods consider uncertainty. On the contrary, our findings are in contradiction with Tang et al. [50] where the authors considered all items in a certain environment, although occasionally the environment is vague in some cases. The assumed reason for the contradiction is differences in the situation of Iran compared with other countries.

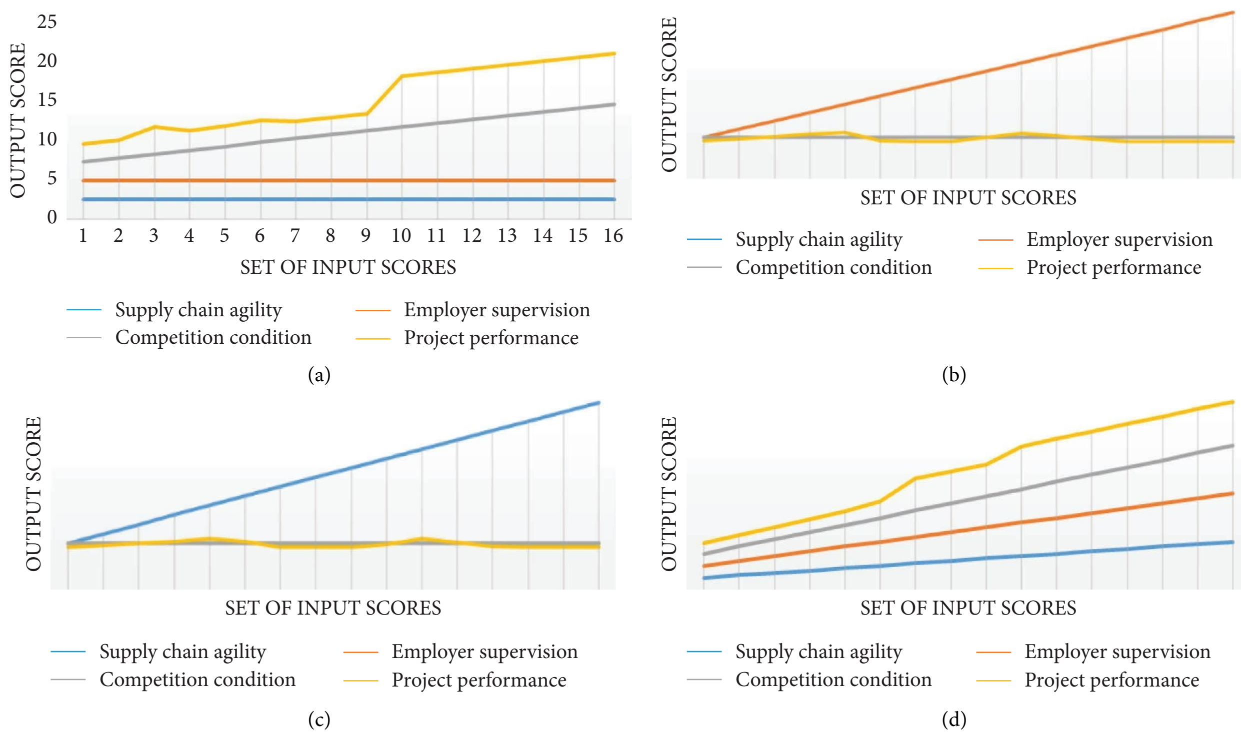

Figure 11: Simultaneous effect of inputs and outputs of FIS2.

Using our model, companies can evaluate projects in the O&G industry. Many countries need to invest in the extraction of oil and natural gas to secure the world's energy supply. A lack of oil and natural gas would harm global economy. Hence, it is essential to find the best projects that have high productivity and high revenue. This model helps O&G companies to evaluate O&G projects according to determined relative factors. The model demonstrated how to customize the plentitude of factors (selection of the relevant factors) by a statistics method to support companies in decision making under uncertainty. Moreover, we have shown through a reliability test that this method can be generally applied in the field of project selection in O&G companies.

5. Conclusions

Today, the O&G industry plays a key role in many countries. Therefore, many governments are striving for sustainable utilization of oil resources. Oil and gas fields are to be utilized at the lowest cost, but many further factors influence the choice of O&G fields. For instance, in the context of this research, there are many similarities between Iran and the Persian Gulf Region Countries (PGRC) with high economic importance. The capacity of the areas, access to refine facilities, expert staff, ports, budget, and other factors can have an impact on decisions to select related O&G projects. Many studies mentioned indices that strongly influence the success of O&G projects. In this study, we have made a literature review and by the help of O&G experts we tried to explore the main indices that influence the success of the O&G projects in Iran. More than 200 experts replied to the questions by completing the questionnaire.

An exploratory factor analysis introduced seven main items that have the largest effect on the successful implementation of O&G projects. Group interviews with experts helped us define a conceptual model that was presented in Figure 2. To make sure that the observed variables correctly estimated the latent variable, a confirmatory factor analysis was conducted. Since the assumption of the normality distribution of data was not supported, the bootstrapping technique helped us rely on the estimates. A two-steps fuzzy inference system was designed to evaluate the project performance of five projects in the Iranian O&G industry. Based on the assessment of the individual factors by experts, the inference system calculated the performance of the projects.

Sensitivity analysis of the inputs and outputs of each FIS revealed the impact of the factors. Results proved that to increase supply chain agility in Iranian O&G projects, it is crucial that all partners in the supply chain, including supplier, contractor, and general contractor show their best performance. To improve project performance besides an agile supply chain it is important that customers have a good supervision and exactly consider the competitive condition in international O&G projects. The proposed framework helps Iranian managers to focus on the important aspects of the O&G projects, and by understanding the relation between them, they can define more effectively supply chain management and project performance strategies. The result of this study demonstrates that among those factors extracted from previous studies, seven main factors were selected using a statistical method. Then, using two FIS methods as a decision support system, O&G projects were selected. This model shows how projects will be selected in an uncertain environment. The reliability test indicates that this model can be generalized in the field for all O&G projects.

A main limitation of this study is the access to DMs. Since the DMs operate in many different regions of Iran, access to them proved difficult. Moreover, most of them were busy, and hence, this research took more time than expected.

For future research, the fuzzy Delphi method can be used for customized CSFs for O&G project selection. In addition, MADM methods can be applied to rank these factors.

Data Availability

The data used to support the findings of this study can be obtained from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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