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Application of Fuzzy Logic in Employee Promotion Decisions: Evidence from a Hypothetical Case

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ABSTRACT

In the article, we have applied fuzzy logic to employee promotion decisions as a human resources management tool. This logic is an extension of Boolean mathematics developed by Lotfi Zadeh which is generalization of the classical set theory. We have defined three fuzzy input variables (number of qualifications in related field, experience in years, and IQ level assessed by special test) and one output variable (quality of an employee). We assume that a hypothetical company's approach to promotional decisions is underpinned by ethical principles like fairness, equality, and objectivity. In the calculation process, "Fuzzy Rank Tests", "Fuzzy Stat Prob." and "Fuzzy MCDM" packages of "R" program have been used in. All the names, values and a company name used in the paper are hypothetical.

KEYWORDS: ***Employee Promotion, Fuzzy Logic, Fuzzy Input, Fuzzy Output***

INTRODUCTION AND LITERATURE REVIEW

When there are vacancies in an organization, these can be filled up by the external or internal candidates. Although the businesses prefers to fill up the vacancies by the external vacancies but the internal candidates may also apply for vacancies for higher level job. Promotion is the reassignment of a higher level job to an internal employee with delegation of responsibilities and authority required to perform that higher job and normally with higher pay. Most companies have their policies regarding promotion based on its corporate responsibility. They should be fair and impartial. In this article, we have applied fuzzy logic in promotion decisions based on a hypothetical case.

Fuzzy logic idea is similar to the human being's feeling and inference process. Unlike classical logic, which is a point-to-point control, fuzzy control is a scope-to-point or scope-to-scope control. The output of a fuzzy controller is derived from fuzzifications of both inputs and outputs using the membership functions. A crisp input will be converted to the different members of the associated membership functions based on its value. From this point of view, the output of a fuzzy logic controller is based on its memberships of the different membership functions, which can be considered as a range of inputs. Fuzzy ideas and fuzzy logic are so often used in our daily life that nobody even pays attention to them. For instance, to answer some questions in certain surveys, most time one could answer with 'normal' or 'quite satisfied', which are also fuzzy answers. Exactly to what degree is one satisfied or dissatisfied with some goods and services for

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those surveys? These fuzzy answers can only be created by human beings, but not machines. Modern computers can only understand either 'zero' or 'one', and 'good' or 'bad'. Those data are called crisp data and can be processed by all smart machines. The idea of fuzzy logic was invented by Professor L. A. Zadeh of the University of California at Berkeley in 1965. This invention was not well recognized until Mamdani, who is a professor at London University, applied the fuzzy logic in a practical application to control an automatic steam engine in 1974.

Fuzzy sets are sets whose elements have degrees of membership. In classical set theory, the membership of elements in a set is assessed in binary terms— an element either belongs or does not belong to the set. By contrast, fuzzy set theory permits the gradual assessment of the membership of elements in a set; this is described with the help of a membership function valued in the real unit interval [0, 1]. The core technique of fuzzy logic is based on three basic concepts:

(1) Fuzzy set: unlike crisp sets, a fuzzy set has a smooth boundary, i.e., the elements of the fuzzy set can be partly within the set.

(2) Linguistic variables: variables that are qualitative, as well as quantitative, described by a fuzzy set. Similar to a traditional set, a fuzzy set can describe the value of variable;

(3) Fuzzy "if-then" rules: a scheme, describing a logic formula that generalizes an implication of two-valued logic. The main feature of the application of fuzzy "if-then" rules is its capability to perform inference under partial matching. It computes the degree the input data matches the condition of a rule. This matching degree is combined with the consequence of the rule to form a conclusion inferred by the fuzzy rule.

ANALYSIS

Here, the company named Nahid Futures produces bottles for one of the biggest juice producer in the industry. One of the departments in Nahid Futures has a vacancy in internal auditing. There are 10 employees in the department. Human Resources Manager faces some problems about how to make decision of promotion. For this, employees' IQ level is assessed by special IQ test. In addition, HRM review their CIMA (Chartered Institute of Management Accountants) exams passed and their experience. For making decision which takes multiple variables into consideration, we should first review descriptive statistics. Actually, kurtosis and skewness shows that these variables are not normally distributed. In normal distribution, skewness is equal to 0, kurtosis is equal to 3. Table 1 shows descriptive statistics of these variables.

Table 1 – Descriptive statistics of variables

Descriptive Statistics	Number of Qualifications	Experience in Years	IQ level
Mean	5.10	4.80	77.20
Standard Error	0.84	0.59	3.62
Median	5.00	5.00	80.00
Mode	6.00	5.00	63.00
Standard Deviation	2.64	1.87	11.44
Sample Variance	6.99	3.51	130.84
Kurtosis	-1.66	-1.07	-0.89
Skewness	0.23	-0.53	-0.11
Range	7.00	5.00	34.00
Minimum	2.00	2.00	62.00
Maximum	9.00	7.00	96.00
Sum	51.00	48.00	772.00
Count	10.00	10.00	10.00

2.1 Defining fuzzy variable

Considering that in literature can't be found a model that assesses the quality of an employee according to the parameters: number of qualifications in related field, experience in years, and IQ level assessed by special test, the authors have proposed special type and values of fuzzy variables in the model. In the model a fuzzy output variable A is defined and fuzzy input

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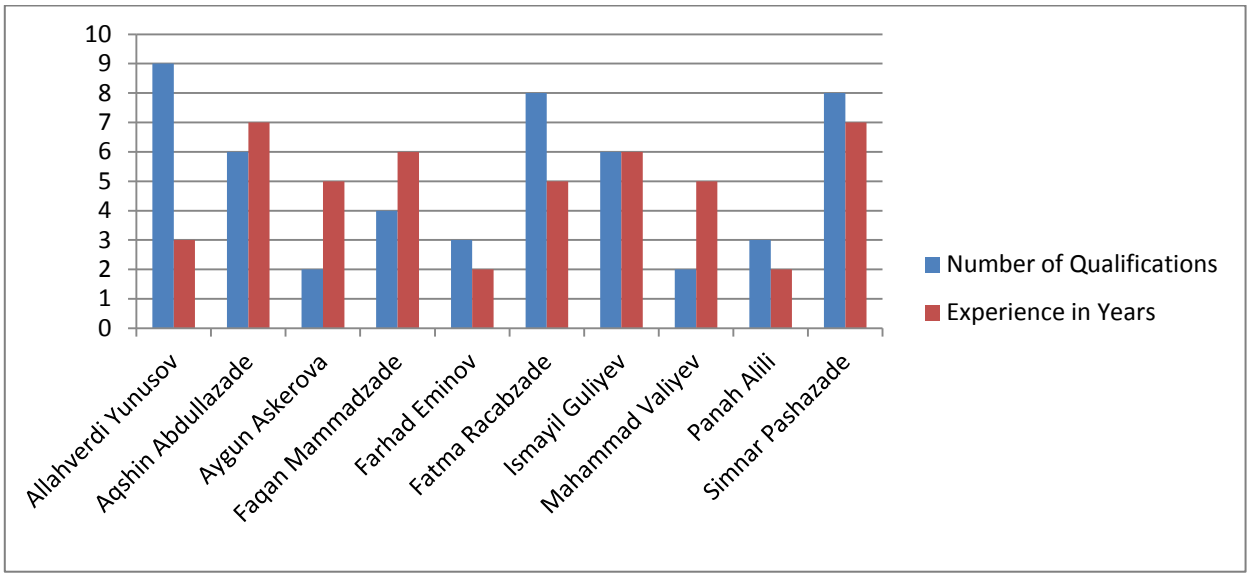
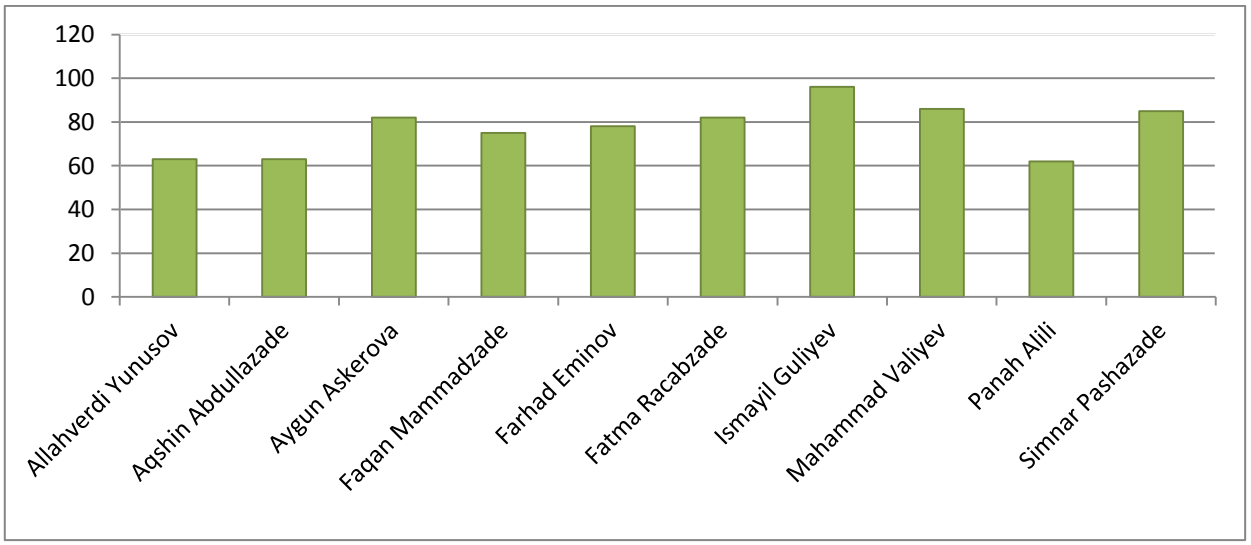
variables: B, C, D. Fuzzy output variable A, assesses the quality of an employee. It is presupposed that the of an employee can be "Bad", "Normal" or "Good" and the quantification of the scores is in range from 0 to 10. Fuzzy input variable B describes the number of qualifications that employee has gained. It is presupposed that there can be "Low", "Medium", or "High" quantity of qualifications and the quantification of the scores is in range from 1 to 10. Fuzzy input variable C describes the experience of an employee in years. It is assumed that the experience in years may be "Low", "Medium", or "High" and the quantification of the scores is in range from 2 to 8 years. Fuzzy input variable D represents IQ level. It is presupposed that there can be "Low", "Medium", or "High" IQ level of an employee and the quantification of the scores is in range from 50 to 100. Graph 1 and 2 describes the input variables.

Graph 1 – Number of qualifications & Experience in years



Graph 2 – IQ level by employees



2.2 Fuzzy logic

Fuzzy mapping rules provide a functional mapping between the input and the output using linguistic variables. The foundation of a fuzzy mapping rule is a fuzzy graph, which describes the

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relationship between the fuzzy input and the fuzzy output. Sometimes, in real applications, it is very hard to derive a certain relationship between the input and the output, or the relationship between those inputs and outputs are very complicated even when that relationship is developed. Fuzzy mapping rules are a good solution for those situations. Fuzzy mapping rules work in a similar way to human intuition or insight, and each fuzzy mapping rule only approximates a limited number of elements of the function, so the entire function should be approximated by a set of fuzzy mapping rules. These have been written in R programming language and intentionally no graphs or system equations are in the article for page limit. Approximate reasoning algorithm for quality of an employee, developed in this paper consist the following rules:

Table 2- Approximate reasoning algorithms

Number of Qualifications	Experience in Years	IQ level	Quality of employee
low	low	low	bad
low	low	high	bad
low	low	medium	bad
low	high	low	bad
low	medium	low	bad
low	high	high	good
low	medium	high	normal
low	medium	medium	normal
low	high	medium	normal
high	high	high	good
high	high	low	good
high	high	medium	good
high	medium	medium	normal
high	medium	low	normal
high	medium	high	good
high	low	high	good
high	low	medium	normal
high	low	low	bad
medium	medium	medium	normal
medium	medium	high	normal
medium	medium	law	normal
medium	law	law	bad
medium	law	high	normal
medium	law	medium	normal
medium	high	law	normal
medium	high	high	good
medium	high	medium	normal

2.3 Defuzzification

The result derived from the combination of inputs, output membership functions and fuzzy rules is still an unclear or fuzzy element and this process in called fuzzy inference. To make that fuzzy output available to real applications, a defuzzification process is needed. The defuzzification process is meant to convert the fuzzy output back to the classical output. The fuzzy conclusion or output is still a linguistic variable, and this linguistic variable needs to be converted to the crisp variable with the defuzzification process. Three defuzzification techniques are commonly used: Mean of Maximum method, Center of Gravity method and the Height method. We have used Center of Gravity method in the article. The Center of Gravity method (COG) is the most popular defuzzification technique and is used in actual applications. This method is same to the formula for calculating the center of gravity in physics. The weighted average of the membership function or the center of the gravity of the area bounded by the membership function curve is computed to be the crispest value of the fuzzy quantity. The COG output can be represented as

All the calculations have been done in R, and results have been given at Graph 3. The vacancy should be filled up by Ismayil Guliyev. Ismayil Guliyev has a rating of 9.6 out of 10.

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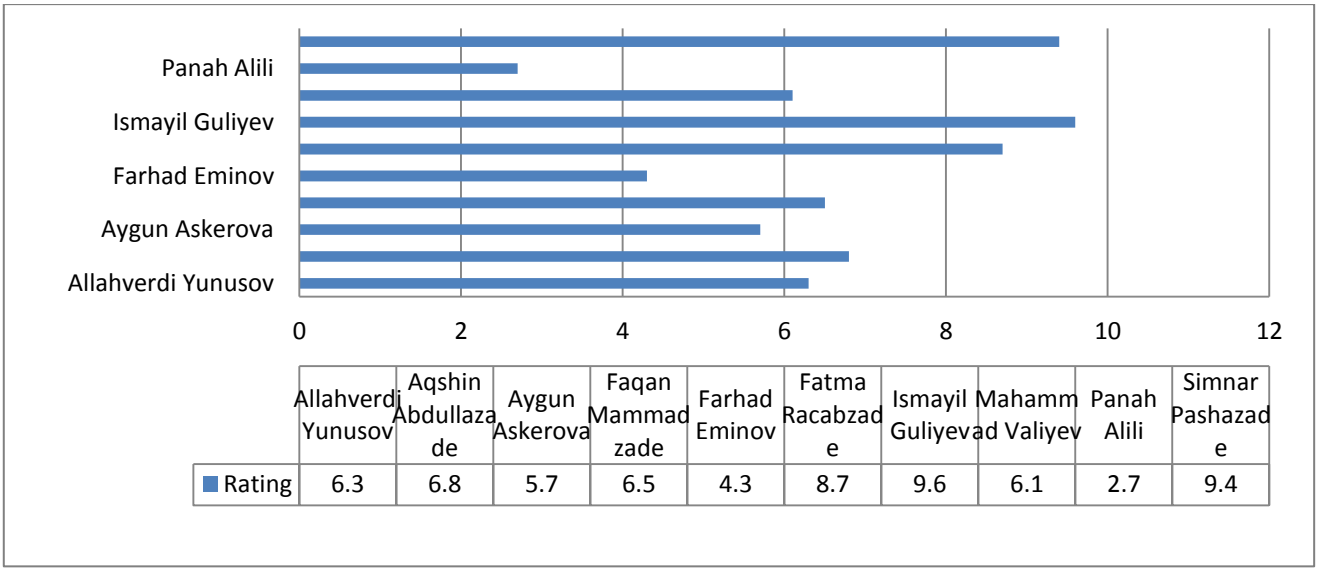
Graph 3 – Fuzzy results and ratings of the employees



	Allahverdi Yunusov	Aqshin Abdullaza de	Aygun Askerova	Faqan Mammad zade	Farhad Eminov	Fatma Racabzad e	Ismayil Guliyev	Mahamm ad Valiyev	Panah Alili	Simnar Pashazad e
Rating	6.3	6.8	5.7	6.5	4.3	8.7	9.6	6.1	2.7	9.4

CONCLUSIONS AND RECOMMENDATIONS

This paper presents a new way of modeling and evaluation of the quality of an employee on the following criteria: number of qualifications in related field, experience in years, and IQ level assessed by special test, using the fuzzy sets theory, which allows solving problems that contain uncertainty, subjectivity, ambiguity and uncertainty. One fuzzy output and three fuzzy input variables were defined. The model testing was conducted by the employees on randomly selected values. This model with appropriate modifications of the rules and variable values can be used to other similar types of employee evaluation.

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