DEVELOPMENT OF FUZZY LOGIC MODEL FOR LEADERSHIP COMPETENCIES ASSESSMENT CASE STUDY: KHOUZESTAN STEEL COMPANY

[1]MOHAMMAD-ALI AFSHARKAZEMI, [2]DARIUSH GHOLAMZADEH, [3]AZADEH TAHVILDAR KHAZANEH

[1]Department of Industrial Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran
[2]Department of Public Management, Central Tehran Branch, Islamic Azad University, Tehran, Iran
[3]Young Researchers and Elite Club, Science and Research Branch, Islamic Azad University, Tehran, Iran
E-mail: [1]dr.mafshar@gmail.com, [2]golamzadeh33@yahoo.com, [3]Azadeh.khazaneh@yahoo.com

Abstract- Leadership competencies assessment (L.C.A.) is a process that evaluate leader's competencies, and is a common function carried out in modern companies. L.C.A. is important for leaders to know their strengths and weaknesses, to improve their competencies and to have a continuous improvement. There are different assessment methodologies, however none of them is universal. In recent years multi-rater (360-degree) assessment became very popular but the critical problem of this method is that, it is based on human judgement and perception. This paper deals with a scientific approach in L.C.A and develop a Simulink model based on fuzzy inference system (F.I.S.). This model uses linguistic labels and adjustable numerical values to represent ambiguous concepts, such as subjectivity. This paper also demonstrates a comparison between the traditional methodology based on Boolean logic approach and the proposed one, based on fuzzy logic approach for L.C.A. The model was validated in Khouzestan steel company (K.S.C.), and final results show fuzzy logic method advantages in comparison with traditional methods.

Keywords- 360-Degree Leadership Competencies Assessment, Fuzzy Inference System, Simulink.

I. INTRODUCTION

Nowadays companies due to changing environment, globalization, technological changes and increased competitiveness of market are facing with more and more challenges in the perspective to survive and progress. No doubt organizations need leaders at all levels to deal with those challenges and position themselves as long term high performing corporations. The studies showed that stock price of companies perceived to be well led, grew 900 percent versus 74 percent for companies perceived to lack leadership over a ten years [1]. "The truth is that no one factor makes a company admirable, but if you were forced to pick the one that makes the most difference, you'd pick leadership". In Warren Buffet's opinion, "people are voting for the artist and not the painting" [1].

Khouzestan steel company was established in 1973 and is one of the largest steel suppliers in Iran which recognizes the importance of leadership and leader's competencies. This company is searching for excellence and is seriously in process of implementing leadership development programs. L.C.A. is necessary to understand each leader's competencies score and is useful for the organization to foresee the leader's progression and inform them in respect to areas that are not doing well and there is need to have coaching and training programs. In addition it can help leaders to know their area of strength for further enrichment and area of weakness for improvement.

The assessment of leader's competencies represent some important issues which can significantly affect the performance and the future competitiveness of an organization. The traditional methods for L.C.A. are based largely on statistical analyzes of test results that are considered as accurate reflections of reality. In this method the assessment is based on questionnaires that involve fixed scales with specific values, such as 0,25,50,75, and 100 percent. This kind of assessment reduce the evaluator opportunity to express points of view and causes a rigid evaluation. In addition, the total score of each competency indicates that a leader has reached the average level of standard or not [2]. This may be in the form of "pass" or "fail". Many researchers have shown concern that the results of traditional evaluations may be subjective due to methodological problems [3]. Due to the increased emphasis on L.C.A., there is a need to develop consistent and fair models. Specifically, this paper addresses the following question: What is the appropriate inference approach that will be utilized to accurately compute the leader's competencies and "work behaviour scores"?

II. LITERATURE REVIEW

White (1959) used the term "competence" for the first time to describe personality characteristics associated with high motivation and superior performance at work and scholastic intelligence tests were used as predictors of successful performance in organizations[4]. McClelland (1973) argued that intelligence tests were not necessarily good predictors of successful performance at work and mentioned that the definition of competency is concrete and should relate to "work behaviours" that should be exhibited during the work [5]. In 1982, Boyatzis defined competence as performance capability that distinguish

high performing managers from low ones and empirically identified a list of managerial competencies [6]. This list give leaders specific behaviour examples that can make them successful in their work. If a leader know the required skills for the position, he/she could verify, analyze, and control its own behaviour according to the requirements.

Different indicators in relation to K.S.C.'s specific organizational needs are used to define and determine leadership competencies. These indicators, found in the K.S.C.'s leadership model, describe the "work behaviour" criteria which a leader behaviour is measured, reviewed and evaluated.

A. Building trust and accountability: The indicators or the "work behaviours" that demonstrate this competency includes:

- *Personal credibility and interpersonal awareness (PCAIA):* The ability to get along and interact positively with others and demonstrate concern that one be perceived as responsible, reliable, and trustworthy.
- *Professionalism (P):* The demonstration and commitment to ethics, and social accountability. The desire to act in a way that is consistent with one's values and what one says is important.

B. Maximizing performance results: The indicators or the "work behaviours" that demonstrate this competency includes:

- *Analytical thinking (AT):* The ability to understand a situation, issue or problem by using a logical, systematic and sequential approach. Breaking it into smaller pieces or tracing its implications in a step-by-step way. Setting priorities on a rational basis and identifying time sequences, casual relationships, or if-then relationships.
- *Decision making (DM):* The ability to make decisions and solve problems involving varied levels of complexity, ambiguity, and risk.

C. Promoting a high performance culture: The indicators or the "work behaviours" that demonstrate this competency includes:

- *Communicating effectively (CE):* The ability to speak and write in a clear, logical and grammatical manner in formal and informal situations. The ability to persuade, convince, influence, or impress others in order to get them to go along with or to support one's opinion or position.
- *Human resource management (HRM):* The ability to effectively recruit, select, develop, and retain competent staff, includes making appropriate assignments and managing staff performance.

D. Executive competence: The indicators or the "work behaviours" that demonstrate this competency includes:

- *Achievement orientation (AO):* A concern for surpassing a standard of excellence. The standard may be one's own past performance or an objective measure or outperforming others, setting challenging goals or has an innovation approach.
- *Performance management (PM):* The ability to understand and use statistical and financial methods and metrics to set goals and measure organizational performance and customer expectations.

E. Creating organizational transformation: *The indicators or the "work behaviours" that demonstrate this competency includes:*

- *Business acumen (BA):* The ability to understand and learn the power relationships in one's own organization or in other organizations. The ability to identify who the real decision makers are, the individuals who can influence them, and to predict how new events or situations will affect individuals and groups within the organization.
- *Leadership (L):* The ability to effectively manage and guide group efforts. This includes providing the appropriate level of feedback concerning group progress.

In Multi-Source Feedback or 360-degree feedback, data about work behaviours of a leader are collected systematically from a number of stakeholders such as his/her superiors, colleagues, subordinates and customers which are called raters [7]. With the increased focus on teamwork, employee development and customer service, the emphasis has shifted to employee feedback from the full circle of sources. This method was first developed at General Electric in 1992. In 2002, 90% of Fortune 500 companies were using 360-degree feedback to help improve the effectiveness of their leaders [2]. This method has become popular in Iran too, K.S.C., Iran Khodro and many others are using this method.

One of the great advantages of implementing a 360-degree feedback evaluation for leaders is that it increases their self-awareness about their leadership competencies. In addition it makes them be aware that they, too have development needs. With the help of the 360-degree feedback, leaders can narrow the "blind" area of "Johari window", learn how others perceive them and if necessary undertake action and start behavioural change. In addition they can expand the "open" area of "Johari window" in the direction of what previously was hidden for them from the outside world [8]. Successful leaders need to continuously add value to their organization by continually learning and growing. The results from a 360-degree feedback determine specific skills and behaviours that represent leaders strengths and potential areas of development to create a specific personal and professional development plan for change and performance improvement [2].

But nowadays the implementation of 360-degree feedback for L.C.A. represent a real challenge for organizations. The regular assessment method is based on questionnaires that involve fixed scales with specific values, such as 0,25,50,and 100 percent [7].

This kind of assessment reduce the rater opportunity to express points of view and causes a rigid feedback.
The logic of traditional mathematical methods has two states 1 or 0. That mean each proposition must either be false or true. In 1965, Zadeh introduced fuzzy logic as means to model and handle uncertainty in natural language [9]. Fuzzy logic describes the qualitative nature aspects of the object while Boolean logic systems focus on their quantitative aspects. Fuzzy set theory appears as an important tool to include inaccurate judgements inherent in L.C.A. process. Fuzzy logic has two main components: membership functions and fuzzy rules. Using them it is possible to move a qualitative to a quantitative description, for example, to represent linguistic expressions as mathematic expressions. Fuzzy membership function express the certainty than an element of the universe belongs to a fuzzy set. It represents the degree of truth as an extension of the valuation [9]. These membership functions can take different shapes according to expertise and preferences of the model designer. In this paper because of the ambiguity of verbal statements the fuzzy logic approach is used to describe "360-degree work behaviour feedbacks", "360-degree frequency of work behaviour feedbacks", "work behaviour passing scores", and "work behaviour scores".

III. METHODOLOGY AND THE MODEL

In the traditional non-fuzzy approach (crisp approach) the "360 work behaviour feedbacks" are considered and assessed on a fixed scale (0,25,50,75,100). The "work behaviour scores" can be evaluated as the average of "360-degree work behaviour feedbacks". Leader's "work behaviour scores" over 50, would be regarded as "areas of strength" otherwise would be regarded as "need to improve" [2].
In this paper, because of the ambiguity of verbal statements, the fuzzy logic approach and Mamdani F.I.S. is used to assess "work behaviour scores". K.S.C. leadership competency model was used and a questionnaire was developed which gives self, superiors, colleagues, subordinates and customers of each leader, the option to answer questions using on a numeric scale (from 1 to 100). Mamdani model which is one of the most common fuzzy inference techniques takes crisp inputs and produces crisp outputs [10]. It performs this depending on expert-defined fuzzy rules on expert-defined fuzzy variables membership functions. Membership functions and fuzzy rules make it possible to move the experiences and human preferences from a qualitative description to a quantitative description. Membership functions and rules can take different forms according to the experts knowledge, experiences and preferences.
Below are the main steps:
A. Step1:Creating Mamdani F.I.S. and defining fuzzy inference mechanism.

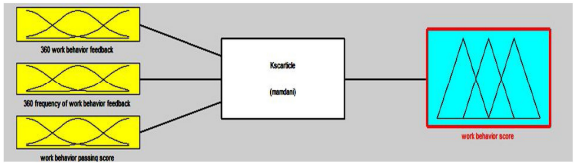


Fig. 1. F.I.S. editor

B. Step2:Fuzzification: This step is to take the crisp inputs and determine the degree to which these inputs belong to each of the appropriate fuzzy linguistic values.

- "360 work behaviour feedbacks", refers to the percentage indicating how well the leader's behaviour matches the competency definition. Here each of ten identified "360 work behaviour feedbacks" have been given a range of [0 100] and have been fuzzified with five linguistic variables (unacceptable, below average, average, above average, excellent) using Gaussian curve membership functions, by experts.

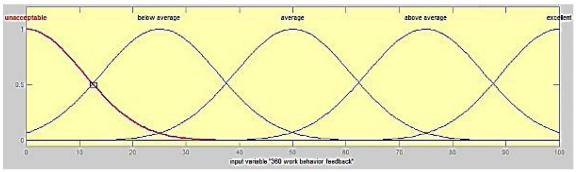


Fig. 2. Fuzzy sets for linguistic input variable: "360 work behaviour feedback"

- "360 frequency of work behaviour feedbacks", refers to the percentage of times they observe that work behaviour. Each of ten identified "360 frequency of work behaviour feedbacks" have been given a range of [0 100] and have been fuzzified with four linguistic variables (never, seldom, sometimes, always) using Gaussian curve membership functions, by experts.

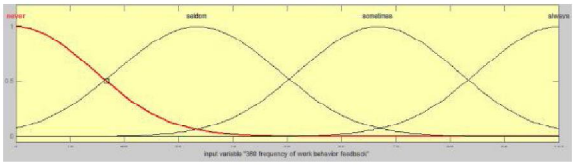


Fig. 3. Fuzzy sets for linguistic input variable: "360 frequency of work behaviour"

- work behaviour passing scores", refers to the percentage which is determined by organization for each position. Each of ten identified "work behaviour passing scores" have been given a range of [0 100] and have been fuzzified with three linguistic variables (low (L) , average (A), high (H)) using Gaussian curve membership functions, by experts.

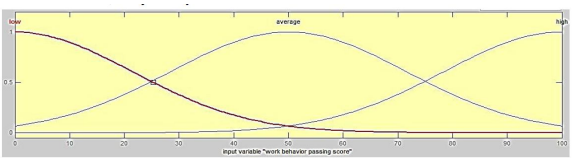


Fig. 4. Fuzzy sets for linguistic input variable: "work behaviour passing score"

- Each of ten identified "work behaviour scores" have been given a range of [0 100] and have been fuzzified with nine linguistic variables (unacceptable (1), extremely poor(2) , poor (3), need to improve (4), average(5) , above average (6), good (7), extremely good(8) , role model (9)) using Gaussian curve membership functions, by experts.

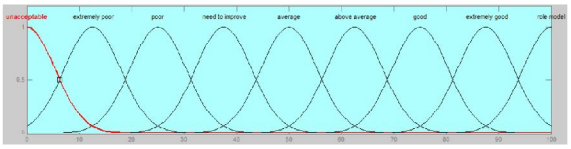


Fig. 5. Fuzzy sets for linguistic output variable: "work behaviour score"

C. Step3: Rules evaluation: Fuzzy rules combine one or more input fuzzy sets and associate them with one or more output fuzzy set. In this paper, "work behaviour scores", "360 frequency of work behaviour feedbacks" and "work behaviour passing scores" are input variables and "work behaviour score" is fuzzy output variable. The fuzzy rules are shown in table 1.

Table 1. Fuzzy Logic Control Rules base

360 frequency of work behaviour feedback	360 work behaviour feedback															
	unacceptable			below average			average			above average			excellent		
never	L 9	A 5	H 1	L 9	A 5	H 1	L 9	A 5	H 1	L 9	A 5	H 1	L 9	A 5	H 1
seldom	L 9	A 5	H 1	L 9	A 6	H 1	L 9	A 7	H 2	L 9	A 7	H 3	L 9	A 8	H 3
sometimes	L 9	A 5	H 1	L 9	A 7	H 2	L 9	A 8	H 3	L 9	A 9	H 5	L 9	A 9	H 7
always	L 9	A 5	H 1	L 9	A 7	H 3	L 9	A 9	H 5	L 9	A 9	H 8	L 9	A 9	H 9

As can be seen from the table above there are sixty rules which are defined by experts. With the help of surface viewer we can easily determine the value of output "work behaviour score" corresponding to inputs. A surface viewer for F.I.S., 1-10 is shown in fig. 6.

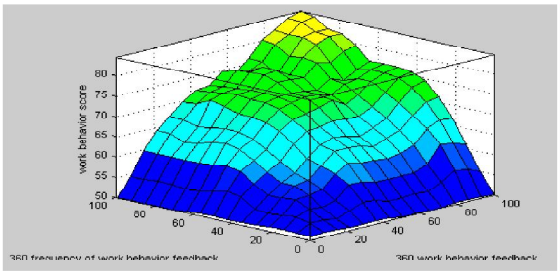


Fig. 6. Surface viewer for F.I.S. 1-10

D. Step4:Aggregation of rule outputs and defuzzification: The membership functions of all rule consequents previously clipped or scaled are combined into a single fuzzy set, as shown in fig. 7. Inference system output is a fuzzy output not a numerical or crisp data. To make it possible and translate it to numerical data, this article used "centroid" or "gravity center" defuzzification method. This method divide total area in partial areas, calculate partial areas value, calculate each partial area centroid, and calculate total centroid.

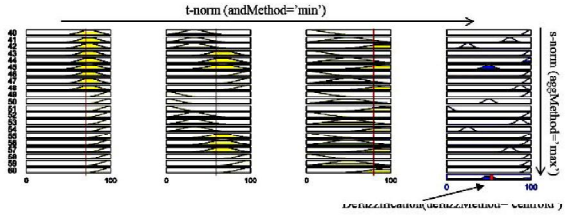


Fig. 7. Rule viewer

IV. COMPARISON OF SIMULATION RESULTS (FUZZY APPROACH) WITH TRADITIONAL OR CRISP RESULTS (NON-FUZZY APPROACH)

- *Traditional or non-fuzzy results:* The results are shown in table 3.

Table 3. Traditional (crisp) results

Work behaviours	Self		superior		colleagues		subordinate	
	score	Frequency	score	Frequency	score	Frequency	score	Frequency
PCAIA (q1-q9)	85	80	60	40	75	50	70	75
P (q10-q14)	70	100	50	80	60	70	80	80
AT (q46-q51)	50	70	40	50	30	60	40	60
DM (q52-q57)	70	80	60	70	45	75	60	80
CE (q15-q22)	75	100	60	90	60	85	80	80
HRM (q23-q30)	100	100	90	80	85	85	100	50
AO (q40-q45)	75	80	80	80	60	50	60	50
PM (q31-q39)	70	100	60	80	75	80	65	60
BA (q58-q63)	85	70	90	80	90	60	70	85
LA(q64-q72)	100	90	90	70	85	80	80	80

Here, the overall crisp leadership competency score is, 70.75.

- *fuzzy logic results:* The simulation (t=10sec) results are shown in fig. 8.

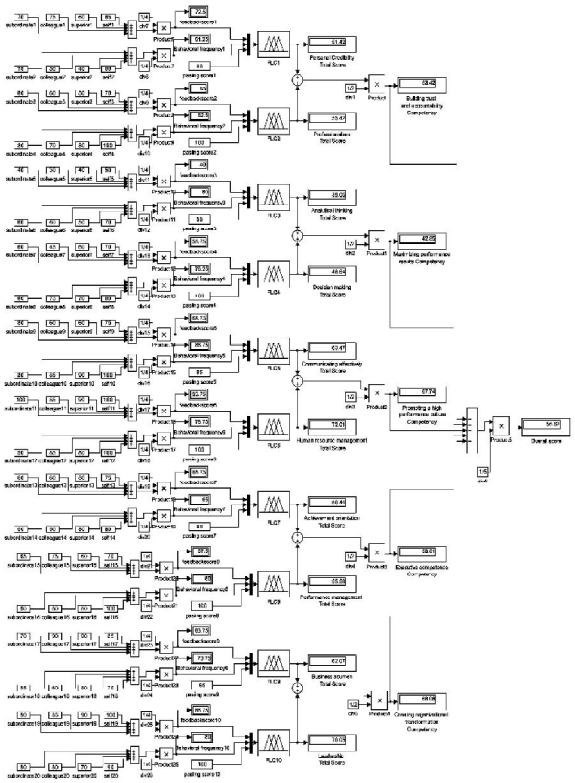


Fig. 8. Simulation results

Here, the overall Leadership competencies score is, 56.62.

Applying the traditional 360-degree methodology to the example above showed that the individual and the company must improve "analytical thinking", "decision making" and "professionalism". But with applying the fuzzy logic model evaluation (Simulink model), the results showed that the individual and the company must improve "analytical thinking", "decision making" and "achievement orientation", since these work behaviours obtained the lower qualifications.

DISCUSSION AND CONCLUSION

The aim of this study was to develop a Simulink model based on fuzzy logic inference system to evaluate Khouzestan Steel Company's leaders competencies. To perform this process, 360-degree feedback method was selected and the K.S.C. leadership competency model was applied as the base of the process. To accurate the results and to avoid losing data through the evaluation with questionnaire, fuzzy approach was adapted. The main advantage in using fuzzy logic methodology is that it simulate the human thinking and allow subjective and ambiguity treatment. The fuzzy logic approach proves to be more realistic as compared to traditional non-fuzzy approach.

Traditional 360-degree methodology involves only one factor, "360 work behaviour feedback". On the other hand, fuzzy logic 360-degree methodology can involve three factors. Besides, questionnaire of L.C.A. for traditional 360-degree feedback, filled with five fixed scale percentages (100, 75, 50, 25 and 0). On the other hand, questionnaires of L.C.A. for fuzzy logic 360-degree feedback have adjustable value scales, allowing improved flexibility for evaluator.

The results of the comparison between the two approaches shows the difference in their respective methodologies. The fuzzy logic provides a more logical approach to L.C.A. and makes better assessment for leader's competencies. It also enhances the flexibility of organizations to give different weights to different work behaviours. Therefore, a new approach for Leadership competencies assessment using fuzzy logic has been proposed, which K.S.C. leaders can identify their training needs and be sure that the results of the assessments are bias-free. A suggestion for further research would be to extend the model with combination of more than three inputs. Also it would be recommended to replicate the Simulink model for other companies based on their specific leadership competency model.

REFERENCES

[1] W. Bennis, "On becoming a leader", New York: Addison-Wesley, 1989.

[2] M. Armstrong, "Armstrong's handbook of performance management", Kogan Page, 2009.

[3] C. Kulik, L. Roberson ,and E. Perry, "The multiple-category problem: category activation and inhibition in the hiring process", Academy of management review, vol.32, no.2, pp.529-548, 2007.

[4] R. White, "Motivation reconsidered: The concept of competence", Psychological Review, vol.66, pp.297-333, 1959.

[5] D. McClelland, "Testing for competence rather than for intelligence", American Psychologist, vol.28, pp.1-14, 1973.

[6] L.M. Spencer and S.M. Spencer, "Competence at work: Models for superior performance", New York: Wiley, 1993.

[7] D. T. Tosti and R. M. Addison, "360-degree feedback:going around in circlrs?", Performance improvement, vol.48, no.3, pp:36-39, 2009.

[8] J. Luft, "The Johari window, Human relations and training news", vol.5, no.1, pp.6-7, 1961.

[9] L. A. Zadeh, "Fuzzy sets", Information and control, vol.8, no.3, pp.338-353, 1965.

[10] E.H. Mamdani and S. Assilian, "An experiment in linguistic synthesis with fuzzy logic controller', International journal of machine studies, vol.7, no.1, 1975.

★★★