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ABSTRACT
Workplace spirituality has gained attention as it is proven to be a contributor to organizational performance improvement. This paper aims to assess the impact of human resource spirituality on the success of organizational strategic change projects. The success of the projects is measured by the well-known criterion of deviation from the planned budget cost. Data collection is based on a questionnaire survey of 252 personnel in 36 large and medium-scale organizational change projects in power industry. The paper proposes an integrated algorithm of fuzzy data envelopment analysis (FDEA) and adaptive network-based fuzzy inference system (ANFIS) for measuring the pure effect of human resource spirituality on the success of organizational change projects in the power industry. It also achieves a verified tool capable of addressing complexity, nonlinearity, ambiguity, and fuzziness for measuring spirituality of human resources in the projects. Results show that spirituality of the project team has a significant effect on project success.

KEYWORDS
ANFIS; fuzzy DEA; human resource; spiritual intelligence; workplace spirituality

Introduction

Spiritual intelligence (SQ) is a type of intelligence with which people address and solve problems of meaning and value, place their actions, and live their life meaningfully. As discussed by Zohar and Marshall (2000), SQ is a shared field of meaning in the organization; hence, spiritual capital could be considered as a cultural aspect of an organization, including shared motives, common behaviors, and joint attitudes. Behavioral changes can be brought about by changes in the business culture and the stock of spiritual capital could ease the process of transformation or change. In the workplace, SQ helps workers in the context of relationships and aligns personal values with a clear sense of purpose, which demonstrates a high level of integrity

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in work (Chin, Anantharaman, and Tong 2011). Accordingly, one may assume that successfully changing organizations that have undergone massive changes in their projects might have benefited from their stock of spiritual capital.

Researchers have gathered evidence that shows workplace spirituality may offer further insights into different aspects of organizational performance including effectiveness (Jurkiewicz and Giacalone 2004), workforce performance (Rani, Abidin, and Hamid 2013; Karakas 2000), cost effectiveness (Boettke 2010), learning (Howard 2002), job satisfaction and involvement (Milliman, Czaplewski, and Ferguson 2003) and commitment and loyalty (Rego and Pina e Cunha 2008). These studies have inspired and encouraged the current study to seek validated tools and development of new methods to quantify the impact of workforce spirituality on project success.

An important issue in spirituality measurement is the multi-faceted nature of SQ (Amram and Dryer 2008; Boettke 2010; Liu and Robertson 2010), rendering the measurement instruments multivariate. Developing a unique and single measure of spirituality may be of interest especially when comparing spirituality in different workplaces. Recently, Taghizadeh Yazdi (2015) has proposed a new multivariate analysis model for SQ quantification. Another issue is the extreme objectivity in spirituality research (Krahnke, Giacalone, and Jurkiewicz 2003; King and Crowther 2004), which in turn calls for nondeterministic approaches like fuzzy logic to address the problem.

This paper makes use of a well-known multivariate analysis method namely fuzzy data envelopment analysis (FDEA) for SQ quantification, which is capable of handling fuzzy uncertainty and ambiguity in the modeling environment. Moreover, this method is integrated with adaptive neuro-fuzzy inference system (ANFIS) to explore the effect of SQ capital of the project team on project success. ANFIS is capable of modeling nonlinear, complex relationships in ambiguous fuzzy modeling environments (Nazari-Shirkouhi, Keramati and Renzaie, 2013). The success of a project is considered from the viewpoint of the project team or project manager and is expressed within the well-known "iron triangular" framework. In this framework, the main project success criteria are cost, time, and quality (Davis 2014).

In recent years, the integration of data envelopment analysis with different expert systems has found interesting applications in human-related qualitative assessment including personnel productivity improvement (Azadeh et al. 2017a), measuring the performance of knowledge management system (Lee, Hong, and Suh 2016; Shirouyehzad, Mokhatab Rafiee, and Berjis 2017), and measuring integrated resilience engineering (Azadeh, Salmanzadeh-Meydani, and Motevali-Haghighi 2017b). Danquah and Amankwah-Amoah (2017) studied relationships between human capital, innovation and technology adoption using DEA model. Using an input-oriented DEA model, Azadeh et al. (2017c) studied used DEA model to evaluate the mutual impacts of managerial and organizational factors and resilience engineering for 41 DMUs including managers and experts in gas refinery.

In this study, a survey was conducted in a large industrial group which had undergone medium- and large-scale strategic change projects, and data on the individuals' SQ as well as the factors that might contribute to project success were collected based on a questionnaire survey of the team members in 36 different projects. The paper aims at developing a quantitative measure to assess the overall level of spirituality of project team members (using FDEA) and then to distinguish the effect on project success of human resource spirituality form the other contributing factors of project success (using ANFIS).

First, the statistical distribution of the scores of questionnaire items related to each of SQ characteristics was aggregated into a single fuzzy measurement. Then, FDEA was used for total SQ quantification. For verification and validation, fuzzy DEA was applied in different α-feasible levels and its result was tested for compatibility and homogeneity. Furthermore, the results of FDEA for SQ quantification are validated with the results of another multivariate method namely principal component analysis (PCA), applied to the same problem. Finally, the study uses ANFIS to estimate the functional relationships of SQ as well as other project success factors including clear mission, competence and commitment, and organizational culture with cost deviations of the projects. This estimated functional relationship provides us with all the necessary information to study the effect of spiritual intelligence on project success.

The rest of the paper is organized as follows. In "Principles of transformation" section, a brief description of the twelve qualities distinctive of spiritual intelligence is presented. "The integrated methodology" section illustrates the integrated methodology, survey study, questionnaire design, and data validation. The results of FDEA and ANFIS are presented in "Experiments and results" section. Validation and verification of model is presented in "Verification and validation" section. The paper ends in "Conclusion" section with the main findings and proper conclusion.

Principles of Transformation

This section is devoted to description of the 12 principles of transformation. These principles are also the main characteristics of the SQ. Following each characteristic, a short list of descriptive phrases is given. For more comprehensive description of these characteristics, interested readers are referred to Zohar and Marshal (2004)

1. *Self-awareness*. To know what I believe in and value and what deeply motivates me. Awareness of my deepest life purposes.
2. *Spontaneity*. To live in and be responsive to the moment and all that it contains.

3. Being vision- and value-led. Acting from principles and deep beliefs, and living life accordingly.
4. *Holism* (a sense of the system or of connectivity). Ability to see larger patterns, relationships, connections. A strong sense of belonging.
5. *Compassion*. Quality of "feeling-with" and deep empathy. Ground-work for universal sympathy.
6. *Celebration of diversity*. Valuing other people and unfamiliar situations for their differences, not despite them.
7. *Field independence*. To be able to stand against the crowd and maintain my own convictions.
8. *Tendency to ask fundamental why?* questions. Need to understand things, to get to the bottom of them. Basis for criticizing the given.
9. *Ability to reframe*. Stand back from the problem or situation and look for the bigger picture or the wider context.
10. *Positive use of adversity*. Ability to own and learn from mistakes, to see problems as opportunities. Resilience.
11. *Humility*. Sense of being a player in a larger drama, sense of my true place in world. Basis for self-criticism and critical judgment.
12. *Sense of vocation*. Being "called" to serve something larger than myself. Gratitude toward those who have helped me, and a wish to give something back. Basis for the "servant leader."

The Integrated Methodology

Figure 1 shows a step-by-step representation of the integrated methodology. Besides, a full description on the theory of FDEA will be presented in this section. In the first step, a questionnaire is designed referring to the 12 characteristics of SQ described in "Principles of transformation" section and project success factors that will be described in "Project success factors" section. Subsequently, data are collected using a questionnaire and then the reliability of the questionnaire is tested. Following the reliability test, FDEA is utilized for individual SQ quantification. Each SQ characteristic is tested for by several questions (items) and then by a single fuzzy set, the characteristics of which (bounds and membership function) are calculated based on statistical characteristics (mean and variance) of the related items. In the next step, the results of fuzzy measurement are formulated as FDEA outputs and FDEA is performed to calculate an overall SQ-score for each of the individuals who had filled in the questionnaire (here the participating members of the projects). Since, the level of spirituality in a project is the total level of spirituality of its participating members, the overall SQ score of each project is calculated by averaging over the SQ scores of its participating members. In the final step, an ANFIS analysis is performed to estimate the effect of spirituality on project success. Three important success factors derived from

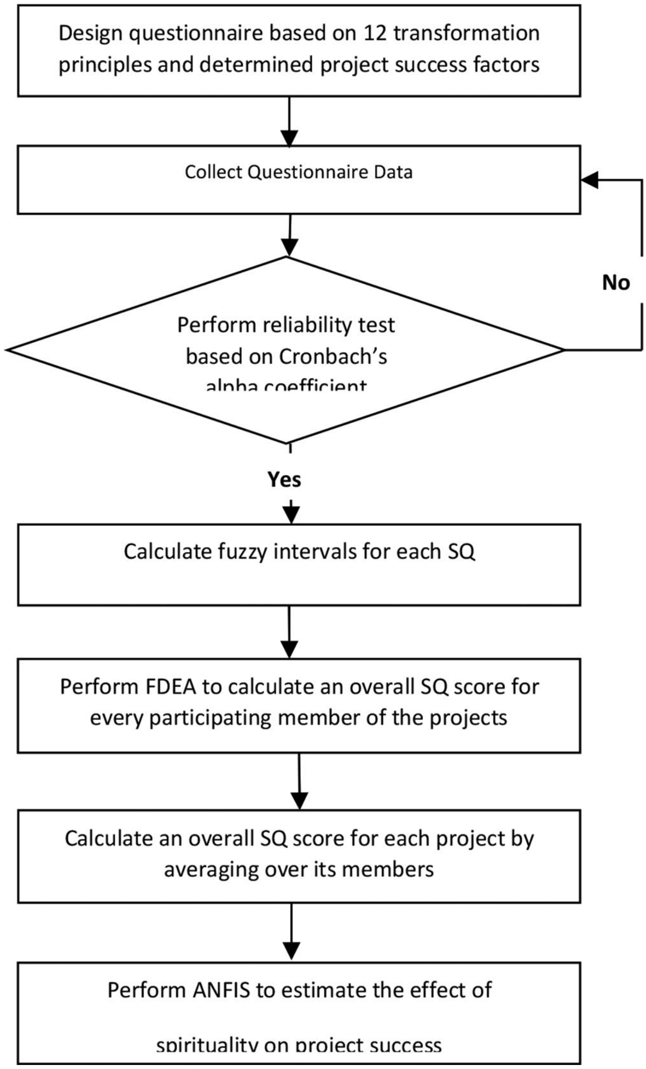

Figure 1. The integrated methodology.

the related literature as well as the spirituality score calculated through FDEA are considered to be the explanatory variables of project success. The criterion of project success is deviation from planned budgeted cost which in turn is considered as the outputs of ANFIS.

Project Success Factors

In the literature of project management, there is a great background on the development of project success, its criteria and its factors (Davis 2014). Cserháti and Szabó (2014) investigated the attributes of the success criteria and factors of organizational event projects and presented an analysis of the relationship between the criteria and factors.

Regarding their research, the success factors (SF) used for this study are listed as follows:

SF1: Clear mission

SF11 Elaboration of the objective structure

SF12 Elaboration of the task structure

SF13 Definition of the scope and responsibilities

SF2: Competence and commitment

SF21 Competence and skills of the project leader

SF22 Competence and skills of the team members

SF23 Commitment of the project team and top organizational management

SF3: Organizational culture

SF31 Communication within the project team

SF32 Information sharing within the project team

SF33 Support of teamwork

SF34 Support of individual efforts

SF35 Organizational learning

Survey

This is an exploratory study performed with a total number of 252 personnel involved in 36 large and medium-scale organizational change projects in a power supply industry in Iran. These projects vary by scope, budget and schedule, but all can be considered as strategic initiatives including eight projects adopting new international market strategy, four reengineering projects, one restructuring project, five transfer pricing projects, eight cross selling projects, and 10 new business development projects. Some of these projects were organized in the same organization and some Respondents possibly participated in more than one project. The minimum number of Respondents who were involved in a certain project was seven and the maximum was 10.

The data collection instrument was a two-section questionnaire that was constructed specially for this study based on the analysis of past studies and semi-structured interviews. In the survey, the Respondents were asked to base their responses on the experience they had had during their participation in the projects.

The first section requested information about the SQ characteristics. In Zohar and Marshall (2004), a full description of the principles includes a check section with some questions to check the status of each characteristic in a person. For the full list of these check questions, the interested readers are referred to Taghizadeh Yazdi (2015). In the current study, the 59-items SQ questionnaire developed by Taghizadeh Yazdi (2015) was used to measure the 12 principles of SQ. Regarding each question in the first section of the questionnaire, the audience were asked to respond with a six-point Likert scale (never or almost never; very infrequently; somewhat infrequently; somewhat frequently; very frequently; always or almost always), showing degrees of their agreement/disagreement with the question statement.

The second section contained questions about project success factors, where, to each factor, an extent of sophistication was assigned based on a five-point scale from very poor to excellent. This section of the questionnaire contained 11 questions corresponding to the success factors presented in "Project success factors" section.

The data regarding the project success criterion, i.e., deviation from the planned budgeted cost are collected from the records of the computerized project management system.

The potential population of respondents included about 600 project team members engaged in 36 medium- and large-scale strategic change projects. To determine the sample size, the Kukran formula is used and the sample size is calculated to be 250 respondents from the key personnel. To adjust the return rate, 20% more questionnaires were distributed than the calculated sample size and finally 252 filled questionnaires were verified to be included in the analysis.

Several meetings with the targeted audience had been held to communicate the purpose of the study and to review the concepts of SQ and project success. The audience was asked to answer the questions according to the working context which they have experienced during the execution of the projects.

Cronbach's alpha coefficient is used to check the reliability of the questionnaire (Table 1). According to Dornyei (2007), the acceptance level of Cronbach's alpha coefficient in assessment of personnel skills and attitudes is 0.7 or above. The results in Table 1 indicate that the results of questionnaires are acceptable and admissible.

Table 1. Cronbach's alpha coefficients.

Factors	Characteristics	Cronbach's alpha
Spirituality	Self-awareness	0.72
	Spontaneity	0.86
	Vision and value led	0.76
	Holism	0.8
	Compassion	0.71
	Diversity	0.78
	Field independence	0.7
	Asking why?	0.77
	Reframing	0.7
	Use of adversity	0.71
	Humility	0.84
	Sense of vocation	0.82
Project success factors	Clear mission	0.72
	Competence and commitment	0.70
	Organizational culture	0.76

Fuzzy Data Envelopment Analysis

Data Envelopment Analysis developed by Charnes, Cooper, and Rhodes (1978) is a nonparametric method to evaluate the relative efficiency of decision making units (DMUs). The DEA model developed by Banker, Charnes, and Cooper (1984), named BCC, could be utilized for the analysis of the relative efficiency of DMUs under assumption of variable returns to scale.

Referring to Zohar and Marshall (2004), the overall score of SQ was positively correlated with all the 12 SQ characteristics. Therefore, in the FDEA model, all the SQ characteristics were outputs and the FDEA model has no input. As a result, an output-oriented FDEA model without inputs was applied for total SQ quantification. Since the assumption of constant return to scale in output-oriented DEA without inputs made no sense here (Lovell and Pastor 1999), the present paper made use of an output-oriented BCC model without inputs introduced by Lovell and Pastor (1999) in which outputs are fuzzy variables (Model (1)).

$$\begin{aligned} \underset{\tau}{\text{Min}} \quad & \sum_{j=1}^{n} \tau_j \\ \text{s.t.} \quad & \sum_{\substack{j=1 \\ \tau \geq 0}}^{n} \tau_j \overline{SQ}_{ij} \geq \overline{SQ}_{io} \qquad i = 1, 2, \ldots, 12 \end{aligned} \tag{1}$$

where the fuzzy number $\overline{\text{SQ}}_{ij}$ is the SQ characteristic i (or output i) for DMU$_j$ (here Respondent j),$\overline{\text{SQ}}_{io}$ denotes the output i for DMU$_o$, i.e., the Respondent being evaluated, and there are n Respondents in the sample. Here $\overline{\text{SQ}}_{ij}$ is fuzzy numbers for which the lower and upper bounds are known. In Eq. (1), two kinds of subscripts are used: j and o. The subscript j represents a DMU and the subscript o represents the DMU under study. It should be noted that model (1) calculates the efficiency score of the DMUo (i.e., the total SQ score for Respondent j). A full run of the FDEA model involved n-times calculation of model (1) for all the respondents in the sample.

Let us show the fuzzy numbers with their upper and lower bounds, e.g., $\overline{\text{SQ}}_{ij} = (\text{SQ}_{ij}^{[1]}, \text{SQ}_{ij}^{[2]})$. Following the defuzzification procedure proposed by Jimenez et al. (2007), the α-feasible defuzzified linear model (1) can be represented as Eq. (2).

$$\begin{aligned} \underset{\tau}{\text{Min}} \quad & \sum_{j=1}^{n} \tau_j \\ \text{s.t.} \quad & \sum_{\substack{j=1 \\ \tau_j \geq 0 \forall j}}^{n} \tau_j \left[(1-\alpha) SQ_{ij}^{[2]} + \alpha SQ_{ij}^{[1]} \right] \geq \left[\alpha SQ_{io}^{[2]} + (1-\alpha) SQ_{io}^{[1]} \right] \end{aligned} \tag{2}$$

where α is the degree with which the inequality constraints are satisfied and $1-\alpha$is a measure of the infeasibility risk of a decision vector. The following definition (Jimenez 1996) will shed light on the meaning of α-feasible:

Definition (α-feasible)—Given two fuzzy numbers $\bar{a}$ and $\bar{b}$, the degree in which $\bar{a}$ is bigger than $\bar{b}$ is defined in Eq. (3):

$$\mu_M(\bar{a},\bar{b}) = \begin{cases} 0 & \text{if } a^{[2]} - b^{[1]} < 0, \\ \frac{a^{[2]} - b^{[1]}}{(a^{[2]} - b^{[1]}) - (a^{[1]} - b^{[2]})} & \text{if } 0 \in [a^{[1]} - b^{[2]}, a^{[2]} - b^{[1]}] \\ 1 & \text{if } a^{[1]} - b^{[2]} > 0. \end{cases} \tag{3}$$

where $[a^{[1]}, a^{[2]}]$ and $[a^{[1]}, a^{[2]}]$ are the expected intervals of $\bar{a}$ and $\bar{b}$, respectively. When $\mu_M(\bar{a},\bar{b}) > \alpha$, it is stated that $\bar{a}$ is bigger than or equal to $\bar{b}$ at least at αdegree and the constraint $\bar{a} \geq \bar{b}$ is α-feasible. According to Kaufmann and Gil Aluja (1992), if $\alpha = 0$, then the solution may be unacceptable. However, if $\alpha = 1$, then the solution is completely acceptable.

Adaptive Network-Based Fuzzy Inference System (ANFIS)

Neuro-fuzzy modeling (Jang 1993; Brown and Harris 1994) refers to the way of applying various learning techniques developed in the neural network literature to fuzzy modeling or a fuzzy inference system. Neuro-fuzzy system, which combines neural networks and fuzzy logic, has recently gained considerable interest in research and application. The neuro-fuzzy approach added the advantage of reduced training time due not only to its smaller dimensions but also to the fact that the network can be initialized with parameters relating to the problem domain. Such results emphasize the benefits of the fusion of fuzzy and neural network technologies as it facilitates an accurate initialization of the network in terms of the parameters of the fuzzy reasoning system.

A specific approach in neuro-fuzzy development is the adaptive neuro-fuzzy inference system (ANFIS), which has yielded significant results in modeling nonlinear functions Jang, Sun, and Mizutani (1997). ANFIS uses a feed forward network to search for fuzzy decision rules. Taking advantage of a given input–output data set, ANFIS creates a FIS whose membership function parameters are adjusted using a backpropagation algorithm alone or a combination of a backpropagation algorithm with a least squares method. This allows the fuzzy systems to learn from the data being modeled. For more details the interested readers are kindly referred to Jang, Sun, and Mizutani (1997).

Experiments and Results

Fuzzy SQ Characteristics

As mentioned before, SQ characteristics are quantified with fuzzy sets for which the lower and upper bounds need to be used in FDEA model.

First, the Project members' answers to the questions regarding each of the 12 SQ characteristics are used to calculate the lower and upper bound of the fuzzy sets. We applied the following formula to calculate the bounds:

$$\begin{aligned} \mu_{ij} &= \frac{\sum_{k=1}^{K_j} \overline{\overline{\mathrm{SQ}}}_{ijk}}{K_j}; \sigma_{\mathrm{ij}}^2 = \frac{\sum_{k=1}^{K_j} (\overline{\overline{\mathrm{SQ}}}_{ijk} - \mu_{ij})^2}{K_j - 1} \\ \mathrm{SQ}_{ij}^{[1]} &= \mu_{ij} - \sigma_{\mathrm{ij}} \\ \mathrm{SQ}_{ij}^{[2]} &= \mu_{ij} + \sigma_{\mathrm{ij}} \end{aligned} \tag{4}$$

where $\overline{\overline{\mathrm{SQ}}}_{ijk}$ is the answer of member j to item k of SQ characteristic i, and μ_{ij} and σ_{ij}^2 are the mean and variance of the answers that member j has given to the items of the SQ characteristic i. The descriptive statistics of the collected data, related to the calculated bounds, are presented in Table 2.

FDEA-SQ Scoring Results

The design of FDEA model is as follows: all the 252 respondents are considered as DMUs and the purpose of FDEA is to calculate overall SQ scores for each of the project members who respond to the questionnaire. In this FDEA model, the 12 SQ characteristics with the fuzzy data in Table 2 are considered as FDEA output variables. The FDEA model is programed in MATLAB and the results are obtained. Hence, the SQ scores for each of the project members are calculated. The level of spirituality in a project is the total level of spirituality of its participating members. Therefore, the overall SQ score of each project is calculated by averaging over the SQ scores of its participating members (Table 3).

The highest level of SQ could be derived from the results of Table 3; nonetheless, before that the reference level of α-feasible level needs to be determined. Following Jimenez et al. (2007) the selection of α-level is a trade-off between two conflicting objectives: to improve the objective function value and the degree of constraints satisfaction. As seen in Table 3 (the last row), the average efficiency scores for the α-feasible levels is increasing and on average for every 0.1 decrease in degree of constraints satisfaction, the objective function smoothly improves by 5%. Therefore, it is possible to refer to α-feasible = 0.7 for SQ quantification as a middle level to have an acceptable objective function as well as an acceptable degree of constraint satisfaction. With reference to α-feasible level 0.7 in Table 3, ANFIS is constructed with three project success factors and SQ score as its inputs and the project cost deviation as its output.

Table 2. Cronbach's alpha coefficients.

Fuzzy bound	SQ characteristic statistics	Self-awareness	Spontaneity	Vision and value led	Holism	Compassion	Diversity	Field independence	Asking why?	Reframing	Use of adversity	Humility	Sense of vocation
Lower bound	Min	0.5	0.7	0.5	0.7	0.7	0.5	0.7	0.5	0.5	0.7	0.7	0.5
	Average	3.0	3.0	3.1	3.0	3.0	3.0	3.1	3.0	3.1	3.1	3.1	3.1
	Max	6.0	6.0	6.0	6.0	5.4	6.0	6.0	6.0	6.0	6.0	6.0	5.4
Upper bound	Min	1.0	1.0	1.0	1.0	1.0	1.8	1.0	1.0	1.6	1.0	1.0	1.0
	Average	4.4	4.4	4.5	4.3	4.4	4.4	4.4	4.3	4.4	4.4	4.4	4.4
	Max	6.3	6.5	6.5	6.5	6.3	6.5	6.5	6.3	6.5	6.5	6.5	6.3
STDEV	2	1.5	1.6	2	1.52	1.5	2	1.5	1.5	1.5	1.54	1.52	

Table 3. FDEA efficiency scores for different α-feasible levels.

	FDEA efficiency in different α-cut					
Project	0.5	0.6	0.7	0.8	0.9	1.0
Project1	0.49	0.51	0.54	0.57	0.61	0.65
Project2	0.97	1.00	1.04	1.09	1.14	1.18
Project3	0.42	0.43	0.45	0.48	0.51	0.54
Project4	0.62	0.65	0.68	0.71	0.74	0.78
Project5	0.99	1.03	1.07	1.11	1.15	1.19
Project6	0.43	0.44	0.47	0.50	0.53	0.56
Project7	0.90	0.93	0.97	1.01	1.06	1.10
Project8	0.96	0.99	1.03	1.07	1.11	1.16
Project9	0.86	0.90	0.94	0.99	1.04	1.09
Project10	0.85	0.88	0.92	0.96	1.01	1.06
Project11	0.44	0.45	0.48	0.50	0.53	0.56
Project12	0.78	0.82	0.86	0.90	0.94	0.99
Project13	0.38	0.40	0.43	0.45	0.48	0.51
Project14	0.45	0.47	0.50	0.53	0.57	0.60
Project15	0.57	0.60	0.63	0.67	0.71	0.75
Project16	0.99	1.03	1.07	1.11	1.15	1.20
Project17	0.73	0.76	0.79	0.83	0.88	0.92
Project18	0.82	0.86	0.89	0.93	0.98	1.02
Project19	0.42	0.44	0.47	0.50	0.53	0.56
Project20	0.42	0.44	0.47	0.50	0.53	0.56
Project21	0.86	0.90	0.94	0.98	1.03	1.08
Project22	0.83	0.87	0.91	0.96	1.00	1.05
Project23	0.69	0.71	0.75	0.78	0.82	0.87
Project24	0.84	0.87	0.92	0.96	1.01	1.05
Project25	0.86	0.89	0.93	0.97	1.01	1.06
Project26	0.79	0.83	0.87	0.91	0.95	1.00
Project27	0.39	0.41	0.43	0.45	0.48	0.51
Project28	0.67	0.69	0.73	0.76	0.81	0.85
Project29	0.74	0.77	0.80	0.84	0.89	0.93
Project30	0.84	0.88	0.92	0.96	1.01	1.05
Project31	0.98	1.02	1.06	1.10	1.14	1.19
Project32	0.38	0.40	0.42	0.45	0.47	0.50
Project33	0.95	0.99	1.03	1.07	1.11	1.16
Project34	0.94	0.97	1.01	1.05	1.09	1.13
Project35	0.99	1.03	1.07	1.11	1.15	1.19
Project36	0.93	0.97	1.01	1.05	1.10	1.14
Average	0.73	0.76	0.79	0.83	0.87	0.91

ANFIS Results

ANFIS is performed to show the nonlinear and complex effect of project team spirituality on project success. Three important success factors derived from the related literature as well as the spirituality score calculated for each project are considered as ANFIS inputs. Deviation from planned budgeted cost as the criterion for project success namely is considered as ANFIS output. The data collected on these inputs and outputs are presented in Table 4.

Figure 2 shows the structure of input–output analysis in ANFIS, in which Y is the dependent variable: cost deviation. SF1, SF2, and SF3 are project success factors and stand for clear project mission, competence and commitment, and organization culture, respectively. SQ represents the level of spirituality in a project.

Table 4. Collected data regarding project success and spirituality variables.

	ANFIS variables				
Project	CSF1	CSF2	CSF3	SQ	Cost deviation (%)
Project1	2.4	4.3	3.1	0.54	12
Project2	2.0	4.7	4.7	1.04	9
Project3	2.2	2.4	2.4	0.45	18
Project4	3.5	4.1	3.8	0.68	9
Project5	3.2	4.8	4.7	1.07	7
Project6	2.4	2.5	2.1	0.47	15
Project7	2.7	4.5	4.6	0.97	8
Project8	4.3	4.6	4.7	1.03	5
Project9	4.7	4.4	4.5	0.94	6
Project10	4.6	4.3	4.4	0.92	7
Project11	2.8	2.2	3.4	0.48	15
Project12	1.9	4.4	4.1	0.86	9
Project13	1.9	3.9	2.2	0.43	17
Project14	2.0	3.5	4.4	0.50	13
Project15	3.6	4.2	4.4	0.63	6
Project16	3.2	4.8	4.7	1.07	6
Project17	4.2	4.1	4.4	0.79	7
Project18	1.9	4.3	4.4	0.89	10
Project19	2.1	3.4	2.8	0.47	13
Project20	1.7	3.7	1.5	0.47	19
Project21	4.0	4.4	4.6	0.94	7
Project22	3.3	4.5	4.3	0.91	8
Project23	1.5	4.2	4.3	0.75	13
Project24	2.6	4.5	4.5	0.92	8
Project25	3.0	4.4	4.5	0.93	8
Project26	1.9	4.2	4.0	0.87	9
Project27	2.3	3.2	2.5	0.43	16
Project28	2.0	3.6	4.0	0.73	12
Project29	2.4	4.5	4.5	0.80	8
Project30	1.6	4.3	4.5	0.92	10
Project31	3.2	4.6	4.8	1.06	6
Project32	2.6	1.5	2.2	0.42	20
Project33	3.5	4.6	4.6	1.03	7
Project34	3.1	4.6	4.7	1.01	9
Project35	4.8	4.7	4.8	1.07	6
Project36	1.6	4.6	4.7	1.01	9
Min	1.50	1.50	1.50	0.42	5
Average	2.80	4.03	3.96	0.79	10
Max	4.80	4.80	4.80	1.07	20
STDEV	0.95	0.79	0.94	0.23	4

Before ANFIS analysis, the input variables should be represented in terms of fuzzy linguistic variables. To do so, subtractive clustering algorithm was utilized. First, genfis2 function of MATLAB® generates an initial FIS which is then trained by ANFIS function to yield a final fuzzy inference system named ANFIS.

Figure 3 illustrates the performance of ANFIS for modeling and estimation of % of project cost deviation for 10 test projects. As seen, the estimated cost deviation by ANFIS (solid line) is remarkably close to the actual data (dashed line).

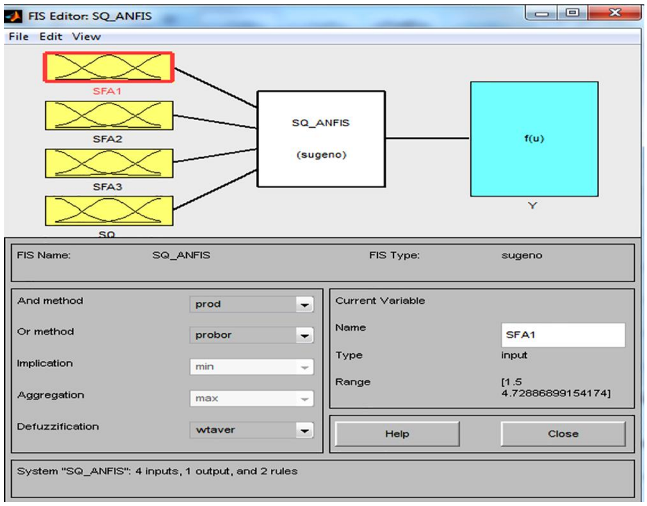

Figure 2. The structure of input–output analysis in ANFIS.

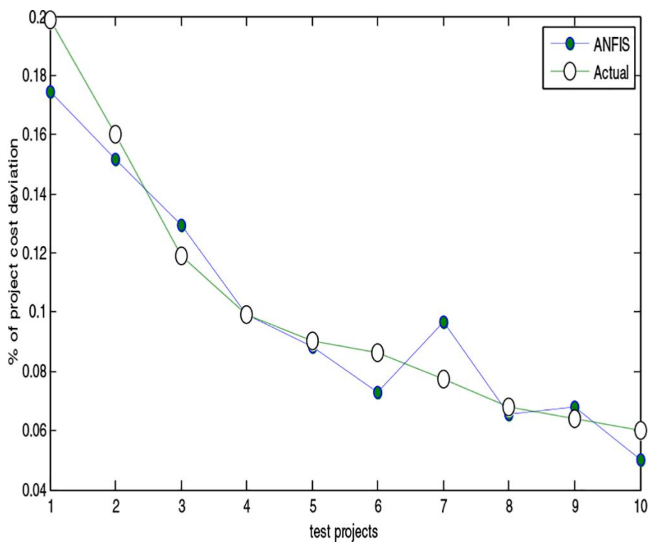

Figure 3. Comparison of ANFIS estimations with actual project data.

Verification and Validation

For verification and validation of FDEA results in different α-feasible levels, its results are compared with the result of another multivariate analysis method that has recently been used for SQ quantification, namely principal component analysis—PCA (Taghizadeh Yazdi 2015). Taghizadeh Yazdi (2015) showed the usefulness and relevance of PCA for SQ quantification and validated its results by comparing them with fuzzy clustering techniques. Here in this study, his PCA method in parallel with FDEA was applied to have

Table 5. The spearman correlation coefficient between SQ scores of FDEA and PCA.

	FDEA efficiency in different α-feasible					
	0.5	0.6	0.7	0.8	0.9	1
PCA (%)	99.3	99.3	99.4	99.2	98.9	98.7

a robust comparison between the results of these two multivariate analysis methods. Interested readers may find more details on the theory and application of PCA for SQ quantification in Taghizadeh Yazdi (2015). It should be noted that PCA is a deterministic approach and its variables are calculated as the average of SQ characteristics (i.e., μ_{ij} in Eq. (4).

The spearman correlation coefficient between SQ scores of FDEA and PCA is presented in Table 5.

The spearman correlation coefficients in Table 5 are all significant at 95% confidence level. These significant correlations indicate that the results of FDEA for SQ quantification are verified by the results of PCA.

The results of PCA-SQ quantification are compared with the results of FDEA (α-feasible = 0.7) in Figure 4. Comparing the SQ scores calculated with these two different methods reveals a close similarity between the FDEA and PCA-SQ quantification. Consequently, as these multivariate techniques are very different in their analytical approaches and yet have produced very close SQ scores, it can be ensured that FDEA is a reliable and valid technique for SQ quantification.

Impact Analysis with ANFIS

In this section, the impact of workforce spirituality on % of project cost deviation is analyzed with ANFIS. The ultimate output of this analysis is a graph indicating the nonlinear relationship between SQ scores and the % of project cost deviation. The graph generated by ANFIS is depicted in Figure 5.

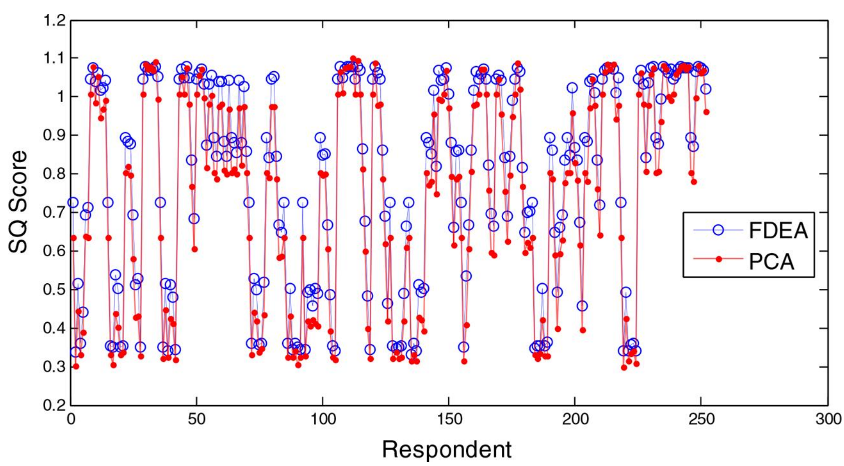

Figure 4. Comparison of FDEA and PCA SQ quantifications.

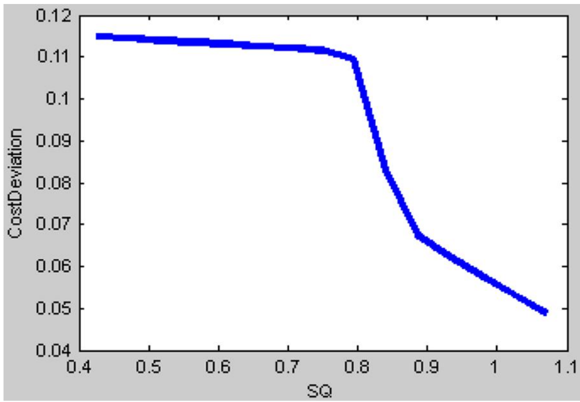

Figure 5. The ANFIS's estimated relationship between SQ and cost deviation.

According to Figure 5, the following conclusions are drawn:

- The pure effect of SQ on project cost deviation is nonlinear and the relationship is monotonically decreasing.
- Remaining almost constant in the projects with SQ scores below 0.8, the cost deviation then starts a dramatic decline when SQ scores start to grow higher than 0.8. The workforce spirituality has a nonlinear negative effect on cost deviation. This effect is especially substantial when the level of project team's spirituality expressed in term of FDEA scores is relatively high (>0.8).

The main product of the ANFIS modeling is a fuzzy rule base in which the relations between ANFIS inputs and output are expressed in terms of some fuzzy IF-THEN rules. The IF part of the rule identifies the degree of membership of each input to its corresponding fuzzy sets. Then in the THEN part the output is calculated based on a linear combination of inputs (in a first-order Takagi–Sugeno ANFIS). The coefficient of each input in the THEN part of a rule determines how an input impacts the output. For the ANFIS of this study, the results of inputs coefficients' estimates are presented in Table 6.

As expected, the negative signs of the coefficients of the first two success factors confirm the negative impact of these factors on deviation from the planned budgeted cost. The conflicting signs of the coefficients of the third success factor in Rules 1 and 2 are indication of nonlinear relationship between this factor and cost deviation. The coefficients of SQ are estimated to be −0.098 and −0.01 in Rules 1 and 2, respectively. The negative sign of

Table 6. The inputs coefficients' estimate in ANFIS rules.

Variable	Rule 1	Rule 2
Clear project mission (SF1)	−0.011	−0.029
Competence and commitment (SF2)	−0.016	−0.015
Organization culture (SF3)	0.029	−0.016
Workforce spirituality (SQ)	−0.098	−0.010

these values reveals the negative nonlinear relationship of deviation from the planned budgeted cost with project members' spirituality. In other words, spirituality of project members would help project implementation to be kept on its planned track.

Conclusion

This paper proposes an integrated fuzzy methodology for quantitative assessment of the effect of workforce spirituality on project success. In doing so, a validated and reliable 59-item SQ questionnaire borrowed from previous research was used to assess SQ characteristics of project team members. The study surveyed 252 individuals in 36 different projects in the organizations which underwent medium- and large-scale strategic change projects. For total SQ quantification, the paper used FDEA which is capable of handling uncertainty and ambiguity in the modeling environment. In the implementation of the methodology, first, the results of the questionnaire were used for fuzzy measurement of the SQ characteristics and then FDEA was applied for total SQ quantification. For verification and validation, another multivariate method namely PCA, previously proposed by Taghizadeh Yazdi (2015) for total SQ quantification, was used to compare its results with FDEA results. Spearman correlation test revealed the conformity between the two methods. Nonetheless, FDEA may be preferred owing to its sensitivity to the changes in SQ level and its advantage in modeling fuzziness and ambiguity. A main finding of this study was to unveil the applicability, validity and usefulness of FDEA for spiritual capital quantification. Another finding is related to the impact of workforce spirituality on project success. With the use of ANFIS which is capable of dealing with complexity, fuzzy uncertainty and nonlinearity, this study unveiled the nonlinear negative impact of spirituality on projects cost deviation. In other words, it was shown that spirituality of project members would help project implementation to be kept on its planned track.

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