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Applying fuzzy logic to assessment of enterprise readiness for changes

Ivanna Zapukhliak[a*], Yaroslav Zaiachuk[b], Alla Polyanska[c] and Iryna Kinash[d]

[a]Professor at Department of Management and Administration, Doctor of Economics, Associate Professor, Ivano-Frankivsk National Technical University of Oil and Gas, Ukraine
[b]Associate Professor of the Department of Computer Systems and Networks, PhD, Associate Professor, Ivano-Frankivsk National Technical University of Oil and Gas, Ukraine
[c]Head of the Department of Management and Administration, Doctor of Economics, Associate Professor, Ivano-Frankivsk National Technical University of Oil and Gas, Ukraine
[d]Professor at Department of Management and Administration, Doctor of Economics, Professor, Ivano-Frankivsk National Technical University of Oil and Gas, Ukraine

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A B S T R A C T

The relevance of using the provisions of the fuzzy logic theory in assessing the readiness of the enterprise to change is substantiated. This made it possible to objectively assess the current state of the enterprise, using the nonlinear principles of forming conclusions, to simulate the experts' reflections on the level of enterprise readiness to change. It is proposed to use the McKinsey 7S model in the process of structuring the enterprise's internal environment. On the basis of this model, a fuzzy-multiplier model for evaluating the enterprise's readiness for changes, is constructed, which is presented in the form of a hierarchical relationship between the input variables, groups of input variables; integral characteristics of the elements of the enterprise that characterize its activities, in particular: strategy, structure, systems, style/culture, staff, skills, common values and output variable and they characterize the integral indicators of enterprise readiness for changes. Questionnaires are developed and a survey of gas transportation company staff is conducted on readiness for changes. The result of the expert opinions elaboration is received on the basis of the following methods application; namely statistical processing of expert opinions; the method of pairwise comparisons and the method of fuzzy clusterization. The functions of all parameters membership of the constructed system are obtained. On the basis of the averaged membership functions of input and output parameter terms, the correspondence between membership functions and control rules according to Zadeh is created and the structure of the Mamdani type in the MATLAB system is synthesized. As a result, the assessment of the gas transportation enterprises readiness level to change is obtained. It is substantiated that the obtained results are considered as the basis for further effective decision making in order to ensure the development in the conditions of the instability of the functioning environment.

1. Introduction

Today, new business conditions require systematic and permanent changes. Changes for modern enterprises become an integral part of their activities and require the formation of additional managerial competencies, namely management of changes in the enterprise. Kantamara and Ractham (2014) point out

* Corresponding author.
E-mail address: y.zaiachuk@nung.edu.ua (Y. Zaiachuk)

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that "with the current change drivers, such as, globalization, advance technology, information age, global economy, market maturation, etc., change is happening at an alarming rate. If an organization wants to maintain its competitive advantage, it has to change the way it thinks and the way it operates to be responsive to these change drivers" (p. 55). And the reaction of the organization to change depends primarily on the people who work there. That is, these changes are made by people. The extent to which people are ready for change is the successful adaptation of the organization to the new conditions.

Informing and communicating are the key of ensuring readiness for change. According to Kantamara and Ractham (2014), sending clear, credible, and heartfelt messages about the direction of change is crucial. More often than not, communication is limited within a small group of top management who develops the vision; and thus, creates suspicion among lower level employees. In order for change to happen, organizational leaders and/or change agents need "gut-level commitment, and liberate more energy from a critical mass of people" (Kotter & Cohen*, 2002). Cummings and Worley (2004) admitted that change involves moving from the known to the unknown. But we believe on the contrary that through change there is a transition from one stable state of the enterprise to another. And successful implementation of changes, in turn, will depend on how the enterprise as a system is ready for their implementation. Therefore, we can confirm the following: the readiness of the enterprise to change is a harmonized state of all subsystems of the enterprise, in which they are able to respond in a coordinated way to the action of external and internal factors, using adaptation or bifurcation mechanisms, while maintaining the stability of its functioning and development (Polyanska A., 2012; Zapukhliak I., 2017).

In this case we consider the conceptual and applied aspects of assessing the enterprise's readiness for change based on the construction of an integrated multifactorial structural model using fuzzy logic theory. The basis of such model constructing is consideration of the enterprise as a system of interconnected elements, the composition of which is determined using the McKinsey 7S model.

1.1 Related Works Analysis

In most studies related to the methodology of enterprise readiness evaluating for change, the emphasis is made to the socio-psychological aspect. Thus, Vikhansky and Naumov (2006, p. 419-428) focuse on the readiness to change workers, which is the basis for changes at the enterprise on the whole. Cohen (2007) proposes an integrative approach of assessing staff readiness for changes by defining a system of indicators for four categories of employees (directors, managers, employees, project teams) for each of the eight stages of change management. The nature of readiness is summarized by three levels: the zone of readiness for change, a zone of possible problems, an area of interference. Gusieva (2013) has formulated an approach of assessing the company's preparedness for change, which involves the calculation of 12 integral indicators of readiness for change in four components: financial and economic provision, organizational efficiency and competent readiness of top managers, middle managers, employees and specialists, involved in the changes on each stage of change management using the methods of the theory of fuzzy sets. The level of the enterprise readiness to change is proposed to be determined on a five-level scale in the context of each of the four components.

Summarizing theoretical, methodological and practical results of scientists researches in solving problems of assessing the company's readiness for change, it can be argued that in existing works, the readiness of the enterprise for changes due to readiness of the staff is mainly covered. However, systematic register of such readiness factors as the readiness of the enterprise structure and systems, the availability of strategy, the general culture and management style, organizational responsiveness to changes and skills of employees, the existence of common values of the enterprise have not been sufficiently reflected in the studies conducted. To eliminate this disadvantage, we propose to expand the scope of the enterprise readiness assessing for changes by using the expert methods of evaluation. Their use requires a certain analytical apparatus, in particular, the method of fuzzy logic.

So, in this article we use the research of the founder of the theory of fuzzy sets (Zade, 1988), who, in particular, proposed to use the function of belonging (with a range covering the interval [0,1]), acting on the domain of all possible values. Lootsma F. (1997) considered the basic concepts of fuzzy logic: the function of belonging, crossing and combining fuzzy sets, fuzzy numbers and the principle of expansion, as well as the possibility of their application in planning and decision-making. Buckley et al. (2002) aims at surveying results in the application of fuzzy sets and fuzzy logic to economics and engineering. Carlsson et al. (2004) argue that fuzzy logic in management demonstrates that difficult problems and changes in the managerial environment can be more easily handled by bringing fuzzy logic into management practice. Shang K. et al. (2013) explored the possibility of applying fuzzy logic to risk assessment and decision-making. Keller A. (2010) believes that the theory of fuzzy sets has been extensively applied to a variety of domains in soft computing, modeling and decision making, and this introduction introduces these attractive techniques with numerical applications to economical single-objective bi-matrix games.

1.2 Goal

The goal of the article is to consider the theoretical and applied aspects of enterprise's readiness assessing for changes based on the construction of the integrated multifactorial structural model using fuzzy logic theory and took into account the system of enterprise's interconnected elements, the composition of which is determined by using the McKinsey 7S model.

2. The model for assessing the readiness of the enterprise to change

Analyzing the internal environment of the enterprise from the standpoint of its readiness for change, we can consider the enterprise as a system of interconnected elements, the composition of which is determined using the McKinsey 7S model proposed by Peters and Waterman (1982), within which a Structure, Strategy, Systems, Shared values, Style, Skills, Staff. The fuzzy-plural model for evaluating enterprise readiness for change is presented in the form of a hierarchical relationship between input variables (X_1-X_{102}), groups of input variables («Mission and Vision», etc. - 24 groups); the integral characteristics of the seven elements of the enterprise: the strategy, structure, systems, style / culture, staff, skills, common values and the output variable - an integral indicator of enterprise readiness to change (Fig. 1). The uncertainty in the model is due to a fuzzy interpretation of the levels of readiness of the enterprise to change. Integral indicator of the level of enterprise readiness for change is some number from the interval [0; 1], we note that the higher the value of the indicator, the higher the level of readiness of the enterprise to change. Accordingly, the task is to formulate a methodology and create software that will make it possible to assess the company's readiness to change based on the input parameters.

3. Method of determining the level of readiness of the enterprise to change

Given the objectively existing obscurity of information about an object, it is necessary to use the fuzzy logic device, which enables to objectively and more effectively evaluate the current state of the enterprise, using nonlinear principles of forming conclusions, to simulate the experts' thoughts about the level of readiness of the enterprise to change. Principles of fuzzy logic are systematic approaches and are based on the intuition and experience of experts, using elements of everyday language for describing the behavior of systems. Therefore, while the assessing current situation in the enterprise from the standpoint of readiness for change, experts use not quantitative values of different indicators, but linguistic quality assessments (linguistic variables): very good, good, satisfactory, bad, very bad. Drawing on the work on the use of fuzzy logic (Rothstein, 1996; Rotshtein & Katel'nikov, 1998; Rothstein, 1999; Rothstein et al., 2008; Katel'nikov, 1998), we note that for defining the readiness of the enterprise to changes we will use the following methodological principles:

- the principle of linguistics of input and output variables. In accordance with this principle, the inputs of an object and its output are regarded as linguistic variables that are evaluated by fuzzy terms;

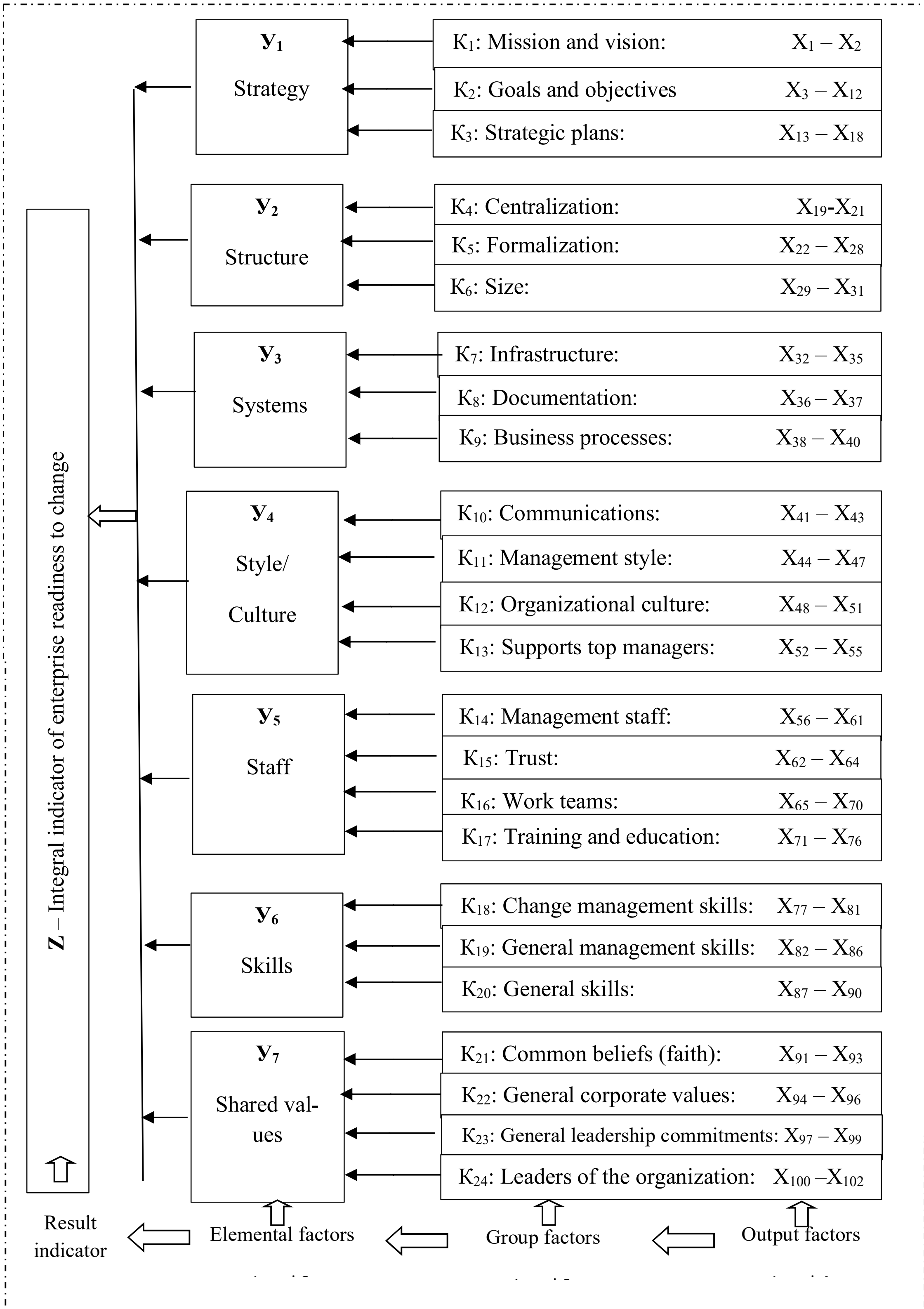

Fig. 1. Scheme of interaction of fuzzy variables hierarchical levels included in the model for assessing the company's readiness for changes

Source: Zapukhliak, I., 2017.

- the principle of forming the structure of the diagnostic dependence of "input-output" in the form of a fuzzy knowledge base. The formation of a fuzzy knowledge base (Rothstein, A., 1996) is interpreted as an analog of the stage of structural identification, on which a rough diagnostic model is constructed with parameters to be configured. In addition, the set of rules <IF - THEN> can be considered as a set of expert points in the space "input-output". The application of a fuzzy conclusion allows us to restore at these points a multidimensional "input-output" surface;

- the principle of training fuzzy knowledge bases. In accordance with this principle constructing the model are carried out in two stages, which, by analogy with the classical methods (Tsypkin, 1984) can be considered as stages of structural and parametric identification. The first stage is the formation of a coarse model based on the available expert information of the fuzzy knowledge base. The higher the professional level of the expert, the better the adequacy of the fuzzy model built in the first stage. However, the coincidence of the results of the fuzzy conclusion (theory) and experimental data is not guaranteed. Therefore, a second stage is required, which teaches the fuzzy model by setting its parameters based on experimental data. The essence of the second stage of identification is the selection of such weights of fuzzy rules of the knowledge base, and those parameters of membership functions that minimize the deviation between the experimental data and the results of the fuzzy conclusion (Rothstein, A.,1996). Learning the fuzzy knowledge base is reduced to the problem of nonlinear optimization, which can be solved by various methods. For the study of large knowledge bases it is expedient to use genetic algorithms (Gen, M., Cheng, R.-John Wiley & Sons., 1997), which allow to solve complex problems of optimization more effectively than usual methods of mathematical programming (fast descent method, quasi-Newtonian methods, etc.). Genetic algorithms are the analogue of a random search that runs simultaneously from different starting points using cross-linking, mutation and selection operations.

The basis of the fuzzy systems design is the construction of a knowledge base (KB). In the knowledge base, the experience and knowledge of the expert can be filled in as follows: the expert forms their action at each situation in the form of products IF ... THEN ..., the set of which is the knowledge base. A set of rules-products is a priori knowledge about the process and obtained by experts on the basis of their experience and intuition using the logical links AND, OR, NO and the implications "IF ... THEN ..." In our case, experts are the top managers, managers of the middle and low levels of management of gas transportation companies. The experts are qualified specialists and have a thorough knowledge of the subject area, including 25% of them are managers, 41% of them middle-level managers, 33% of them are low-level managers.

As it was previously defined, the main parameters which were selected to determine the gas companies' readiness for changes are following: input variables ($X_1 - X_{102}$), groups of input variables (Mission and Vision (K_1), totally 24 groups); integral characteristics of the seven elements of the enterprise: strategy (Y_1), structure (Y_2), system (Y_3), style / culture (Y_4), staff (Y_5), skills (Y_6), general values (Y_7). Output variable is an integral indicator of gas transportation enterprises readiness for changes (Z).

There is a certain functional relationship between these parameters:

$$\begin{aligned} K_j &= f\left(X_1, X_2, ..., X_{102}\right), j = \overline{1,m}, m = 24, \\ Y_k &= f\left(K_1, K_2, ..., K_{24}\right), j = \overline{1,n}, n = 7, \\ Z &= f\left(Y_1, Y_2, ..., Y_7\right), \end{aligned} \tag{1}$$

where m – the number of groups of input variables, n - number of elements, describing the enterprise activity. The areas of parameters change that characterize the company's readiness to changes are based on the theoretical achievements of Zadeh (1998) and reside in the range of 0 to 1. Assume that input and output variables are linguistic variables that are given on universal sets (2) and (3). The values of a linguistic variable are words or sentences of a natural language, that is, terms. To evaluate linguistic variables we will use qualitative terms from the following term sets:

$$L_i^{(f)} = \left\{ l_i^{(1)}, l_i^{(2)}, ..., l_i^{(q_f)} \right\}, \quad (2)$$

$$Z = \left\{ z^{(1)}, z^{(2)}, ..., z^{(s)} \right\}, \quad (3)$$

where $L_i^{(f)}$, Z - the term of the set of input and output variables, respectively;

$l_i^{(p)}$ - p - the linguistic term of the input variable $x_i^{(f)}$, $p = \overline{1, q_f}$;

$z_i^{(s)}$ - s - the linguistic term of the output variable z_i, $s = \overline{1, b_i}$;

q_f, b_i - the number of linguistic terms of variables and; $x_i^{(f)}$ i z_i;

f – variable number.

Then the phasing process takes place on the basis of fuzzy rules $R_i^{(j)}$ that have the following form (Rutkovskaya et al., 2004):

$$R_i^{(j)}: \text{if } (x_i^{(1)} \text{ is } L_i^{(j1)} \text{ and } x_i^{(2)} \text{ is } L_i^{(j2)} \dots \text{ and } x_i^{(k)} \text{ is } L_i^{(jf)}), \text{ then } Z \text{ is } z_i^{(js)}, \ j = \overline{1, D}, \quad (4)$$

where D - the number of fuzzy rules;

$L_i^{(jp)}$, $z_i^{(js)}$ - elements of sets $L_i^{(p)}$ and $Z_i^{(s)}$.

To manipulate by the linguistic values, they need to be interpreted. To this end, a fuzzy set device is used, where each function value is assigned a membership function. Membership functions can be obtained by specially developed methods, among which there are the most common: the method of static information processing and the method of pair comparisons. In addition, you can use the standard membership functions (Rothstein et al., 2008) Sementsov G. notes that fuzzy sets that have to be operated in solving practical problems are unimodal and normal. One of the unimodal methods for approximating unimodal normal fuzzy sets is approximation with the help of functions (L-R) type (Sementsov & Fadeeva, 2005). However, the use of such functions involves a laborious procedure for selecting unknown parameters based on expert information. Therefore, there is a problem of constructing a membership function in the conditions of output data minimum, which include:

- parameter name $x_i^{(f)}$, $f = \overline{1, d}$, $i = \overline{1, m}$;
- range $\left[\overline{x}_i^{(f)} \ \underline{x}_i^{(f)} \right]$ of parameter change $x_i^{(f)}$;
- the number of terms q_f used to evaluate the parameters $x_i^{(f)}$;
- the name of each linguistic term.

In the literature concerning the definition of the number of terms there is not specific recommendations. Their number is chosen from the interval 7 ± 2 (Sementsov & Fadeeva, 2005) A further increasing in the number of terms leads to a complication of the model without increasing its accuracy. Taking into account the above noted, there is a problem of choosing the number of terms parameters that characterize the level of enterprise readiness to changes.

The number of terms can be determined in two ways (Sementsov & Fadeeva, 2005):

- the task of a certain universal set, and then the transition to real values based on the use of expert knowledge;
- definition of the number of terms, based on the range of change of some size X_i and quantization interval ΔX_i:

$$r = \frac{X_i}{\Delta X_i}, \ \Delta X_i = X_{i+1}^* - X_i^*, \quad (5)$$

where X_i^* is the quantization level. Applying the first method, the number of terms that is needed to phase out the parameters of the model for assessing the readiness of the enterprise to change (Table 1) is determined.

Table 1
The number of terms that are needed to phase out the parameters

Parameters	X_i	K_j	Y_k	Z
Required number of terms	5	7	3	3

Source: Zapukhliak, I., 2017.

Functions of inputs X_i, K_j, Y_k and output Z parameters are constructed using several methods (Rutkovskaya, D., Pylinsky, M. & Rutkovskii *L.,* 2004): a method based on statistical processing of the statements of many experts; pair comparison method performed by one expert; fuzzy clustering method. In this case, the set of sets: the set of terms $L = \{L, ML, M, MH, H\}$ and the universal set of input and output parameters. Let's dwell briefly on the results obtained from the use of each of these methods. Within the application of the method of statistical processing of expert information, each expert filled out a questionnaire in which he expressed his opinion about the presence of elements of the properties of a fuzzy set (Table 2).

Table 2
A fragment of elaboration of expert questionnaires

	Expert				
Diapason	**1**	**2**	**3**	**…**	**N**
Presence of the declared mission and vision of development					
0 ÷ 0,2	L	L	L	…	L
0,15 ÷ 0,3	ML	L	L, ML	…	L
0,3 ÷ 0,45	ML	ML	ML	…	ML
0,45 ÷ 0,6	M	M	M	…	M
0.6 ÷ 0.75	M, MH	MH	M	…	M
0.75 ÷ 0.9	MH, H	MH	MH	…	MH
0.9 ÷ 1	H	H	H	…	H
Is the development of individual branch y enterprises in the general business model presented?					
0 ÷ 0,2	L	L	L	…	L
0,15 ÷ 0,3	L, ML	L, ML	ML	…	ML
0,3 ÷ 0,45	ML	ML	M, ML	…	ML, M
0,45 ÷ 0,6	ML, M	M	M	…	M
0.6 ÷ 0.75	M	MH	MH	…	M, MH
0.75 ÷ 0.9	MH	MH, H	MH, H	…	MH
0.9 ÷ 1	H	H	H	…	H
…					
The presence of the best employees at the top level of enterprise management					
0 ÷ 0,2	L	L	L	…	L
0,15 ÷ 0,3	L	L	L, ML	…	L
0,3 ÷ 0,45	ML, M	ML	ML, M	…	ML
0,45 ÷ 0,6	M	M	M	…	ML
0.6 ÷ 0.75	M	M	M, MH	…	M
0.75 ÷ 0.9	MH, H	MH	MH, H	…	MH
0.9 ÷ 1	H	H	H	…	H

Source: Zapukhliak, I., 2017.

According to the results of the questionnaire, the degrees of membership $u_{i,j}$ of the fuzzy set l_p were calculated as follows:

$$\mu_{l_p}(u_{i,j}) = \frac{1}{K}\sum_{k=1}^{K} b_{p,j}^{k}, \tag{6}$$

where $b_{p,i}^{k}$ – the opinion of k expert about the presence of $u_{i,j}$ elements of fuzzy set l_p properties, with $b_j^k = 1$, if the element has the properties of a fuzzy set, and $b_j^k = 0$, if not.

$p = \overline{1,q}$, q - the number of linguistic terms;

i - number of parameters;

j - number of subsets of the set U_i of parameters;

K - number of experts.

The results of working out the expert opinions by using the method of pairwise comparisons are summarized as Table 3.

Table 3

A fragment of the results of the processing of expert information

			Presence of the declared mission and vision of development				
term	$[0,0.15)$	$[0.15,0.3)$	$[0.3,0.45)$	$[0.45,0.6)$	$[0.6,0.75)$	$[0.75,0.9)$	$[0.9,1)$
L	1	0,8	0	0	0	0	0
ML	0	0,6	1	0	0	0	0
M	0	0	0	1	0,6	0	0
MH	0	0	0	0	0,6	1	0
H	0	0	0	0	0	0	1
			Is the development of individual branch y enterprises in the general business model presented?				
term	$[0.7,0.74)$	$[0.74,0.78)$	$[0.78,0.82)$	$[0.82,0.86)$	$[0.86,0.9)$	$[0.9,0.95)$	$[0.95,1)$
L	1	0,4	0	0	0	0	0
ML	0	1	0,8	0,2	0	0	0
M	0	0	0,6	1	0,2	0	0
MH	0	0	0	0	0,8	1	0
H	0	0	0	0	0	0,4	1
			…				
			The presence of the best employees at the top level of enterprise management				
term	$[0.5,0.57)$	$[0.57,0.64)$	$[0.64,0.71$	$[0.71,0.78)$	$[0.78,0.85)$	$[0.85,0.93)$	$[0.93,1)$
L	1	0,8	0	0	0	0	0
ML	0	0,4	1	0	0	0	0
M	0	0	0,4	1	0,8	0	0
MH	0	0	0	0	0,4	1	0
H	0	0	0	0	0	0,4	1

Source: Zapukhliak, I., 2017.

In the application of the fuzzy clustering method, the subclust function was used, which allowed made the subtractive clustering of output data that characterizes the level of enterprise readiness for change. Received three clusters present the clustering results for the data "Enterprise readiness to change" - "Existing system of authority and responsibility at the enterprise" (Fig. 2). Centers of received clusters are the centers of the terms of the respective membership functions.

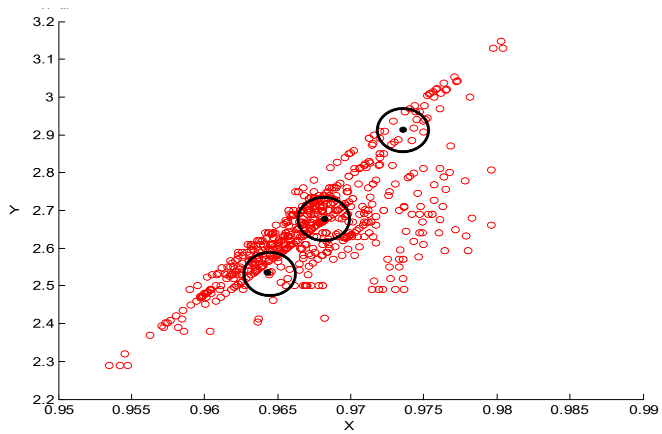

Fig. 2. Output Clustering (fragment)

Source: Zapukhliak, I., 2017.

As a result of the three above-mentioned methods usage, the functions of all system parameters membership were obtained (Table 4).

Table 4

Levels of readiness of elements of the enterprise for changes are determined on the basis of the fuzzy logic method

Analytical expression of the enterprise elements readiness levels to changes based on the method of fuzzy logic	Interpretation of readiness for changes
$x_1(H)=\begin{cases}1, h\le 0.128,\\ 1-128\cdot(h-0.128)^2, 0.128<h\le 0.192,\\ 128\cdot(0.255-h)^2, 0.192<h\le 0.255,\\ 0, h>0.255.\end{cases}$	Very bad
$x_2(H)=\begin{cases}0, h\le 0.145,\\ 10\cdot(h-0.145), 0.145<h\le 0.245,\\ 1, 0.245<h\le 0.325,\\ 9.8\cdot(0.427-h), 0.325<h\le 0.427,\\ 0, h>0.427.\end{cases}$	Bad
$x_3(H)=\begin{cases}0, h\le 0.318,\\ 8.93\cdot(h-0.318), 0.318<h\le 0.430,\\ 1, 0.430<h\le 0.590,\\ 11.11\cdot(0.680-h), 0.590<h\le 0.680,\\ 0, h>0.680.\end{cases}$	Satisfactory
$x_4(H)=\begin{cases}0, h\le 0.560,\\ 7.93\cdot(h-0.560), 0.560<h\le 0.686,\\ 1, 0.686<h\le 0.776,\\ 10.989\cdot(0.867-h), 0.776<h\le 0.867,\\ 0, h>0.867.\end{cases}$	Good
$x_5(H)=\begin{cases}0, h\le 0.740,\\ 42.72\cdot(h-0.740)^2, 0.740<h\le 0.817,\\ 1-42.72\cdot(0.893-h)^2, 0.817<h\le 893,\\ 1, h\ge 0.893.\end{cases}$	Very good
$k_1(X)=\begin{cases}1, h\le 0.071,\\ 1-210\cdot(h-0.071)^2, 0.071<h\le 0.106,\\ 210\cdot(0.140-h)^2, 0.106<h\le 0.140,\\ 0, h>0.140.\end{cases}$	Critical level

Analytical expression of the enterprise elements readiness levels to changes based on the method of fuzzy logic	Interpretation of readiness for changes
$k_2(X)=\begin{cases}0, h\le 0.071,\\ 13.8\cdot(h-0.071), 0.071<h\le 0.143,\\ 1, 0.143<h\le 0.214,\\ 13.88\cdot(0.286-h), 0.214<h\le 0.286,\\ 0, h>0.286.\end{cases}$	Low levelь
$k_3(X)=\begin{cases}0, h\le 0.214,\\ 13.9\cdot(h-0.214), 0.214<h\le 0.286,\\ 1, 0.286<h\le 0.357,\\ 13.9\cdot(0.429-h), 0.357<h\le 0.429,\\ 0, h>0.429.\end{cases}$	Lower than average level
$k_4(X)=\begin{cases}0, h\le 0.357,\\ 15.87\cdot(h-0.357), 0.357<h\le 0.420,\\ 1, 0.420<h\le 0.500,\\ 14.08\cdot(0.571-h), 0.500<h\le 0.571,\\ 0, h>0.571.\end{cases}$	Average level
$k_5(X)=\begin{cases}0, h\le 0.500,\\ 14.08\cdot(h-0.500), 0.500<h\le 0.571,\\ 1, 0.571<h\le 0.643,\\ 14.08\cdot(0.714-h), 0.643<h\le 0.714,\\ 0, h>0.714.\end{cases}$	Higher than average level
$k_6(X)=\begin{cases}0, h\le 0.643,\\ 14.08\cdot(h-0.643), 0.643<h\le 0.714,\\ 1, 0.714<h\le 0.786,\\ 14.08\cdot(0.857-h), 0.786<h\le 0.857,\\ 0, h>0.857.\end{cases}$	High level
$k_7(X)=\begin{cases}0, h\le 0.781,\\ 198.37\cdot(h-0.781)^2, 0.781<h\le 0.817,\\ 1-198.37\cdot(0.852-h)^2, 0.817<h\le 0.852,\\ 1, h\ge 0.852.\end{cases}$	The ideal level
$y_1(K)=\begin{cases}1, h\le 0.200,\\ 1-25\cdot(h-0.200)^2, 0.200<h\le 0.300,\\ 25\cdot(0.400-h)^2, 0.300<h\le 0.400,\\ 0, h>0.400.\end{cases}$	Low level of readiness
$y_2(K)=\begin{cases}0, h\le 0.200,\\ 5\cdot(h-0.145), 0.200<h\le 0.400,\\ 1, 0.400<h\le 0.600,\\ 5\cdot(0.800-h), 0.600<h\le 0.800,\\ 0, h>0.800.\end{cases}$	Average level of readiness
$y_3(K)=\begin{cases}0, h\le 0.600,\\ 25\cdot(h-0.600)^2, 0.600<h\le 0.700,\\ 1-25\cdot(0.800-h)^2, 0.700<h\le 0.800,\\ 1, h\ge 0.800.\end{cases}$	High level of readiness
$z_1(Y)=\begin{cases}1, h\le 0.200,\\ 1-25\cdot(h-0.200)^2, 0.200<h\le 0.300,\\ 25\cdot(0.400-h)^2, 0.300<h\le 0.400,\\ 0, h>0.400.\end{cases}$	Low level of readiness

Analytical expression of the enterprise elements readiness levels to changes based on the method of fuzzy logic	Interpretation of readiness for changes
$z_2(Y)=\begin{cases}0, h \le 0.200,\\ 5\cdot(h-0.145), 0.200 < h \le 0.400,\\ 1, 0.400 < h \le 0.600,\\ 5\cdot(0.800-h), 0.600 < h \le 0.800,\\ 0, h > 0.800.\end{cases}$	Average level of readiness
$z_3(Y)=\begin{cases}0, h \le 0.600,\\ 25\cdot(h-0.600)^2, 0.600 < h \le 0.700,\\ 1-25\cdot(0.800-h)^2, 0.700 < h \le 0.800,\\ 1, h \ge 0.800.\end{cases}$	High level of readiness

Source: Received on the basis of calculations

On the basis of the averaged membership functions of the input and output parameters terms, the correspondences between the membership functions l_i and the rules of control of Pl_i according to Zade are created. Dahl synthesized a structure of the Mamdani type in the MATLAB system and, are based on the results of it work, obtained the values of the gas transportation enterprises readiness level for changes based on the source data collected by the questionnaire. Among all the rules, active rules are considered, in which the appropriate conditions are used and these rules are used in the process of fuzzy conclusion.

4. Results

The summary results of the previous calculations in the Fuzzy logic program have presenting graphically the level of readiness for changes to the seven elements of the gas transportation enterprises at different levels of management that is shown in Figs. 3-5.

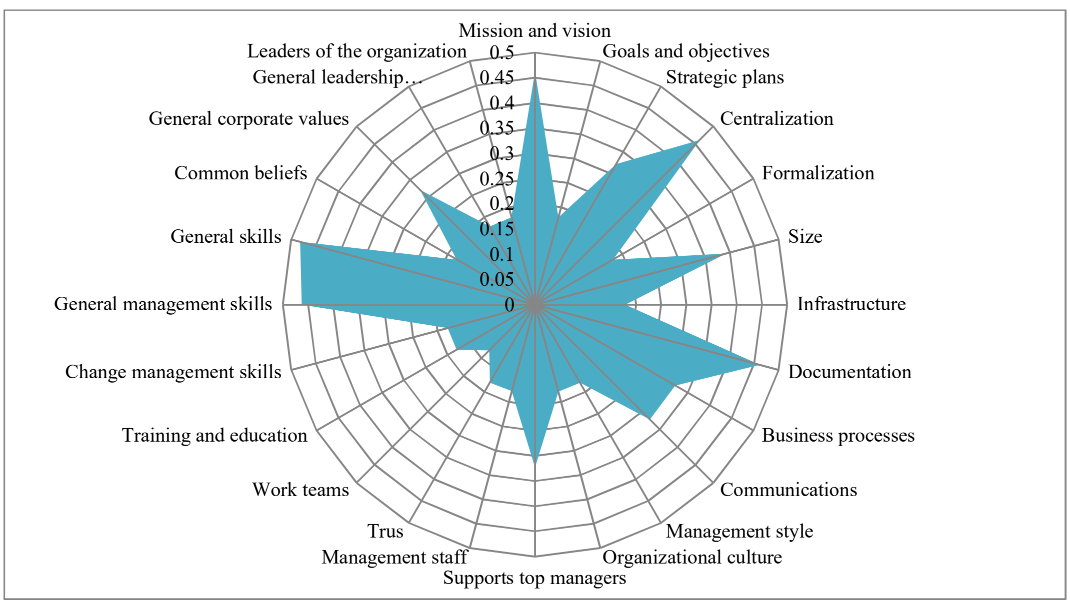

Fig. 3. Readiness of gas transportation enterprises activity components to changes at top-level management

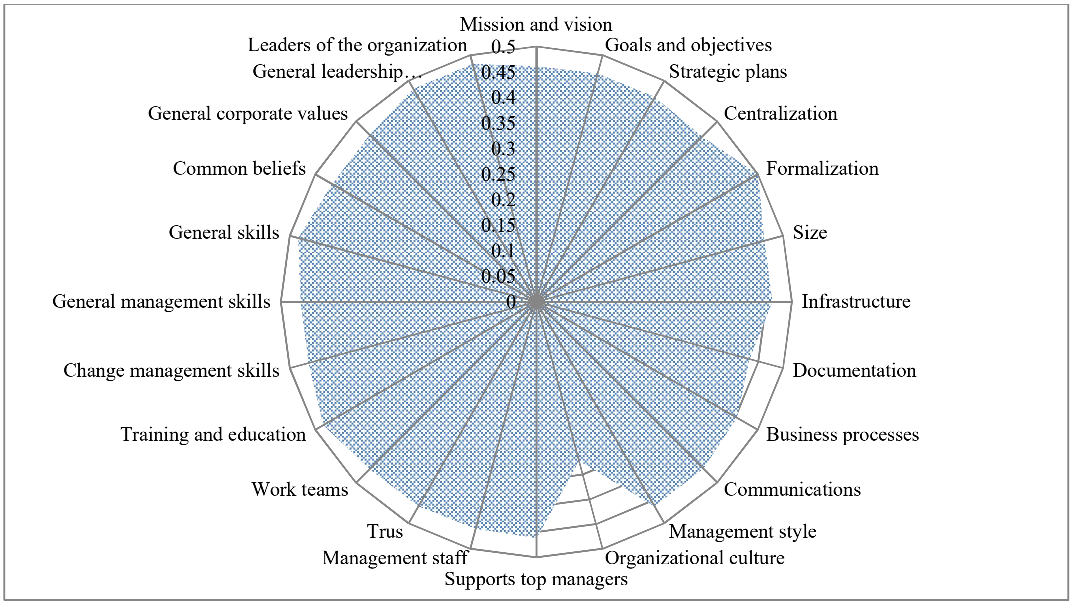

Fig. 4. Readiness of gas transportation enterprises activity components to changes at middle-level management

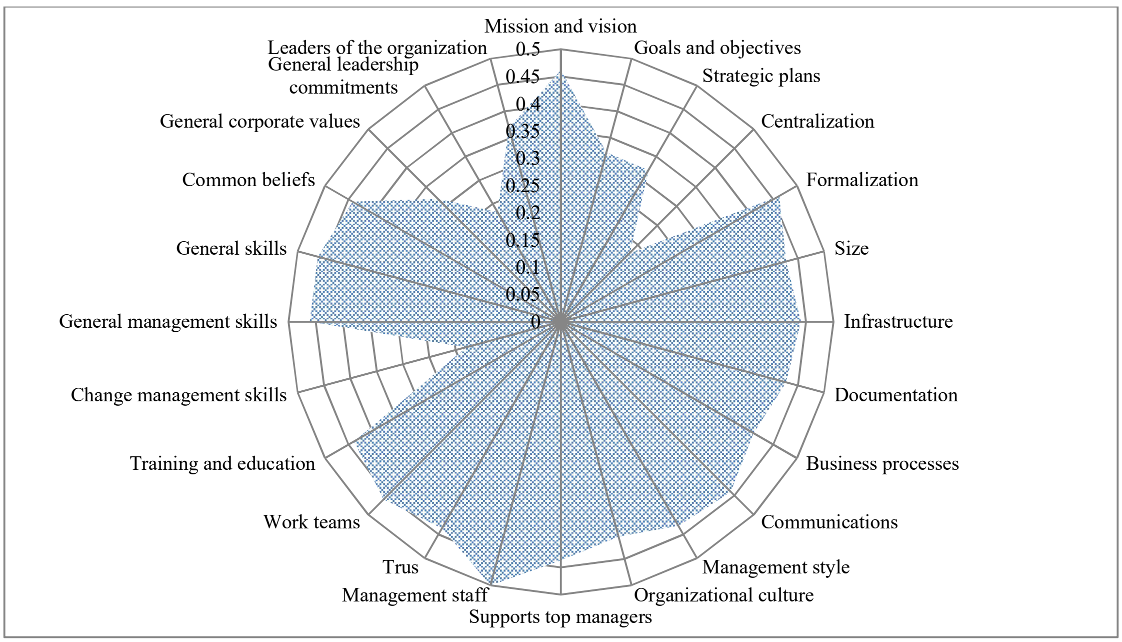

Fig. 5. Readiness of gas transportation enterprises activity components to changes at low-level management

The results of readiness for changes assessment for gas transportation enterprises at all levels of management have showed that today the least prepared for change is a general-corporate governance apparatus whose level of readiness is low, in particular due to low level of trust, change management skills, lack exchange of experience. There is also a low level of corporate culture and a lack of a built-in system of common values. The most prepared to changes are employees at the level of middle management for branches enterprises. Lack of sufficient training of employees in change managing, inaccurate implementation of strategic goals and targets as well as the low level of general corporate values are the reasons for a slightly lower level of readiness for changes in the level of employees.

4. Conclusions

Comprehensive and complete assessment of the level of readiness of the enterprise for changes allowed developing an adequate model of a specific task of fuzzy management of the internal elements of the enterprise readiness to changes in order to further make effective decisions to ensure their development in conditions of the instability of the functioning environment. The developed software allowing re-determination of the enterprise readiness level to changes and to identify trends of changes. The simplicity and low cost of developing fuzzy systems to assess the degree of readiness of the elements of the enterprise to changes r to the widespread use of this technology in the industry. Principles of fuzzy logic are systematic approaches and are based on the intuition and experience of experts, using elements of everyday language to describe the behavior of systems, which is difficult to estimate by traditional indicators. The formation of a fuzzy description of the internal elements of the enterprise can be accomplished in a number of possible ways, including at the expense of the following:

- considering that the structure and volumes of input data for assessing the company's readiness for change can change with the changing environment, the preparation and download of a sample file with new input values that are not included in the sample of expert data that may be generated during the process of the GTP.
- making changes and editing the types and values of the parameters of the functions of the terms of input and output variables is possible using the editor of membership functions of the MATLAB system.

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