African Journal of Business Management Vol. 7(7), pp. 515-525, 21 February, 2013
Available online at http://www.academicjournals.org/AJBM
DOI: 10.5897/AJBM11.015
ISSN 1993-8233 ©2013 Academic Journals

Full Length Research Paper

Fuzzy mathematical model for evaluation of infrastructure business functions of administrative bodies of organizational structures

Dragan Pamučar*, Boban Đorović and Darko Božanić

Management Department, Military Academy, Generala Pavla Jurisica Sturma 33, 11000 Belgrade, Serbia.

Accepted 14 April, 2011

This paper presents a fuzzy mathematical model for the analysis of organizational structure of administrative bodies. The organizational structure of administrative bodies of logistic support of the Petroleum Industry of Serbia has been analyzed in order to analyze the situation and optimize the existing organizational structure. Analysis of the state of organization is aimed at creating a picture of the current mode of organization and, on the basis of that, removing identified deficiencies. This model has been applied for the analysis of process and business functions, and tasks of the administrative bodies of the organizational structure taking into account the fact that administrative bodies should be designed and sized so that they can meet the basic goals and tasks of their existence. Each task set before the administrative bodies should be completed in a quality and reliable way in all environmental conditions. Since most of the data collected during the study of organizational structure are characterized by a high degree of uncertainty, subjectivity and ambiguity, fuzzy logic was used to show the described uncertainties and ambiguities. Fuzzy linguistic descriptors were used to describe the criteria used for assessing the organizational structure. In this way, fuzzy logic has enabled the exploitation of tolerance that exists in imprecision, ambiguity and partial truth of the research results obtained.

Key words: Organizational structure design, administrative bodies, fuzzy logic.

INTRODUCTION

The organizational structure of business systems is necessary to be designed and sized to meet the basic corporate goals and objectives. Almost every task set before the system management should be completed in a quality and reliable way in different environmental conditions. To make complex business systems with such dynamic and stochastic controllable and non-controllable variables effective and able to respond to market challenges, they must constantly adapt its organizational structure.

One of the possible approaches to analyzing the degree of coordination and effectiveness of organizational structure is based on the division of the organization according to business and process functions, and on their evaluation.

Organizational or business functions relate to a group of different activities that are centered on a single task. This way, organizational and business functions are differentiated by type. Process functions relate to particular phases of activity taking place within each organizational function and within each of the subdivisions of organizational functions, or work areas of organizational functions.

The nature and number of business and process functions is not specified or definite. Some analysts, for example, believe that management and leadership does not make a business function, but that these activities

*Corresponding author. E-mail: dpamucar@gmail.com. Tel: +38164 23 77 908, +38111 360 31 35. Fax: +38111 360 31 87.

belong to the administrative functions in accordance with the criteria that some of the authors of the science of organization mentioned (Fayol, 1947). Urwick (1964) believes that business and administrative functions at the same level of itemization should be of the same or nearly the same importance and complexity. However, business and process functions of formally the same rank differ by “difficulty” and complexity. This approach was also used when creating a model for assessing the infrastructure of business functions. The paper presents the fuzzy model for the analysis of the organizational structure of administrative structures of business system. In complex organizational systems that operate in a changing environment, there are many problems at all levels of management whose solutions are characterized by different types of uncertainty and imprecision. They can be described by the linguistic expressions and modeling uncertain numbers. In the classical approach, modeling uncertainty is based on the application of probability theory, where the uncertainties are modeled by random variables which are differently distributed. Treatment of uncertainty in this way has certain limitations. One of the limitations is that calculating the probability of each random variable requires a large number of data from the records, and the fact that the combination of different uncertainties leads to a complex probability distribution which requires complex mathematical expressions, and thus increases the complexity and volume of calculations. Development of new fields in mathematics made it possible to describe the uncertainty and imprecision in a more realistic way. In other words, soft computing methods are alternatives to the classical approach of treating uncertainties. One of the methods of soft computing is fuzzy theory.

For evaluation of successful functioning of the existing administrative bodies, as well as for assessing the organization of certain business functions, a mathematical model based on fuzzy logic has been developed. In the next part of this paper, the phases of this model and its application will be presented.

RELEVANT LITERATURE REVIEW FOR ORGANIZATIONAL DESIGN

Organizational design is specific to every organization, and therefore a unitary organizational structuring cannot be established. Various approaches to organizational design are possible not only due to the differences between companies, but also because certain factors affect different companies in different ways.

In recent years, the methodological approaches of computational modeling and simulation are becoming increasingly popular among organizational researchers. Simulation, unlike mathematical modeling, allows researchers to reflect the natural complexity of organization systems as given. Computational modeling facilitates studies of more complex systems than traditional mathematical approaches.

Many authors approached organizational design as an information-process problem (Levitt et al., 1999; Jin and Levitt, 1996; Galbraith, 1977; March and Simon, 1958). This approach relies on the assumption that information transmission methods are relevant to considering and designing organizational models.

Computational and mathematical models of organizational design by Carley (1995) and Carley and Lin (1995) may be found in the paper. Kujacic and Bojovic (2003) proposed the model for selecting the organizational structure using the fuzzy multi-criteria analysis. The developed fuzzy multi-criteria methodology takes into consideration the uncertainty and imprecision of the input data. Researchers in the field of computational organization theory use computational analysis methods to study both humans and organizations as computational entities. Human organizations can be viewed as intrinsically computational, as many of their activities involve sharing and transforming information from one form to another and also because organizational activity is often information-driven (Simon, 1976; Carley and Gasser, 1999).

For this reason, many researchers have developed simulation-based analysis tools for organizations during the past two decades primarily based on information processing theory (Cyert and March, 1963, 1992; Simon, 1976; March and Simon 1958). Starting with computational modeling tools such as OrgCon in the late 1980s, VDT in the early 90’s and OrgAhead in the mid-90’s, researchers and practitioners have begun using computational models of organizations for analyzing existing organizations and designing better ones. The virtual design team (VDT) is a project organization modeling and simulation tool that integrates organizational and process views of strategic, time-critical projects (Jin and Levitt 1996). The vision behind VDT is to offer a methodology to design an organization the way an engineer designs a bridge.

Khosraviani and Levitt (2004) developed organizational design optimization using genetic programming. Genetic programming is used as an evolutionary computational optimization approach, to help project managers find near optimal designs for their project organizations. Organizational Consultant or OrgCon is another example of a computational model that is built based on the viewpoint that an organization is an information processing entity (Burton and Obel 2004). Other examples are OrgAhead (Loue et al., 2003) an organizational learning model designed to test different forms of organizations under a common task representation, or OrgMem (Carley et al., 2000), a multi-agent simulation program that imitates the interpersonal communication, information processing and decision making processes in

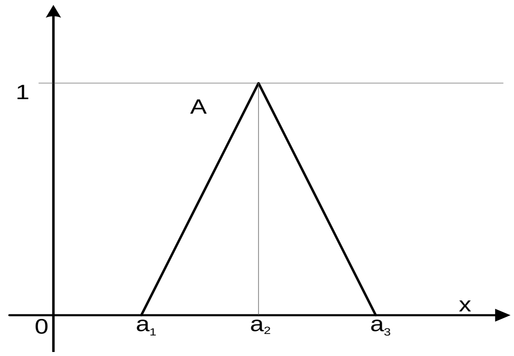

Figure 1. Triangular fuzzy number.

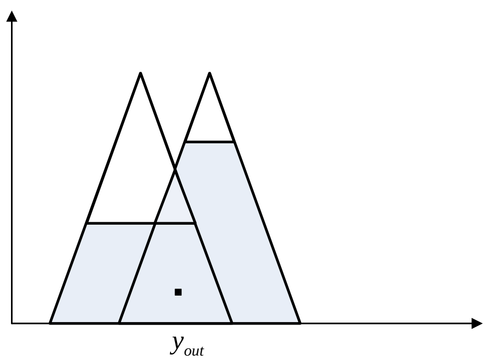

Figure 2. Defuzzification.

organizations.

An interesting approach to computational organizational modeling was used by inter alia (Hyatt et al., 1997). In this paper, an object-oriented simulation environment using difference equations for organization network modeling was developed. This model also relies in the information-process approach. Joslyn and Rocha (2000) modeled socio-technical organizations by employing the principles of semiotics. The fundamental principles of semiotic agents as decision-making entities embedded in artificial environments and exchanging and interpreting semiotic tokens were introduced. The previous part of the paper presented some of the approaches to designing organizational structures through highlighting the main characteristics of each of these models. In the next part of the paper, based on relevant theoretical approaches, a new model for the analysis of organization of the administrative bodies which is based on fuzzy logic is developed. Fuzzy mathematical model is tested on the example of the organizational structure of administrative bodies of logistic support of the Petroleum Industry of Serbia in order to analyze the situation and optimize the existing organizational structure. The aforementioned model will be shown in the next part of work.

FUZZY SETS

In the process of designing the organizational structure, certain decisions have to be made. Subjective evaluation of certain parameters differs from one decision-maker to another, and it is worth pointing out. Quite a convenient approach in quantifying these parameters is fuzzy set theory.

Fuzzy sets theory (Zadeh, 1965) defines fuzzy set A as a set of ordered pairs:

$$A=\{(x,\mu_A(x))|x\in X, 0\le\mu_A(x)\le1\},$$

Where $\mu_A(x)$ is a membership function which shows to what extent $x\in X$ meets the criterions for membership in a set A. For the membership function $0\le\mu_A(x)\le1$, for every $x\in A$, that is, $\mu_A: X\to[0,1]$.

According to the fuzzy theory, the choice of membership functions, that is, the form of the function and confidence intervals width are usually made based on subjective estimates or experience. The most commonly used are trapezoidal and triangular fuzzy numbers. Triangular fuzzy numbers with membership functions (Figure 1) are used in this paper.

Triangular fuzzy numbers are usually given in the form $A=(a_1,a_2,a_3)$, where a_2 is the value where the membership function of the fuzzy number is 1.0, a_1 is the left distribution of the confidence interval and a_3 the right distribution of the confidence interval of the fuzzy number A.

Fuzzy number A membership function is defined as:

$$\mu_A(x)=\begin{cases}0, & x<a_1\\ \dfrac{x-a_1}{a_2-a_1}, & a_1\le x\le a_2\\ \dfrac{a_3-x}{a_3-a_2}, & a_2\le x\le a_3\\ 0, & x>a_3\end{cases}$$

For defuzzification and mapping of the fuzzy number $A=(a_1,a_2,a_3)$ value into a real numbers, numerous methods are used (Figure 2). The centre of gravity method has been used in the paper.

$$defazzy\ \mathrm{A}=\left[(a_3-a_1)+(a_2-a_1)\right]\otimes3^{-1}+a_1$$

BASIC MODEL - FUZZY MATHEMATICAL MODEL FOR EVALUATION OF INFRASTRUCTURE BUSINESS FUNCTIONS

In order to successfully describe the fuzzy mathematical model, it is necessary to define basic principles of fuzzy arithmetic.

Let X be a finite set $X = \{x_1, x_2, ..., x_n\}$. Fuzzy set $\tilde{L}$ is defined on a set X and is a set of ordered pairs $\{(x_1, f_{\tilde{L}}(x_1)), (x_2, f_{\tilde{L}}(x_2)), ..., (x_n, f_{\tilde{L}}(x_n))\}$, where $f_{\tilde{L}} : X \to [0,1]$ is a membership function of fuzzy number $\tilde{L}$, where $f_{\tilde{L}}(x_i)$ is the degree of belonging of element x_i to the set $\tilde{L}$.

Definition 1: Fuzzy set $\tilde{L}$ defined on a set X that represents a finite set of elements $X = \{x_1, x_2, ..., x_n\}$ is defined as:

$$L = \frac{\mu_L(x_1)}{x_1} + \frac{\mu_L(x_2)}{x_2} + ... + \frac{\mu_L(x_n)}{x_n} = \sum_{i=1}^{n} \frac{\mu_L(x_i)}{x_i} \tag{1}$$

where the sign "+" indicates the union of elements.

Definition 2: Fuzzy set $\tilde{L}$ is a convex set if it satisfies the condition

$$\mu_L(\lambda l_1 + (1-\lambda) l_2) \geq \mu_L(x_1) \wedge \mu_L(x_2),\ \forall l_1, l_2 \in L,\ \forall \lambda \in [0,1]$$

Definition 3: Fuzzy set $\tilde{L}$ which is defined over a set X is normal if membership function $f_{\tilde{L}}(x_i)$ satisfies the condition $\max_x f_{\tilde{L}}(x) = 1$.

Definition 4: Alpha cut $(\alpha - cut)$ of the fuzzy set $\tilde{L}_\alpha$ and strong alpha cut $(\alpha - strong\ cut)$ of the fuzzy set $\tilde{L}_{\alpha+}$ is defined as:

$$\tilde{L}_\alpha = \{x_i \mid f_{\tilde{L}}(x_i) \geq \alpha,\ x_i \in X\},\ \alpha \in [0,1] \tag{2}$$

$$\tilde{L}_\alpha = \{x_i \mid f_{\tilde{L}}(x_i) > \alpha,\ x_i \in X\},\ \alpha \in [0,1] \tag{3}$$

Definition 5: Membership function of fuzzy set $\tilde{L}$ is defined as:

$$\mu_l(x) = \begin{cases} 0, & x < l_1 \\ \dfrac{x - l_1}{l_2 - l_1}, & l_1 \leq x \leq l_2 \\ \dfrac{l_3 - x}{l_3 - l_2}, & l_2 \leq x \leq l_3 \\ 0, & x > l_3 \end{cases} \tag{4}$$

where $l_1 \leq l_2 \leq l_3$ и $l_1, l_2, l_3 \in [0,10]$

Let $\tilde{A} = (a_1, a_2, a_3,)$ and $\tilde{B} = (b_1, b_2, b_3,)$ be triangular fuzzy numbers. The basic rules of fuzzy arithmetic can be described as:

$$\tilde{A}(+)\tilde{B} = (a_1, a_2, a_3)(+)(b_1, b_2, b_3) = (a_1 + b_1, a_2 + b_2, a_3 + b_3) \tag{5}$$

$$\tilde{A}(-)\tilde{B} = (a_1, a_2, a_3)(-)(b_1, b_2, b_3) = (a_1 - b_1, a_2 - b_2, a_3 - b_3) \tag{6}$$

$$\tilde{A}(\times)\tilde{B} = (a_1, a_2, a_3)(\times)(b_1, b_2, b_3) = (a_1 \times b_1, a_2 \times b_2, a_3 \times b_3) \tag{7}$$

$$\tilde{A}(\div)\tilde{B} = (a_1, a_2, a_3)(\div)(b_1, b_2, b_3) = (a_1 \div b_3, a_2 \div b_2, a_3 \div b_1) \tag{8}$$

$$k \times \tilde{A} = k \times (a_1, a_2, a_3) = (k \times a_1, k \times a_2, k \times a_3) \tag{9}$$

$$(\tilde{A})^{-1} = \left(\frac{1}{a_1}, \frac{1}{a_2}, \frac{1}{a_3}\right) \tag{10}$$

Fuzzy mathematical model for evaluation of infrastructure business functions includes the following steps:

Step 1: Selection and identification of business functions. Define and make the choice of n business functions that are assessed $(P_1, P_2, ..., P_n)$. The choice of business functions depend on the purpose and tasks performed by the organizational structures.

Step 2: Selection and identification of k business functions $(P_{p1}, P_{p2}, ..., P_{pk})$.

Step 3: Define and make the choice of i process functions $(P_{f1}, P_{f2}, ..., P_{fi})$.

Step 4: Determining the correlation of process functions P_{fi}, $(i = 1, ..., M)$ and tasks P_{pk} $(k = 1, ..., K)$ for a selected business function P_n $(n = 1, ..., N)$.

Correlation is a correlation matrix $A = [f_{ik}]_{M \times K}$, where:

$$f_{ik} = \begin{cases} 1, & \forall P_{fi} \in P_k \\ 0, & \forall P_{fi} \notin P_k \end{cases},\ (i = \overline{1M},\ k = \overline{1K})$$

Step 5: Defining a set of linguistic descriptors $S = \{l_1, l_2, \ldots, l_i\}, i \in H = \{0, \ldots, T\}$ where T is the total number of linguistic descriptors. Linguistic variables are represented by triangular fuzzy number which is defined as $\tilde{L} = (l_1, l_2, l_3)$, (Figure 1), where l_2 represent the value where the membership function of fuzzy number has a maximum value.

In Figure 3, values l_1 and l_3 represent the left and right

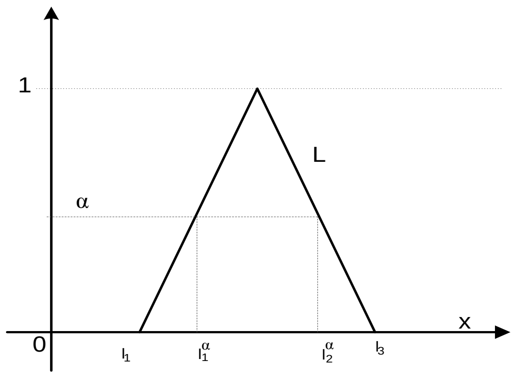

Figure 3. Fuzzy number L with the appropriate confidence interval and degree of conviction.

distribution of membership function of the value in which the membership function reaches its maximum value.

$$\tilde{L} = (l_1, l_2, l_3) = \left\{ \begin{array}{l} l_1 = \min\left(B_{ijk}\right) \\ l_2 = \sqrt[n]{\prod_{k=1}^{n} B_{ijk}} \\ l_3 = \max\left(B_{ijk}\right) \end{array} \right\},$$

where B_{ijk} is preference k of the expert

Step 6: Defuzzification of linguistic descriptors is performed using the method developed by Liou and Wang (1992):

$$g_{\alpha,\beta}\left(\tilde{L}\right) = \left[\beta \cdot f_\alpha\left(l_1\right) + (1-\beta) \cdot f_\alpha\left(l_3\right)\right],\ 0 \le \beta \le 1,\ 0 \le \alpha \le 1 \tag{11}$$

where $f_\alpha\left(l_3\right) = l_3 - \left(l_3 - l_2\right) \cdot \alpha$ is the left border of the confidence interval of fuzzy number $\tilde{L}$ while $f_\alpha\left(l_1\right) = \left(l_2 - l_1\right) \cdot \alpha + l_1$ is the right border of the confidence interval of fuzzy number $\tilde{L}$.

Step 7: Determination of process weights for each of the studied business functions by forming a matrix $W = \left[\tilde{w}_{P_{fi}}\right]_{l \times l}$.

Step 8: Determination of the task weights for each of the studied business functions by forming a matrix $W = \left[\tilde{w}_{P_{pi}}\right]_{l \times l}$. Elements of the matrix in steps 7 and 8 are linguistic descriptors defined in step 5. Most often, it happens that in the situation analysis of organizational structure numerous experts, that is, decision-makers, are included. In this case, valuation of task and process weights by all group members should be obtained first in order to perform necessary synthesis and proceed to step 9. In other cases, proceed to step 10.

Step 9: When in the process of situation analysis of the organizational structure, more experts, that is, decision makers, are involved, valuation by all group members should be obtained first in order to perform necessary synthesis.

In the case of group synthesis with complete information, individual preference ratings at all levels of hierarchy are aggregated by using the expression:

$$w'_i = \left[\prod_{j=1}^{n} \lambda_j a_{ij}\right]^{1/n} \longrightarrow \tilde{w}_{kij} = \frac{\lambda_j \cdot \tilde{w}'_{k_j}}{\sum_{j=1}^{K} \lambda_j \cdot \tilde{w}'_{k_j}} = \left[\prod_{j=1}^{n} \lambda_j a_{ij}\right]^{1/n} \cdot \left\{\sum_{i=1}^{n}\left[\left[\prod_{j=1}^{n} \lambda_j a_{ij}\right]^{1/n}\right]\right\}^{-1} \tag{12}$$

$$\sum_{j=1}^{K} \tilde{w}_k = 1,\ \tilde{w}_k \in \left[0,1\right],\ \lambda \in \left[0,1\right] \tag{13}$$

where λ_j is the preference of decision maker, that is degree of conviction.

In the case of group synthesis with incomplete information, micro aggregation in position (i, j) in a given matrix is done by geometric averaging of ratings of those group members which have been declared on element E_i preference in relation to element E_j. In this case, it is necessary that at least one of the decision makers declare on value a_{ij}. By modifying the previous form we get:

$$w^G{}_i = \left[\prod_{l \in L}^{n} \lambda_j \cdot a_{ij}(l)\right]^{1/M} \longrightarrow \tilde{w}_{kij} = \frac{\lambda_j \cdot \tilde{w}^G{}_{k_j}}{\sum_{j=1}^{K} \lambda_j \cdot \tilde{w}^G{}_{k_j}} = \left[\prod_{j=1}^{n} \lambda_j a_{ij}\right]^{1/n} \cdot \left\{\sum_{i=1}^{n}\left[\left[\prod_{j=1}^{n} \lambda_j a_{ij}\right]^{1/M}\right]\right\}^{-1} \tag{14}$$

$$\sum_{j=1}^{K} \tilde{w}_k = 1,\ \tilde{w}_k \in \left[0,1\right],\ \lambda \in \left[0,1\right] \tag{15}$$

where l is a set of group members who evaluated a couple of elements $\left(E_i, E_j\right)$, and M is number of such members.

Step 10: Defining the matrix of required weights $\left[\tilde{W}_{pp}\right]_{\tilde{w}_{P_f} \times \tilde{w}_{P_p}}$, where $\tilde{W}_{pp}$ is represented by the following expression:

$$\tilde{W}_{pp} = \left\{ \begin{array}{ll} \tilde{w}_{P_{fi}} \cdot \tilde{w}_{P_p}, & \forall f_{ik} = 1 \\ 0, & \forall f_{ik} = 0 \end{array} \right\},\ (i = \overline{1M},\ k = \overline{1K}) \tag{16}$$

Step 11: Assessment of implementation of activities of administrative bodies. Using Equations 12 and 13, the matrix of task assessment is defined $\left[\tilde{C}_{ij}\right]_{l\times l}$:

$$\tilde{C}_{ij} = \begin{cases} O_{ij}, & \forall f_{ik} = 1 \\ 0, & \forall f_{ik} = 0 \end{cases} \quad (17)$$

Step 12: Defining the matrix of actual weights $\left[\tilde{W}_{sp_{ij}}\right]$ from the expression:

$$\tilde{W}_{sp_{ij}} = \begin{cases} \tilde{W}_{pp_{ij}} \cdot \dfrac{\tilde{C}_{ij}}{T}, & \forall f_{ik} = 1 \\ 0, & \forall f_{ik} = 0 \end{cases} \quad (18)$$

Step 13: Calculating the average task assessment $\overline{O_i}$:

$$\tilde{O}_i = \frac{\sum_i \tilde{W}_{sp}}{\sum_j \tilde{W}_{pp}} \cdot T \quad (19)$$

Step 14: Calculating the average score of logistics functions $\overline{O_p}$:

$$\tilde{O}_p = \frac{\sum_i \sum_j \tilde{W}_{sp}}{\sum_i \sum_j \tilde{W}_{pp}} \cdot T \quad (20)$$

Average ratings of business functions are obtained based on the average ratings of each business function individually, and their common view is shown in tables, where you can see the sum of the weights required, the sum of actual weights and the average rating for each business function and the overall average rating of functioning organizational structure.

Step 15: Calculating the average rating of process functions and their ranking. Average ratings of process functions are calculated by means of actual and required weights (O_{pf}) using the form:

$$\tilde{O}_{pf} = \frac{\tilde{W}_{spf}}{\tilde{W}_{ppf}} \cdot T \quad (21)$$

where:

$\tilde{W}_{spf}$, actual process weight,

$\tilde{W}_{ppf}$, required process weight and

T , total number of linguistic descriptors.

Based on the results, process and business functions of the organizational structure according to the average ratings obtained are ranked.

On the basis of the proposed algorithm, a program based on the concepts of object-oriented programming in Visual Basic programming package has been developed. The program has been created and designed on the basis of the presented fuzzy mathematical model and can be used to analyze the performance of administrative bodies in all business systems.

RESULTS AND DISCUSSION

Application of the described model will be presented through evaluation of organization of the logistics administrative bodies in the Petroleum Industry of Serbia. The logistics administrative bodies are organized on a functional principle and carry out their tasks through the following logistic functions:

(i) Supply (P_1),

(ii) Maintenance (P_2),

(iii) Transportation (P_3),

(iv) General logistics (P_4) and

(v) Security and safety at work (P_5).

For each of the following logistic functions k tasks have been identified. In the analysis of performance of the logistics administrative bodies in the Petroleum Industry of Serbia, apart from nine characteristic process functions, there is also another process function, command and control, which is typical of military organization.

Identification of tasks was followed by determining the correlation between process functions (Table 1) and tasks P_{pk} $(k = 1,...,K)$ for the studied logistic function. The correlation between process functions and tasks of the logistic function is shown by correlation matrix $A = \left[f_{ik}\right]_{M\times K}$.

In order to determine the process and task weights ($W = \left[\tilde{w}_{P_{fi}}\right]_{l\times l}$) of logistic functions ($W = \left[\tilde{w}_{P_{pi}}\right]_{l\times l}$) a set of linguistic descriptors is defined $S = \{l_1, l_2, \ldots, l_i\}$, $i \in H = \{0, \ldots, T\}$ (Figure 4).

After decision aggregation, the process weights for each of the studied logistic functions were obtained and, were the same (Table 2). The task weights for each of the studies logistic functions are obtained by aggregation of the examinees' preferences (Table 3).

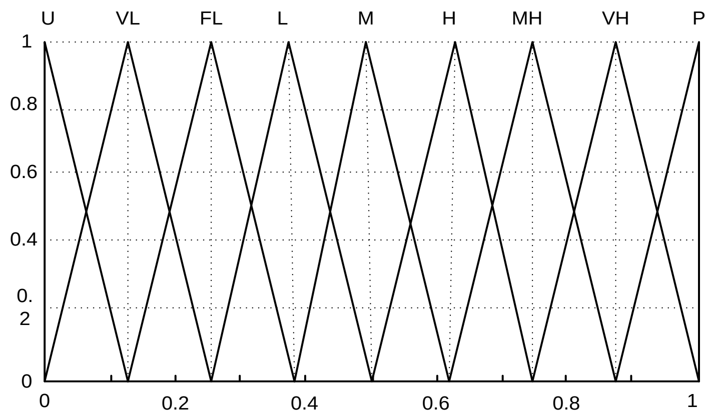

Figure 4. Graphical display of linguistic descriptors. Where: U – unessential, VL – very low, FL - fairly low, L - low, M - medium, H - high, MH - medium high, VH - very high and P - perfect.

Table 1. Review of process functions with abbreviations and meanings.

Name of process function	Symbol	Meaning
Recording	Rc	Inclusion of all business activities within organization
Informing	In	Submission of data and information on all positions in the organization
Monitoring	Mn	Comparison of activities performed with pre-set criteria, standards and guidelines
Analyzing	An	Dismantling, comparing and reasoning about the causes of deviations
Decision-making	Dm	Re-intervention on the developments in the existing processes and designing future processes
Planning	Pl	Provision of necessary elements for the implementation of decisions
Harmonizing	Har	Combining and directing individual efforts into the overall effort
Organizing	Org	Search and design of appropriate organizational procedures and execution of tasks
Performance	Per	The execution of tasks in all positions in the organization
Command and control	Cmc	Assigning tasks to subordinate units and bodies. By issuing orders the plans and decisions are exercised.

Table 2. Process weights of logistic function “maintenance”.

Process symbol	Maintenance (P_1)				
	$\left(\min\left(B_{ijk}\right), \sqrt[n]{\prod_{k=1}^{n} B_{ijk}}, \max\left(B_{ijk}\right)\right)$	Process weights ($W_{P_{foi}}$)			
		$\alpha = 0.35$	$\alpha = 0.5$	$\alpha = 1$	$\sqrt[3]{\prod_{k=1}^{3} W_{P_{foi}}}$
P_{fRc}	(0.056, 0.168, 0.333)	0.160	0.181	0.251	0.197
P_{fIn}	(0.168, 0.314, 0.481)	0.296	0.319	0.398	0.338
P_{fMn}	(0.354, 0.516, 0.686)	0.493	0.518	0.601	0.537
P_{fAn}	(0.317, 0.479, 0.649)	0.456	0.481	0.564	0.500

Table 2. Contd.

P_{fDm}	(0.630, 0.794, 0.927)	0.764	0.786	0.861	0.804
P_{fPl}	(0.668, 0.832, 0.962)	0.802	0.824	0.897	0.841
P_{fHar}	(0.389, 0.554, 0.704)	0.527	0.551	0.629	0.569
P_{fOrg}	(0.408, 0.572, 0.723)	0.545	0.569	0.648	0.587
P_{fPer}	(0.130, 0.298, 0.461)	0.272	0.297	0.379	0.316
P_{fCmc}	(0.554, 0.723, 0.851)	0.691	0.713	0.787	0.730

Table 3. Task weights of logistic function “maintenance”.

Task symbol	Maintenance(P_1)				
	$\left(\min\left(B_{ijk}\right), \sqrt[n]{\prod_{k=1}^{n} B_{ijk}}, \max\left(B_{ijk}\right)\right)$	Task weights ($W_{P_{foi}}$)			
		$\alpha = 0.35$	$\alpha = 0.5$	$\alpha = 1$	$\sqrt[3]{\prod_{k=1}^{3} W_{P_{foi}}}$
P_{po1}	(0.444, 0.611, 0.767)	0.584	0.608	0.689	0.627
P_{po2}	(0.233, 0.401, 0.566)	0.375	0.400	0.483	0.420
P_{po3}	(0.357, 0.521, 0.678)	0.495	0.519	0.599	0.538
P_{po4}	(0.611, 0.778, 0.899)	0.745	0.767	0.839	0.783
P_{po5}	(0.289, 0.456, 0.622)	0.431	0.456	0.539	0.475
P_{po6}	(0.401, 0.566, 0.722)	0.540	0.564	0.644	0.582
P_{po7}	(0.479, 0.645, 0.799)	0.618	0.642	0.722	0.660
P_{po8}	(0.168, 0.321, 0.489)	0.301	0.325	0.405	0.344
P_{po9}	(0.622, 0.789, 0.910)	0.756	0.778	0.850	0.794
P_{po10}	(0.479, 0.643, 0.811)	0.619	0.644	0.727	0.664
P_{po11}	(0.367, 0.533, 0.700)	0.508	0.533	0.616	0.553
P_{po12}	(0.345, 0.511, 0.678)	0.486	0.511	0.594	0.530
P_{po13}	(0.245, 0.399, 0.567)	0.378	0.403	0.483	0.421
P_{po14}	(0.223, 0.389, 0.555)	0.364	0.389	0.472	0.408
P_{po15}	(0.311, 0.478, 0.645)	0.453	0.478	0.561	0.497

Table 4. Average task assessments within logistic functions.

Process symbol	Task assessments				
	Supply (P_1)	Maintenance (P_2)	Transportation (P_3)	General logistics (P_4)	Security and safety at work (P_5)
P_{po1}	0.794	0.788	0.794	0.772	0.495
P_{po2}	0.713	0.696	0.712	0.696	0.605
P_{po3}	0.842	0.744	0.841	0.812	0.757
P_{po4}	0.711	0.644	0.724	0.661	0.608
P_{po5}	0.589	0.638	0.669	0.614	0.566
P_{po6}	0.617	0.620	0.635	0.567	0.564
P_{po7}	0.555	0.577	0.635	0.518	0.536
P_{po8}	0.540	0.541	0.565	0.523	0.517
P_{po9}	0.603	0.555	0.622	0.527	0.523
P_{po10}	0.639	0.643	0.632	0.627	0.639
P_{po11}	0.644	0.646			0.511
P_{po12}	0.496	0.508			0.519
P_{po13}	0.790	0.790			0.662
P_{po14}	0.638				
P_{po15}	0.542				

After defining the necessary matrix of weights $\left[\tilde{W}_{pp}\right]_{\tilde{w}_{P_f} \times \tilde{w}_{P_p}}$, according to Equation 16, the evaluation activities at the workplace according to process functions within each logistic function are defined. Defining the matrix of actual weights $\left[\tilde{W}_{sp_{ij}}\right]$ using Equations 18 and 19, average task assessments of logistic functions were obtained (Table 4).

Average ratings of logistic functions were obtained using Equation 20 (Table 5).

On the basis of Equation 21, the ratings of process functions within logistic functions were obtained (Table 6).

Average ratings of business functions indicate the importance that they have in the overall functioning of the organizational structure. If these ratings are very different, it points to the unadjusted leadership and management. In addition, average rating of business functions is the evaluation of the organizational level of the organizational structure. Average task ratings indicate the importance they have in the overall functioning of administrative bodies. As these ratings are very different ranging from 0.496 to 0.811, this means that the cause was the unadjusted task management.

Strengths and weaknesses of the existing organization and functioning of the organizational structure show the ranking of process functions. The ranking shows what process functions should be given more attention; this

Table 5 Average ratings of logistic functions.

Logistic functions	Average score of logistic function
Supply (P_1)	0.648
Maintenance (P_2)	0.641
Transportation (P_3)	0.669
General logistics (P_4)	0.625
Security and safety at work (P_5)	0.576

Table 6. Average Task Assessments within Logistic Functions

Process symbol	Task Assessments				
	Supply (P_1)	Maintenance (P_2)	Transportation (P_3)	General Logistics (P_4)	Security and Safety at Work (P_5)
P_{po1}	0.794	0.788	0.794	0.772	0.495
P_{po2}	0.713	0.696	0.712	0.696	0.605
P_{po3}	0.842	0.744	0.841	0.812	0.757
P_{po4}	0.711	0.644	0.724	0.661	0.608
P_{po5}	0.589	0.638	0.669	0.614	0.566
P_{po6}	0.617	0.620	0.635	0.567	0.564
P_{po7}	0.555	0.577	0.635	0.518	0.536
P_{po8}	0.540	0.541	0.565	0.523	0.517
P_{po9}	0.603	0.555	0.622	0.527	0.523
P_{po10}	0.639	0.643	0.632	0.627	0.639
P_{po11}	0.644	0.646			0.511
P_{po12}	0.496	0.508			0.519
P_{po13}	0.790	0.790			0.662
P_{po14}	0.638				
P_{po15}	0.542				

Law of average ratings point out those tasks that are neglected in the organizational structure. All average ratings with a value below 0.55 indicate the tasks and functions that are critical points in the organization.

applies especially to those process functions that have high weights, and low average ratings. Average ratings of process functions indicate those process functions which have to be significantly changed and improved. This applies particularly to those process functions that are rated below average, and in this case it is process function harmonizing with an average rating of 0.5332.

CONCLUSION

Designing leadership and management systems has great impact on the creation, adaptation, survival and quality functioning of the studied business system. There is not an organizational system that can function without its management subsystem, as it issues commands for the desired behavior of the system, while the actual behavior can deviate from that desired.

In addition, to organizations operating in an uncertain environment, there is a degree of uncertainty and ambiguity of the criteria used in the organization design process. Fuzzy mathematical model developed in this paper allows the quantification of the specified criteria and analysis of the degree of organization of the business system. The presented model allows the analysis of organizational structure regardless of the number of business functions. The model predicts the selection of tasks and functions that are problem points.

Since the process of designing organization often involves a number of experts, the model considers the possibility of value synthesis of the optimality criterion in case of group decision-making. Decision-making in the group differs from individual decision-making on the methodological and mathematical level. The model considers the group synthesis with complete information and with incomplete information.

Application of the described model is shown on the example of the analysis of administrative bodies of logistic support in the Petroleum Industry of Serbia.

Complex environment of the administrative bodies does not allow organizational improvisations, but requires planned and methodological project of the organization and its continuous modification and adaptation. Choosing the appropriate organizational structure is one of the most important decisions, because if one adopts an organizational structure that does not correspond to the situation in which the organization is, it will slow down the ability of the management system. Analytical procedure obtained by this method provides a quantitative assessment of organizational level and on the fact taking measures for further organizational activity.

Although, shown on the example of the administrative bodies of logistic support of the Petroleum Industry of Serbia, the model has great adaptability and ability to adapt to the particular problem. It can easily be applied to analyze the organizational structure of any business system in the society.

REFERENCES

Burton R, Obel B (2004). Strategic organizational diagnosis and design: The dynamics of fit, 3th edition, Boston, MA: Academic Publishers.

Carley KM (1995). Computational and mathematical organization theory: perspective and directions. Comput. Math. Organ. Theory 1(1):39-56

Carley KM, Gasser L (1999). Computational organization theory (Weiss, Gerhard, ed.) distributed artificial intelligence, Ch. 7 Cambridge. MA: MIT Press.

Carley KM, Lin ZH (1995). Organizational designs suited to high performance under stress. IEEE T. Syst. Man. Cybernet. 25(2):221-230.

Carley KM, Ren Y, Krackhardt D (2000). Measuring and modeling change in C3I architecture in proceedings of the 2000 Command and control research and technology symposium, Conference held in naval postgraduate school, Monterey, CA, Vienna.

Cyert RM, March JG (1963 and 1992). A behavioral theory of the firm, 2nd edition, MA : Blackwell Business, Cambridge.

Fayol H (1947). General and Industrial Management, Pitman, United Kingdom.

Galbraith JR (1977). Organization design, Addison-Wesley Publishing Company.

Hyatt AN, Jones P (1997). Computational organizational network modeling: Strategies and an example. Comput. Math. Organ. Theory 3(4):285-300.

Jin Y, Levitt RE (1996). The virtual design Team: A computational model of project organizations. Comput. Math. Organ. Theory 2(3):171-196.

Joslyn C, Rocha L (2000). Towards semiotic agent-based models of socio-technical organizations, Proceedings AI, Simulation and planning in high autonomy systems, ed. HS Sarjoughian et al. pp. 70-79.

Khosraviani B, Levitt R (2004). Organization design optimization using genetic programming, CIFE center for integrated facility engineering, working paper WP085, Stanford University.

Kujacic M, Bojovic N (2003). Organizational design of post corporation structure using fuzzy multicriteria decision making. Comput. Math. Organ. Theory 9:5-18.

Lawrence PR, Lorsch J (1967). Organization and environment: Managing differentiation and integration MA: Harvard University, Boston.

Levitt RE, Thomsen J, Christiansen TR, Kunz, J C, Jin Y, Nass C (1999). Simulating project work processes and organizations: Toward a micro-contingency theory of organizational design. Manage. Sci. 45(11):1479-1495.

Liou TS, Wang MJJ (1992). Ranking fuzzy numbers with integral value. Fuzzy Set. Syst. 50:247-256.

Louie M, Carley KM, Haghshenass L, Kunz JC, Levitt RE, (2003). Model comparisons: Docking OrgAhead and SimVision. In proceedings of 2003 North American computational social and organization science (NAACSOS) NAACSOS Conference, Pittsburgh.

March J, Simon H (1958). Organizations. John Wiley and Sons, New York.

Simon HA (1976). Administrative behavior: A study of decision-making processes in administrative organization, New York.

Urwick L (1964). Education and Training for Management. In T. N. Robertson, Monopolies and Management, F.W.Cheshire, Melbourne pp.22-54.

Zadeh LA (1965). Fuzzy sets. Inform. Control 8:338-353.