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The Identification of Job Satisfaction under Z-Information

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ABSTRACT
Complexities in organizational and economical environments have lead psychologists, management scholars, and economists to investigate the multi-dimensional essence of job satisfaction. Unfortunately, existing studies are based on exact data, whereas relevant information is imperfect. To deal with imprecise and partially reliable information, Zadeh proposed the concept of a Z-number. In this paper we consider the Z-number valued rule based model to represent the relationship between job satisfaction and the facets/factors influencing job satisfaction. A real-world job satisfaction index evaluation problem is used to illustrate the suggested approach

KEYWORDS
Job satisfaction; Z-number; IF-THEN rules; Interpolative reasoning

1. Introduction

Job satisfaction is one of the most widely discussed issues in organizational behavior, human resource management and organizational management. A detailed understanding of job satisfaction is the key to improving the well-being of working individuals. Numerous studies have shown that job satisfaction has a direct impact on the performance of employees in different professions and at different levels. One of the most popular definitions for job satisfaction is the one provided by Locke (1976) who defined job satisfaction as "a pleasurable or positive emotional state resulting from the appraisal of one's job experiences".

Mahdavi, Fazlollahtabar, Mahdavi-Amiri, Arabmaghsudi, and Kolbadinejad (2011) considered an application of fuzzy logic to the evaluation of job satisfaction in an organization. The authors attempted to use the STRATA technique, fuzzy rules and a job satisfaction matrix in evaluation of job satisfaction. The study, however, did not include any concrete rule base, reasoning method, or computing procedures.

Fuzzy logic is an adequate formalism to model perception and feelings (Aliev, Pedrycz, & Huseynov, 2012; Aliev & Tserkovny, 2011). Rasmani and Shahari (2007) and Yuzainee, Mohd, and Azami (2013) proposed the use of fuzzy sets to represent linguistic terms in Likert-type scale and to employ the technique using the fuzzy conjoint method in the evaluation of job satisfaction. The application of fuzzy logic to job satisfaction problems was also considered by Gupta and Chakraborty (1998). In the study conducted by Rasmani and Shen (2006) the academic performance of students was evaluated and investigated using fuzzy IF-Then rules. Crocetta and Delvecchio (2007) proposed a fuzzy approach to measure satisfaction of graduates on the suitability of their university education for working purposes. De Battisti, Marasini, and Nicolini (2013) applied the fuzzy set theory in order to define a measure of subject satisfaction related to all social aspects, (quality of life, job, a service, etc.). Souza-Poza, Correa, and Bedoya (2003) examined the job satisfaction of individuals based on changes in situational factors using a simulation model based on fuzzy set theory and system dynamics.

Job satisfaction is related to mental, psychological and other factors, which are characterized by imperfect information (Aliev, 2013; Aliev, Alizadeh, & Guirimov, 2010). Unfortunately, the existing studies on job satisfaction found in the literature did not take into account fuzziness and partial reliability of real-world information. Although numerous studies have utilized fuzzy logic, no studies describe in detail how to compute job satisfaction under the combination of fuzzy and probabilistic uncertainties. In order to deal with real-world information, Zadeh (2011) suggested the concept of a Z-number, $Z = (A, B)$, where A is a fuzzy constraint on values of a random variable X and B is a fuzzy reliability of A. Aliev, Alizadeh, and Huseynov (2015) and Aliev, Huseynov, Aliyev, and Alizadeh (2015) have developed basic arithmetic operations over Z-numbers based on fuzzy arithmetic and probabilistic arithmetic. In this study we propose a Z-number valued IF-THEN rules based model to evaluate job satisfaction induced by its influencing facets/factors. The model utilizes the basic arithmetic operations over Z-numbers.

2. Preliminaries

Definition. A discrete Z-number: A discrete Z-number is an ordered pair $Z = (A, B)$ where A is a discrete fuzzy number playing a role of a fuzzy constraint on values of a random variable X: X *is* A. B is a discrete fuzzy number with a membership function $\mu_B:\{b_1, ..., b_m\} \to [0, 1]$, $\{b_1, ..., b_m\} \subset [0, 1]$, playing a role of a fuzzy constraint on the probability measure of A:

$$P(A) = \sum_{i=1}^{n} \mu_A(x_i)p(x_i) \ is \ B \quad (1)$$

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Table 1. The Encoded Linguistic Terms for Job Satisfaction.

Scale	Level of Satisfaction	Linguistic value
1.	Unsatisfied (U)	$\left\{ {}^{1}/_{1} \quad {}^{0}/_{2} \right\}$
2.	Less Satisfied (LS)	$\left\{ {}^{0}/_{1} \quad {}^{1}/_{2} \quad {}^{1}/_{2.5} \quad {}^{0}/_{3} \right\}$
3.	Quite Satisfied (QS)	$\left\{ {}^{0}/_{2.5} \quad {}^{1}/_{3} \quad {}^{1}/_{3.5} \quad {}^{0}/_{4} \right\}$
4.	Satisfied (S)	$\left\{ {}^{0}/_{3.5} \quad {}^{1}/_{4} \quad {}^{1}/_{4.5} \quad {}^{0}/_{5} \right\}$
5.	Very Satisfied (VS)	$\left\{ {}^{0}/_{4.5} \quad {}^{1}/_{5} \right\}$

Table 2. The Encoded Linguistic Terms for Reliability.

1.	Low (L)	$\left\{ {}^{0}/_{1} \quad {}^{1}/_{0} \quad {}^{1}/_{0.3} \quad {}^{0}/_{0.4} \right\}$
2.	Medium (M)	$\left\{ {}^{0}/_{0.3} \quad {}^{1}/_{0.4} \quad {}^{1}/_{0.6} \quad {}^{0}/_{0.7} \right\}$
3.	High (H)	$\left\{ {}^{0}/_{0.6} \quad {}^{1}/_{0.7} \quad {}^{1}/_{1} \quad {}^{0}/_{1} \right\}$

Operations over Discrete Z-numbers: Let $Z_1 = (A_1, B_1)$ and $Z_2 = (A_2, B_2)$ be discrete Z-numbers describing information about values of X_1 and X_2. Consider the computation of $Z_{12} = Z_1 * Z_2,\ * \in \{+, -, \cdot, /\}$. The first stage is the computation of $A_{12} = A_1 * A_2$ (Aliev et al., 2015).

The second stage involves construction of $B_{12.}$ We realize that in Z_1 and Z_2, the "true" probability distributions p_1 and p_2 are not exactly known, and fuzzy restrictions are only available:

$$\mu_{P_1}(p_1) = \mu_{B_1}\left(\sum_{k=1}^{n_1} \mu_{A_1}(x_{1k}) P_1(x_{1k})\right),$$
$$\mu_{P_2}(p_2) = \mu_{B_2}\left(\sum_{k=1}^{n_2} \mu_{A_2}(x_{2k}) P_2(x_{2k})\right). \tag{2}$$

Probability distributions p_1, p_2 induce probabilistic uncertainty over $X_{12} = X_1 + X_2$. Given any possible pair p_1, p_2, the convolution $p_{12} = p_1 \circ p_2$ is computed as

$$p_{12}(x) = \sum_{x_1 + x_2 = x} p_1(x_1) p_2(x_2),\ \forall x \in X_{12};\ .x_1 \in X_1, x_2 \in X_2. \tag{3}$$

Given p_{12}, the value of probability measure of A_{12} is computed:

$$P(A_{12}) = \sum\nolimits_{k=1}^{n} \mu_{A_{12}}(x_{12k}) p_{12}(x_{12k}) \tag{4}$$

However, p_1 and p_2 are described by fuzzy restrictions, which induce a fuzzy set of convolutions:

$$\mu_{p_{12}}(p_{12}) = \max_{\{p_1, p_2 : p_{12} = p_1 \circ p_2\}} \min\{\mu_{p_1}(p_1), \mu_{p_2}(p_2)\} \tag{5}$$

Fuzziness of information on p_{12} induces fuzziness of $P(A_{12})$ as a discrete fuzzy number B_{12}. The membership function $\mu_{B_{12}}$ is defined as

$$\mu_{B_{12}}(b_{12}) = \sup(\mu_{p_{12}}(p_{12})) \tag{6}$$

subject to

$$b_{12} = \sum_k p_{12}(x_k) \mu_{A_{12}}(x_k) \tag{7}$$

As a result, $Z_{12} = Z_1 * Z_2$ is obtained as $Z_{12} = (A_{12}, B_{12})$.

A scalar multiplication $Z = \lambda Z_1,\ \lambda \in R$ is a determined as $Z = (\lambda A_1, B_1)$ (Aliev et al., 2015).

Table 3. Z-rules.

	Inputs																				Output
Z-rule No.	Activity	Independence	Variety	Social status	Supervision-Human relations	Supervision-technical	Moral values	Security	Socialservice	Authority	Ability	Company policies and practices	Compensation	Advancement	Responsibility	Creativity	Working conditions	Co-workers	Recognition	Achievement	Overall Satisfaction
1	(VS,H)	(VS,H)	(QS, H)	(U,M)	(QS, H)	(QS, H)	(VS, H)	(S, H)	(VS, H)	(QS, H)	(VS, H)	(S, H)	(VS, H)	(VS, H)	(VS, H)	(VS, H)	(VS, H)	(QS, H)	(S, H)	(VS, H)	(S, H)
2	(VS, H)	(S, H)	(VS, H)	(VS, H)	(VS, H)	(S, H)	(QS, H)	(QS, H)	(VS, H)	(S, H)	(VS, H)	(QS,H)	(S,H)	(VS,H)	(VS,H)	(VS,H)	(S,H)	(QS,H)	(VS,H)	(VS,H)	(S,H)
3	(S,H)	(S, H)	(S, H)	(S, H)	(QS, H)	(QS, H)	(QS, H)	(QS, H)	(S, H)	(S, H)	(S, H)	(LS,M)	(LS,M)	(QS, H)	(S, H)	(S, H)	(LS, M)	(S,H)	(QS,H)	(QS, H)	(QS, H)
4	(LS,M)	(S, H)	(LS,M)	(QS, H)	(VS, H)	(S, H)	(S, H)	(S, H)	(S, H)	(S, H)	(VS, H)	(S, H)	(LS,M)	(S, H)	(S, H)	(QS, H)	(S, H)	(S, H)	(S, H)	(VS, H)	(S, H)
5	(S, H)	(QS, H)	(LS,M)	(S, H)	(S, H)	(S, H)	(LS, M)	(LS,M)	(S, H)	(S, H)	(S, H)	(S, H)	(LS,M)	(QS, H)	(S, H)	(S, H)	(QS, H)	(S, H)	(S, H)	(S, H)	(S, H)
6	(QS, H)	(S, H)	(S, H)	(QS, H)	(S, H)	(S, H)	(S, H)	(QS, H)	(S, H)	(QS, H)	(S, H)	(QS, H)	(QS, H)	(QS, H)	(QS, H)	(S, H)	(QS, H)	(QS, H)	(S, H)	(QS, H)	(QS, H)
7	(S, H)	(S, H)	(LS,M)	(S, H)	(US,M)	(US,M)	(US,M)	(S, H)	(QS, H)	(US,M)	(LS,M)	(LS, M)	(QS, H)	(S, H)	(LS,M)	(LS, M)	(QS, H)	(S, H)	(VS, H)	(S, H)	(LS,M
8	(S, H)	(S, H)	(S, H)	(QS, H)	(S, H)	(S, H)	(QS, H)	(QS, H)	(QS, H)	(QS, H)	(S, H)	(QS, H)	(LS,M)	(QS, H)	(QS, H)	(S, H)	(LS,M)	(S,H)	(QS,H)	(QS,H)	(S,H)
9	(S,H)	(S,H)	(S, H)	(QS, H)	(S, H)	(S, H)	(QS, H)	(QS, H)	(QS, H)	(QS, H)	(S, H)	(QS, H)	(LS,M)	(LS,M)	(QS,H)	(QS, H)	(QS, H)	(S, H)	(QS, H)	(QS, H)	(QS, H)
10	(QS, H)	(QS, H)	(QS, H)	(QS, H)	(S, H)	(S, H)	(QS, H)	(QS, H)	(QS, H)	(QS, H)	(QS, H)	(LS,M)	(LS,M)	(QS,H)	(S,H)	(QS,H)	(LS,M)	(S,H)	(QS,H)	(QS, H)	(QS, H)

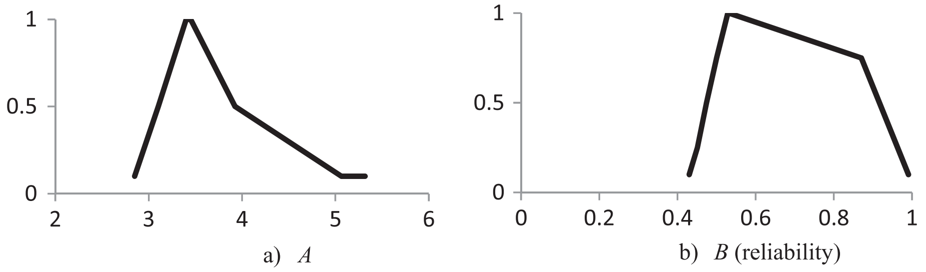


Figure 1. The Computed Z-number Valued Overall Job Satisfaction.

3. Problem Statement and Solution Method

Our investigation shows that the following are the main facets/factors for the evaluation of job satisfaction performance: **Activity, X_1, Independence, X_2, Variety, X_3, Social status, X_4, Supervision-human relations, X_5, Supervision–technical, X_6, Moral values, X_7, Security, X_8, Social service, X_9, Authority, X_{10}, Ability, X_{11}, Company policies and practices, X_{12}, Compensation, X_{13}, Advancement, X_{14}, Responsibility, X_{15}, Creativity, X_{16}, Working conditions, X_{17}, Co-workers, X_{18}, Recognition, X_{19}, Achievement, X_{20}.**

In general, a job satisfaction evaluation is based on human interpretations, which are vague and uncertain. Perception and feelings, which underlie the job satisfaction factors are rather qualitative indices expressed as "very satisfied", "less satisfied", etc. For such evaluation fuzzy sets-description can be used (Aliev, 1994; Aliev & Aliev, 2001; Aliev, Mamedova, & Aliev, 1993). On the other hand, perception and feelings are partially reliable. Thus, an application of Z-evaluation based logic would provide more adequate basis for an evaluation process. The linguistic terms for the factors are given in Tables 1 and 2.

The problem of overall job satisfaction evaluation is stated as follows; raw data is created from the questionnaires (to evaluate *activity, independence, variety, social status* and other facets/factors) completed by experts. This data involves imprecision and partial reliability related to the experts' knowledge. Next, the problem of the aggregation of experts' opinions described by Z-numbers should be solved. For this purpose, various aggregation operators can be used. We proposed to use Z-valued weighted arithmetic mean. Let $Z_{j1}, Z_{j2}, \ldots, Z_{jK}$, $j = 1, \ldots, 20$ are Z-number valued evaluations of the j-th factor of job satisfaction assigned by each of K experts. Denote W_k, $k = 1, \ldots, K$ Z-number valued weights measuring competence of experts. Then, the overall Z-number valued evaluation Z_j of the j-th factor is computed by using Z-valued weighted arithmetic mean: $Z_j = \sum_{k=1}^{K} W_k Z_{jk}$.

Thus, the values of the factors X_j are determined as Z-numbers $X_j = Z_j$. The relationship between overall job satisfaction and influencing factors are presented as Z-rules (Table 3).

Given the Z-rules obtained from Table 3 and the facets

$$X_1\ is(S,H),\ X_2\ is(U,M),\ X_3\ is(VS,H), X_4\ is(S,H),$$
$$X_5\ is(U,M), X_6\ is(LS,M), X_7\ is(S,H), X_8\ is(VS,H),$$
$$X_9\ is(U,M), X_{10}\ is(VS,H), X_{11}\ is(LS,M), X_{12}\ is(U,M),$$
$$X_{13}\ is(S,H), X_{14}\ is(S,H), X_{15}\ is(VS,H), X_{16}\ is(S,H),$$
$$X_{17}\ is(VS,H), X_{18}\ is(QS,H), X_{19}\ is(U,M), X_{20}\ is(QS,H),$$

It is needed to compute a Z-valued overall job satisfaction index. The problem is solved as follows: At the *first step*, we compute activation degree of the i - th rule, λ_i, on the basis of similarity between a vector of current Z-valued evaluations Z_j of X_j, $j = 1, \ldots, 20$ and the corresponding Z-valued antecedent; Z_{ij}: $\lambda_i = \min_{j=1,\ldots,20} S(Z_j, Z_{ij})$. We suggest to compute $S(Z_j, Z_{ij})$ by using the Jaccard similarity measure J:

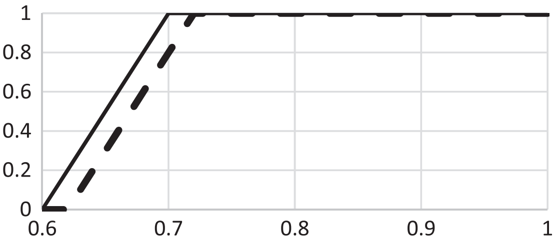


Figure 2. The Reliability "High" used in Table 2 (Solid Curve) and New One (Dashed Curve).

$$S(Z_j, Z_{ij}) = \frac{1}{2} \frac{\sum_{k=1}^{n} \mu_{A_j}(x_k) \cdot \mu_{A_{ij}}(x_k)}{\sum_{k=1}^{n} \left(\mu_{A_j}(x_k)\right)^2 + \sum_{k=1}^{n} \left(\mu_{A_{ij}}(x_k)\right)^2 - \sum_{k=1}^{n} \mu_{A_j}(x_k) \cdot \mu_{A_{ij}}(x_k)}$$
$$+ \frac{1}{2} \frac{\sum_{k=1}^{m} \mu_{B_j}(x_k) \cdot \mu_{B_{ij}}(x_k)}{\sum_{k=1}^{m} \left(\mu_{B_j}(x_k)\right)^2 + \sum_{k=1}^{m} \left(\mu_{B_{ij}}(x_k)\right)^2 - \sum_{k=1}^{m} \mu_{B_j}(x_k) \cdot \mu_{B_{ij}}(x_k)}. \quad (10)$$

For example, some of $S(Z_j, Z_{ij})$ values of the current input and the antecedents of the 3rd rule are $S(Z_2, Z_{32}) = S((U,M),(S,H)) = 0.54$, $S(Z_8, Z_{38}) = S((VS,H),(QS,H)) = 0.5$. Given the values of $S(Z_j, Z_{3j})$, the activation degree of the 3rd rule is obtained as $\lambda_3 = 0.014$.

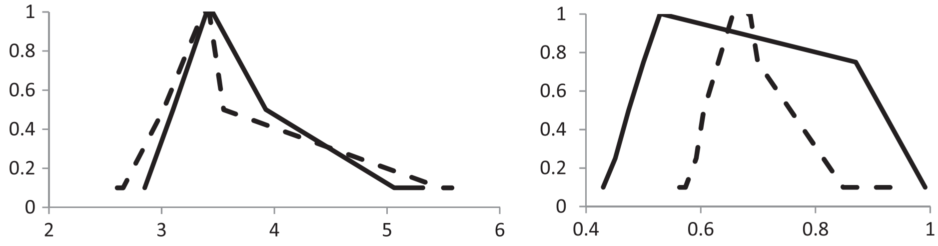
At the *second step* we compute the overall Z-valued job satisfaction evaluation Z_Y by aggregating Z-number based values Z_{Y_i} of the consequents Y_i, $i = 1, \ldots, 10$ as follows:

$$Z_Y = \sum_{i=1}^{10} \lambda_i Z_{Y_i} \Big/ \sum_{i=1}^{10} \lambda_i \quad (11)$$

The addition and the scalar multiplication in (10) are performed as shown in Section 2.

The computed Z-number of overall job satisfaction is given in Figure 1.

The linguistic approximation of the obtained Z-number is found as (S, M). The use of Z-valued information in job satisfaction evaluation provides realistic results. The reason is that an evaluation in such problem characterized by complexity and uncertainty of psychological and perceptual factors cannot be fully reliable.



c) *A* d) *B* (reliability)

Figure 3. The Z-number Valued Overall Job Satisfaction Computed under the New Fuzzy Reliability (Dashed Curve) and the One Computed under the Original Fuzzy Reliability (Solid Curve).

Let us conduct a sensitivity test of the used job satisfaction model. We slightly changed the reliability in the Z-value (QS, H) of the 19th factor in the third rule to the following fuzzy number (Figure 2).

Given the new fuzzy number, we computed the Z-valued overall job satisfaction (Figure 3).

The linguistic approximation of the new Z-value of job satisfaction is found as (S, M)=(Satisfied, Medium), which is the same as that of the original result. It is intuitive that the Z-value of job satisfaction does not change qualitatively under the small change in the rule base.

Let us compare the results of the job satisfaction evaluation obtained by using Z-valued rules with results obtained by using fuzzy rules. Suppose that the used fuzzy evaluations are fully reliable. Then, we can use fuzzy rules whose fuzzy terms coincide with *A* components of Z-valued rules. The obtained result is $Y = \{0/2.8, 0.5/3.1,\ 1/3.36, 1/3.86, 0.5/4.11, 0/4.36\}$The linguistic approximation of this fuzzy value is "*satisfied*". This coincides with the first component of the result obtained by using the Z-valued rules. However, generating a completely reliable evaluation for the problem characterized by ensemble of 20 influential factors such as *independence, moral values, creativity* etc. is counterintuitive.

4. Conclusion

In this paper we have suggested a Z-number valued IF-THEN rules-based model for the evaluation of job satisfaction. The approach handles inherent fuzzy and probabilistic uncertainties. A real-world job satisfaction evaluation problem indicates the validity of the suggested approach.

Disclosure statement

No potential conflict of interest was reported by the authors.

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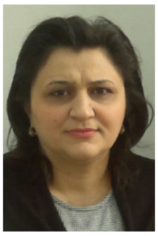

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