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A Fuzzy Inference System for Supporting the Retention Strategies of Human Capital

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Abstract

Planning to retain ICT knowledge workers is one of the main necessities of a successful business in telecommunication industry in Iran and in the world; because in a competitive environment, organizations can hardly retain their specialized and expert human resources and they are constantly exposed to recruitment policies of competing organizations. Considering these conditions, suitable strategies must be implemented to prevent employee turnover. In this regard, the aim of the present research is to design an expert-based fuzzy inference system in order to study ICT knowledge workers' turnover in Iranian telecommunication industry. Therefore, based on the process of decision making in a fuzzy environment which consists of the three phases of fuzzification, fuzzy inference and defuzzification, the system was designed and inference rules were formulated by consulting experts and those involved in this industry. The obtained model makes it possible to predict turnover based on various inputs (variables affecting turnover). Thus, human resources planners and managers in Iranian telecommunication industry can use fuzzy inference system for predicting turnover in order to support decision-making and develop strategies and plans for retention of their knowledge workers.

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Keywords: employee turnover, ICT knowledge workers, expert-based fuzzy inference system, retention strategy.

1. Introduction

Nowadays, retention of productive human resources is as important as recruiting them; however, in a competitive environment, retention of human capital is even more important. In noncompetitive environments or under the conditions where the supply of human resources far exceeds the demand, retention of human capitals is rarely the case, because whenever a person leaves his position, a large number of qualified and expert applicants line up to apply for that position. In Iran's business environment, the latter is often the case and either a number of employees at organizations lack any special knowledge or skills or numerous people with similar abilities are available in the market. Nonetheless, in some of Iran's industries competition is more intense. One of these sectors is Iran's mobile

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communications industry. Companies such as Mobile Telecommunication Company of Iran (Hamrahe Aval), Irancell and Rightel as mobile operators as well as a large number of domestic and foreign contracting, consulting and engineering companies are involved in this sector. International companies such as ZTE, Huawei, Nokia Siemens, Ericsson and numerous domestic companies are engaged in an intense competition over attracting expert human resources. Under such circumstances, formulation and implementation of a wise strategy regarding retention of human capital is a necessity for organizations operating in this sector. Decision support systems are one of the tools which can enhance the precision of these strategies. These systems enable the strategists and organizational planners so that by considering the relationship between the factors affecting turnover and having access to estimations of likelihood of turnover among human resources, they may strengthen their capabilities for developing and implementing retention strategies. It is noteworthy that such systems have been rarely designed or implemented in academic research or the practical area of Iranian organizations.

2. Literature Review And Hypotheses

In management literature, research in the field of turnover has a long and growing history. Some of the notable recent works in this field include the works of Tett and Meyer (1993), Lambert et al. (2008), Harter et al (2006), etc. Peterson (2004) has classified turnover models and theories in three categories: models that focus on the process of turnover, socialization models and comprehensive models.

In another research, Zheng and Lamond (2009) have divided these models and theories into four categories: process models, socialization models, expanded models and shocks model. Regarding the phenomenon of turnover among ICT professionals or mobile communications industry employees, there is a handful of published research; among these the works of Joseph and Ang (2003), Niederman et al. (2006), Joseph et al. (2007), Shoaib et al. (2009), Ghapanchi et al. (2010), and Mehregan & Seyed Kalali (2013b) are mentionable.

On the other hand, regarding the application of fuzzy models in social, behavioral and management sciences, it should be admitted that they are not widely used for modeling problems of this kind; especially in the field of human resource management and organizational behavior, few studies have been conducted using these models. In fact, most of the papers seeking to explain the relationships or causal links among studied variables in these disciplines and particularly the issue of job turnover, use statistical techniques and especially structural equation modeling; for instance, in a research conducted by Robinson and Beesley (2010), regression analysis has been used to study the relationship between the variable of creativity and turnover intention; in another paper, Shim (2010) has used Logistic Regression Model (LRM) to study the relationship between organizational culture and atmosphere and employees' turnover; In another research, Rose and Gordon (2010) have used ANOVA technique in order to study the relationship between the variables of gender and job type and the variable of staying in the organization; in a research, Yan and Zhou (2010) have used structural equation modeling to study the relationship among the factors affecting fear of turnover; in a research conducted by Zheng and Lamond (2009), multiple regression analysis has been used to examine the relationship between a number of variables and turnover in Asian multinational companies; and finally, in a research conducted by Mehregan & Seyed Kalali (2013b), factor analysis has been used to identify and classify the factors affecting turnover.

However, the use of fuzzy logic in the studies related to personnel recruitment is more common as compared to those related to retention and turnover. For example, in a study by Daramola et al. (2010), a Fuzzy Expert System (FES) was developed for online recruitment of personnel. In the research conducted by Lin (2010), ANP and FDEA techniques were employed to present a model for selection of personnel. In contrast, fuzzy models are seriously absent from the researches related to personnel retention. In a study by Craiger and Coovert (1994), the use of FCM model has been proposed in order to explain the relationship between personal, organizational and external variables and job turnover; also in a paper, Guangyu et al. (2008) have used FCA for management of knowledge workers' turnover risk in high-tech organizations. Also in a paper by Mehregan & Seyed Kalali (2013a), using fuzzy cognitive maps, the relationship between the factors affecting turnover of IT and ICT knowledge workers in Iran's Mobile Communications Industry has been studied.

It is worth mentioning that the use of statistical models, such as SEM, has many limitations as a method of approach in the solution of complex problems and application of fuzzy methods can solve many of these problems (Craiger and Coovert, 1994). Fuzzy set theory includes concepts which can be helpful in overcoming the complexities of certain problems and modeling some uncertainties related to them. Human problems involve uncertainty. Fuzzy logic approach is a very suitable tool for dealing with uncertainty (Menhaj, 2007); accordingly, fuzzy logic can be used in order to explain the relationships among behavioral variables.

3. Methodology

In the present research, the researcher sought to design a fuzzy inference system for studying ICT experts' turnover in Iran's communications industry. For this purpose, in the first step, the factors affecting turnover were identified based on review of the literature and interviewing experts. The large number of these variables (20) and the necessity of reducing the number of variables and identifying the most important variables required development of a questionnaire. The designed questionnaire contained 20 questions in which 5-point Likert scale had been used. 220 questionnaires were distributed, out of which 203 were filled and returned. Cronbach's alpha was used as a measure of reliability of the questionnaire and its value was obtained 0.76. The experts who were questioned had the experience of cooperation with or providing management consultancy services to the companies operating in Iran's Information and Communications Industry; companies such as Hamrahe Aval, Irancell, Nokia Siemens, ZTE and Huawei. Conducting the test of the mean of a population on the research data, out of twenty variables, in the first step, nine were removed due to their lower significance and eleven variables were used in the next phase of the research as more important variables. Twenty variables included age, educational level, organizational tenure, gender, career orientation, salary, role conflict, role ambiguity, autonomy, workload, task variety, job feedback, role spanning activities, job satisfaction, job commitment, career satisfaction, emotional exhaustion, job alternatives, a bad boss and fairness of the reward. As mentioned, these variables were reduced to eleven items (age, educational level, organizational tenure, gender, salary, role ambiguity, task variety, job satisfaction, job alternatives, a bad boss and fairness of the reward). Then, based on the process of decision making in a fuzzy environment which consists of the three phases of fuzzification, fuzzy inference and defuzzification, the system was designed and inference rules were formulated; in this regard, ten experts were consulted. The obtained model made it possible to predict turnover based on various inputs (variables affecting turnover). To validate the model, the obtained results were compared with the actual condition of turnover variable related to a number of knowledge workers who were working at or had abandoned their jobs at Hamrahe Aval Company. In the statistical tests section, data analysis was conducted using SPSS statistical software, and for designing the fuzzy inference system, Matlab software was used.

4. Findings

4.1. Results of the test of the mean of a population

Using the test of the population mean at the 95% confidence level, it was tried to identify the main antecedents of turnover from the viewpoint of the experts. The results indicated that from the twenty studied variables, eleven variables, namely, age, educational level, organizational tenure, gender, salary, role ambiguity, task variety, job satisfaction, job alternatives, a bad boss and fairness of the reward are considered important.

Table 1. The results of the test of the population mean for research variables

	One Sample Test					
	Test Value= 3					
	t	df	Sig. (2- tailed)	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Age	13.072	201	0.000	1.079	0.92	1.24
Educational Level	16.631	202	0.000	1.236	1.09	1.38
Organizational Tenure	11.318	201	0.000	0.921	0.76	1.08
Gender	13.839	201	0.000	1.050	0.90	1.20
Career Orientation	-12.603	202	0.000	-0.911	-1.05	-0.77
Salary	32.991	200	0.000	1.473	1.38	1.56
Role Conflict	-6.179	201	0.000	-0.510	-0.67	-0.35
Role Ambiguity	2.803	201	0.006	0.188	0.06	0.32
Autonomy	-6.752	201	0.000	-0.545	-0.70	-0.39
Workload	-12.191	202	0.000	-0.867	-1.01	-0.73
Task Variety	4.114	199	0.000	0.280	0.15	0.41
Job Feedback	-5.463	202	0.000	-0.443	-0.60	-0.28
Role Spanning Activities	-6.110	202	0.000	-0.468	-0.62	-0.32
Job Satisfaction	6.900	202	0.000	0.621	0.44	0.80

Career Satisfaction	-5.827	201	0.000	-0.569	-0.76	-0.38
Job Commitment	-5.917	202	0.000	-0.567	-0.76	-0.38
Emotional Exhaustion	-7.461	201	0.000	-0.733	-0.93	-0.54
Job Alternatives	19.597	201	0.000	1.277	1.15	1.41
A Bad Boss	11.873	200	0.000	0.910	0.76	1.06
Fairness of the Reward	35.906	202	0.000	1.468	1.39	1.55

4.2. Modeling fuzzy inference system

4.2.1. The process of modeling fuzzy inference system

The fuzzy inference system is developed using fuzzy logic toolbox in MATLAB (FLTB) software through three steps including definition of inputs, definition of outputs and finally, formulation of fuzzy rules:

1- Definition of inputs: the first stage in definition of inputs is encoding them. A name or code must be selected for each input that while being simple, is associated with that concept. The codes defined in the present research are presented in Table 2:

Table 2. Encoding inputs in turnover fuzzy inference system

Concept	Code
Age	A
Educational Level	EL
Organizational Tenure	OT
Gender	G
Salary	S
Role Ambiguity	RoAm
Task Variety	TV
Job Satisfaction	JS
Job Alternatives	JA
A Bad Boss	ABB
Fairness of the Reward	FR

The second stage is determining fuzzy sets for each of the input concepts and encoding them. In fact, each fuzzy set comprises one of the levels of its corresponding input concept. In Table 3, fuzzy sets for the input concepts and the defined codes are shown:

Table 3. Fuzzy sets for the input concepts and the defined codes

Concept code	Fuzzy sets code
A, EL, OT, S, RoAm, TV, JS, JA, ABB, FR	Low
	Middle
	High
G	Male
	Female

In the third stage, the function determining the degree of membership in each fuzzy set must be defined. For the ten variables of age, educational level, organizational tenure, gender, salary, role ambiguity, task variety, job satisfaction, job alternatives, a bad boss and fairness of the reward, triangular membership functions were defined as shown in Table 4 and for the variable of gender, triangular membership function was defined as shown in Table 5. The values defined for the parameters of triangular functions were selected based on the literature review and experts' views.

Table 4. The values defined for the parameters of triangular functions of low, middle and high fuzzy sets

Fuzzy sets	Parameters		
	a	B	c
Low	-0.5	1	2.5
Middle	1.5	3	4.5
High	3.5	5	6.5

Table 5. The values defined for the parameters of triangular functions of male and female fuzzy sets

Fuzzy sets	Parameters		
	a	b	c
Male	0.999	1	1.001
Female	-0.001	0	0.001

2- Definition of outputs: outputs, like inputs, are fuzzy concepts consisting of a number of fuzzy sets. The concept which has been defined as output is turnover of employees. This concept has been encoded as “Tur” and three levels, namely, low, middle and high have been defined for it. Definition of fuzzy sets and membership functions for the output variable was similar to that of the input variables. Only one output has been defined for the system. In Tables 6, 7 and 8, the codes defined for the output variable, fuzzy sets and membership functions of the output variable have been presented:

Table 6. Encoding the output in turnover fuzzy inference system

Concept	Code
Turnover	Tur

Table 7. Fuzzy sets for the output variable

Concept code	Fuzzy sets code
Tur	Low
	Middle
	High

Table 8. Defined values for triangular functions’ parameters of low, middle and high fuzzy sets

Fuzzy sets	Parameters		
	a	b	c
Low	-0.5	1	2.5
Middle	1.5	3	4.5
High	3.5	5	6.5

Finally, after defining all the input and output variables, the fuzzy inference system has been presented in Figure 1:

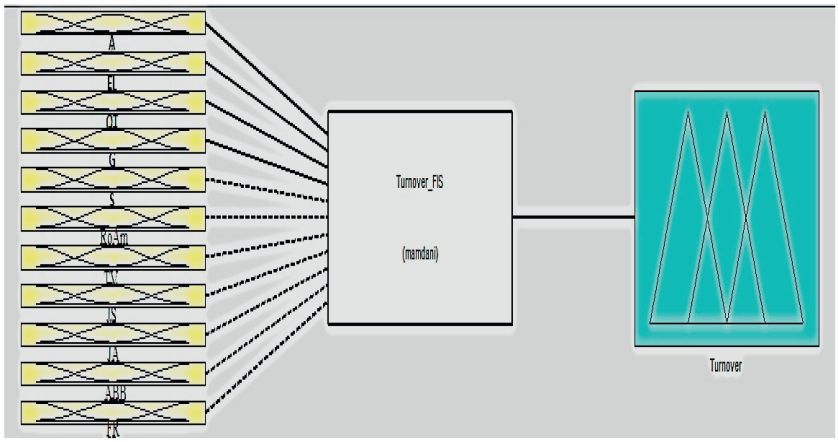

Figure 1. Turnover fuzzy inference system

3- Fuzzy rules: in a fuzzy inference system, the formulated fuzzy rules determine how various fuzzy sets are combined. Such a combination which is created based on the three operators related to union, intersection, and complement of sets, is defined in fuzzy rules. Fuzzy rules link inputs and outputs. The main sources for developing fuzzy rules are theoretical frameworks related to the subject, experts' views and the research literature review (Ghasemi, 2010). In the present research, the researcher asked ten experts to develop fuzzy rules. It is noteworthy that the operator used at the beginning of each statement is the operator "and". Some of these rules have been presented in Table 9.

Table 9. Some of the fuzzy rules defined for FLTB

Rule	If											Then
	A	EL	OT	G	S	RoAm	TV	JS	JA	ABB	FR	Tur
1	High	Middle	Middle	Male	Middle			Low	High			Low
2	Low	High	Low	Male	Middle			Low	Middle	High		High
3	Middle	Middle	Middle	Male				Middle		High		Low
4	Low	High	Low	Female	Low	High	Low	Low	High	High	Low	High
5	Low	Middle		Female	Low						Low	High

Thus, the set of fuzzy rules were entered in FLTB and the fuzzy inference system model was completed (Figure 2).

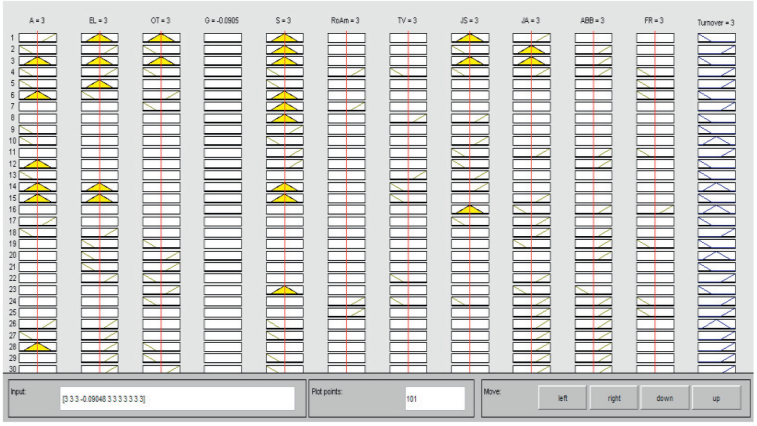

Figure 2. The final fuzzy inference system in FLTB

4.2.2. Testing the model

In order to examine the accuracy of the model, Ten employees who, at the time of the research, were either working at or had abandoned their jobs at Iran's Hamrahe Aval (First Operator) Company were asked to state their condition in terms of 11 research variables (age, educational level, organizational tenure, gender, salary, role ambiguity, task variety, job satisfaction, job alternatives, a bad boss and fairness of the reward) at the time of the research (the employees currently working) or at the time they had left the company (those who had abandoned their jobs). Inputs were entered into the fuzzy inference system designed by the researcher and outputs were observed (Table 10). Regarding those who had left the company, it was expected that software outputs predict turnover; in addition, according to the experts, receiving outputs for turnover variable with the score of 4 in MATLAB software was considered as turnover event. As it is seen, the software prediction (ForcTur) for five of the six individuals who had actually left the company (Act Tur=Yes) corresponds with the fact and the software prediction (ForcTur) for all the four individuals who were working at the company and had no turnover intention (Act Tur=No) corresponds with the fact. Thus, it could be claimed that the designed model is up to 90% capable of accurate prediction. However, it should be explained that feedback from such experiments can lead to review of the formulated fuzzy inference rules and improvement of FIS as long as it meets the requirements of organizational planners and their expected level of accuracy.

Table 10. Actual data for examining the accuracy of FIS

Code	Persons									
No.	1	2	3	4	5	6	7	8	9	10
A	4.56	4.46	2.13	1.4	1.1	1.6	1.92	1.6	3	1.41
EL	2.23	3.16	2.06	2.8	4.1	4.71	4.07	2.4	3.74	4.65
OT	3.9	4.8	1.98	2.1	1.32	1.73	2.24	4.28	1.92	1.67
G	0	1	0	1	1	1	0	0	0	1
S	2.21	3.12	1.81	2.97	1.35	1.68	2.32	3	3	4.07
RoAm	2.75	2.95	1.65	4.4	4.9	4.14	2.17	3.25	4.6	5
TV	3.1	2.35	4.26	4.9	4.7	3.94	3.23	1.53	3.1	3
JS	3.99	4.1	4.29	1	3.1	2.3	1	3.99	1.35	5
JA	1.87	2.1	2.37	4.86	4.85	4.33	3.95	1.87	5	4.78
ABB	1.32	1.25	2.38	4.88	4.1	5	4.71	1.43	4.9	4.9
FR	1.51	1.31	1.73	4.89	1.34	1.35	1.73	2.32	1.29	1.22
ForcTur	1.65	1.89	3.73	3	4.4	4.44	4.37	1.6	4.48	4.5
Act Tur	No	No	No	Yes	Yes	Yes	Yes	No	Yes	Yes

4.2.3. Graphical analysis

Finally, the graphical analysis of turnover was conducted based on the relationship between pairs of research variables for one of the cases in order to provide a clearer picture of application of FIS model. Person No. 9 (one of the individuals selected for examining the accuracy of FIS) was selected based on the variables presented in Table 9 in order to do the analysis. Figures 3, 4, and 5 show the condition of turnover within the various ranges of the variables of job satisfaction and role ambiguity, salary and age, a bad boss and job alternatives respectively. As it can be seen, Figure 3 suggests that as role ambiguity increases to higher levels, job satisfaction cannot prevent job turnover effectively. Figure 4 shows that even though at younger ages, low salary leads to turnover, yet at older ages, low salary does not lead to turnover. Figure 5 shows that a bad boss leads to turnover only if there are job alternatives in the job market. In fact, FIS makes it possible to predict the condition of turnover for each studied individual based on effective variables. Obviously, given this comprehensive database, human capital retention policies can be developed into plans for each and every individual.

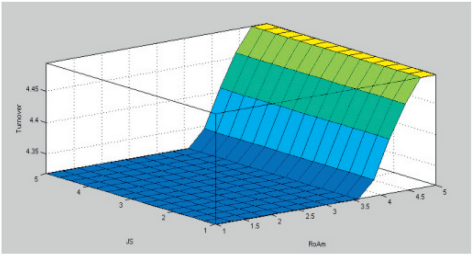

Figure 3. Representation of turnover based on the two variables of job satisfaction and role ambiguity

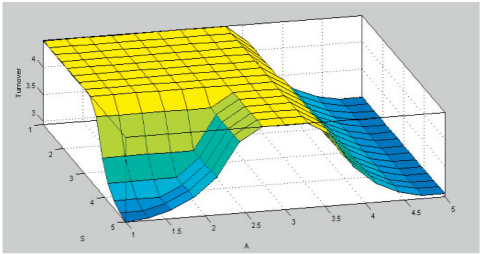

Figure 4. Representation of turnover based on the two variables of salary and age

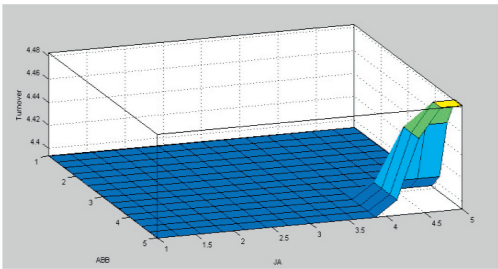

Figure 5. Representation of turnover based on the two variables of a bad boss and job alternatives

5. Conclusion

With the help of fuzzy inference systems, a planner can change the input values and observe the impact on output(s). For instance, it can be observed that if job satisfaction increases as much as A, role ambiguity decreases as much as B, salary increases as much as C, and task variety reaches D, then what the condition of turnover will be. In addition, by conducting a sensitivity analysis, it can be determined, based on the defined rules, the impact of which inputs on the output is higher and the impact of which inputs is lower.

Nowadays, environmental complexities and variables involved in management decisions have become so extensive that formulating any new strategies, except through accurate and scientific methods, is doomed to fail. Fuzzy inference systems are among the tools which, through simultaneous application of qualitative and quantitative methods, can provide an acceptable model of various organizational problems. Human capital strategies are also among issues which, considering the pivotal role of knowledge workers in new businesses of the twenty-first century, require more accuracy and more elaborate deign than before. Human capital strategies deal with issues such as recruitment strategies, performance assessment, training, retention, etc. Human capital retention strategies are among topics which gains additional significance in leading industries such as mobile communications, because creating competitive advantage in such industries is only possible through development and creation of new products and services based on innovative and creative ideas and obviously, creativity is not possible unless through productive human capital and knowledge workers; thus retention of knowledge workers is one of the main functions of human resource departments in the companies involved in mobile communication industry. Formulating and implementing proper strategies for retention of knowledge workers prevents the expenses imposed upon the organization due to knowledge workers' turnover and provides a condition under which their potential for creativity and innovation will be further realized.

Future researchers can use fuzzy inference systems to develop strategy for human resource subsystems such as training strategies, career planning, etc. In addition, fuzzy inference systems can be used in other organizational functions including development of customer retention strategies, research and development strategies, corporate financial strategies, etc.

In the present research, the role of environmental variables has not been studied. Considering factors such as inflation, unemployment rate, etc. can help better explain the phenomenon of job turnover among knowledge workers of Iran's telecommunications industry. Finally, what has so far been mentioned regarding fuzzy inference systems primarily concerns formulation of systems which can be considered as theory-based or expert-based systems. The use of Adaptive Neuro-Fuzzy Inference Systems (ANFIS) will lead to development of systems which can be labeled data-based systems and thus are mainly considered as exploratory systems. In the present research, in order to construct a fuzzy inference system, the opinions of experts were used; while future researchers can use adaptive neuro-fuzzy techniques based on real data and the behavior of knowledge workers to develop system rules.

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