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ASSESSMENT OF ADAPTIVE CAPACITY OF SMALL AND MEDIUM ENTERPRISES

Abstract: *High level of organizational adaptive capacity represents one of organization target values during the normal period of operating. In the period of crisis, the presence of adaptive capacity is even more needed as well as the presence of resilience. The contribution of this paper is shown through the fuzzy mathematical model for adaptive capacity assessment. The model is verified through the illustrative example.*
Keywords: *adaptive capacity, organizational resilience, fuzzy sets*

1. INTRODUCTION

Adaptation and adaptive capacity is the most studied field of science related to the systems that are vulnerable to climate change. Theoretically, adaptive capacity represents a part of resilience but it must be noted that there is no scientific consensus about the overlapping of these two concepts. One part of academic opinion argues that the adaptation and adaptive capacity is related to the capacity / ability / potential systems or components within the system to be resistant to disturbances [1]. The other part of academic opinion treats adaptive capacity as a component of organizational resilience that refers to the learning part of organization and response to disturbances [2] which is supported by this paper. Elements of organizational adaptive capacity are presented in the demands of ASIS SPC.1-2009 standard [3]. Indicators that represent the assessment tool of organizational adaptive capacity are given by McManus [4]. Indicators which cover the phases of ASIS SPC.1-2009 standard (in the way of: planning, implementation and operation, checking and management review of PDCA cycle) are: (1) Silo mentality, (2) Proactive management approach, (3) Knowledge management, (4) Leadership, management and governance structure, (5) Innovation and creativity.

In general, the importance of each business process depends on multiple factors, such as the type of economic activity, organization size, and others. It can be assumed that the relative importance of business processes at the enterprise level have different relative importance. Weight values of business processes are almost unchanged during a predefined period of time and they involve a high degree of subjective assessment of the management team. In this paper, the weight of business processes and the weight of adaptive capacity indicators are given by a matrix pairs of comparison the relative importance of business processes and indicators, respectively (analogous to the AHP method). It is believed that this approach is closest to the human way of thinking.

In this paper, the values of adaptive capacity indicators are described by fuzzy rating of management team. Their judgments are are expressed by predefined linguistic expressions. Uncertainty in relative importance of business processes, the relative importance of indicators and parameters values are modelled by fuzzy sets [5, 6, 7]. Fuzzy set theory can provide a valuable framework for handling

imprecise and ambiguous data, and provides reasoning and decision making methods based on such data. Fuzzy set theory resembles human reasoning in its use of approximate information and uncertainty to generate decisions [7].

The main contribution of this paper is introduction of structured model for assessment of organizational adaptive capacity. The model is based on fuzzy mathematical support which makes it robust and reliable tool. Adaptive capacity indicators which are incorporated in the mathematical model are induced from model [4]. Relevant indicators are adapted with the requirements of ASIS SPC.1-2009 standard for Organizational Resilience: Security, Preparedness, and Continuity Management Systems. ASIS SPC.1-2009 sets the requirements which are needed in order to enable adequate resilience of organization.

The paper is structured as follows: The literature review set the structure of indicators that represent organizational adaptive capacity as well as mathematical assessment tool for measuring them. The chapter 3 sets the model for adaptive capacity assessment with the process approach and fuzzy mathematical tool. In the chapter 4 is presented the case study of 25 SMEs of production sector. The chapter five sets the conclusion.

2. INDICATORS OF ADAPTIVE CAPACITY AND BUSINESS PROCESSES

2.1 Indicators of adaptive capacty

Silo menatality represents culture barriers as well as attitude barriers which may lead to structural divisions inside organizational parts. It is maniphested through the bad communication and creation of nonconforming, unrelated and harmful ways of business [8]. The results of research in the field of knowledge management have shown many factors that have influence on the decrease of the silo mentality, such as culture, organizational infrastructure, and creativity [9]. The rating of this indicator should consider the collaboration of organizational units, the way they work in practice and awareness of the processes that operate within other organizational units.

Proactive approach can be defined as controlling the situation by taking certain actions rather than responses to the consequences of events that have occurred [10]. The rating of this indicator should take into account the functioning of management and its implementation in practice activities.

Information and knowledge management aims to provide inputs that will enable raising awareness of new business trends, technologies and knowledge and facilitate capacity building for recovery. The rating of this indicator should take into account the capacity of the organization for learning, the effectiveness of information management processes and knowledge utilization in practice.

Leadership, management and governance structures include an approach that successfully balances the needs of internal and external stakeholders with business priorities with the ability to ensure good governance and decision making during emergencies [11]. The rating of this indicator should take into account the operation of the organization or leadership, its usefulness and adaptability of management structures.

Inovation and creativity are the main driver of generating and evaluating new ideas during crises or emergencies. They are key factors for raising the performance of the organization [8]. The assessment of this indicator should take into account the creative potential of organizations through the implementation of the innovation product range and / or troubleshooting. At the level of employees, creativity can be analyzed through the ability to generate

ideas and as such can be measured [12].

2.2. The business processes in the SME

Business conditions that have changed recently and put in the first plan global economic crisis induced presence of organizations that can manage its own vulnerabilities and even strive in the moments after disturbances emphasizing the process approach. Process approach is one way that organization can be described. Different reference models - PERA (Purdue Enterprize Reference Model), GRAI / GIM (Group de Recherche en Automatisation Integree / Integrated Methodology), etc can be used to represent the organization as well as reference standard [13]. In this paper, the organization is represented by its processes. Business process is directly linked to business objectives and business environment. Its basic characteristic is the relationship with business entities (eg customers, suppliers). Division of the business activities which are primary activities and support activities in its value chain model was made by Porter [14]. Primary activities contribute to the economic output of the organization, because they create a certain level of value for the buyer of a product / service, eg. activities of purchasing, marketing, sale, etc. Support activities are not related to the realization of products / services, and they do not affect to the creation of new value, eg. activities of human resource management, accounting, information support, etc. From the aspect of value creation, the processes are divided into main processes and support processes that involve the management process. The number and types of processes that can be defined in one organization depends on many factors: company size, types of economic activities which are implemented in the organization, etc. In this paper, SME that belong to the manufacturing industry sector are analysed. This type of organization can be described by:

- process 1 - management which is viewed as a single process,

four main processes -

- process 2 - production,
- process 3 - marketing and sales,
- process 4- purchase,
- process 5 - design and development,

and support processes -

- process 6 - which is treated with respect to the assessment that its impact on the organizational resilience is lower than the impact of the main process.

3. MODELING OF UNCERTAINTIES

This Section describes modelling of uncertainty applied in proposed fuzzy model. The number and type of linguistic expressions representing relative importance of business processes and indicators of adaptive capacity are determined by the management team.

3.1 The relative importance of business processes and indicators of adaptive capacity

In this paper, it is assumed that the members of management team express their assessment using linguistic expressions. These expressions are modelled using triangular fuzzy numbers defined in interval [1,5], where 1 denote as the lowest relative importance and 5 denotes the highest relative importance:

- *very low importance* - $\tilde{R}_1 = (x;1,1,2)$
- *low importance* - $\tilde{R}_2 = (x;1,2,3)$
- *medium importance* - $\tilde{R}_3 = (x;2,3,4)$

- *high importance* - $\tilde{R}4 = (x;3,4,5)$
- *very high importance*- $\tilde{R}5 = (x;4,5,5)$

The importance of business process p compared to the business process $p', p, p' = 1,..,P$, and the importance of indicator i compared to the indicator i' in every enterprise f, f=1,..,F is described by one of five predefined linguistic expressions which are modeled by fuzzy triangular number $\tilde{w}^f_{pp'}$, and $\tilde{w}^f_{ii'}$, $i,i' = 1,...,I$, respectively. The highest and the lowest limit of these fuzzy numbers is highlighted as $l^f_{pp'}$, , $u^f_{pp'}$, , and $l^f_{ii'}$, , $u^f_{ii'}$, and modal value is $m^f_{pp'}$, and $m^f_{ii'}$, respectively.

If the importance of process p' compared to the process p, and the importance of indicator i' compared to the indicator i in the enterprise f, $p = 1,..,P_f; f = 1,..,F$ is significantly greater, respectively, then the value of element in the pairs matrix of process comparation must be presented by fuzzy triangular number:

$$\tilde{w}^f_{pp'} = \left(\frac{1}{u^f_{pp'}}, \frac{1}{m^f_{pp'}}, \frac{1}{l^f_{pp'}} \right), \quad \text{and,}$$

$$\tilde{w}^f_{ii'} = \left(\frac{1}{u^f_{ii'}}, \frac{1}{m^f_{ii'}}, \frac{1}{l^f_{ii'}} \right) \text{ respectively.}$$

If the importance of the matrix elements described above are equal, it can be represented by a single point whose value is 1 and which is represented by triangular fuzzy number (1,1,1).

3.2 Fuzzy rating of parameter values

Every indicator of adaptive capacity i, i=1,..,I on the level of process p, p=1,..,P P in the enterprise f, f=1,..,F involve subjective judgments of and individual preferences of each decision maker of management team.

In this paper the SMEs are in the focus so it can be assumed that decision makers of management team can be made decisions by consensus.

It is closer to human reasoning if decision makers express their opinions and evaluations by using linguistic expressions rather than numeric values. In this paper, fuzzy rating of management team is expressed by predefined linguistic expressions, which are modelled by triangular fuzzy numbers,

$\tilde{v}^{pf}_{ij}$, $i = 1,..,I; j = 1,2,3; p = 1,....P_f; f = 1,..,F$. The lowest and the highest limit of this modal value of triangular fuzzy number $\tilde{v}^{pf}_{ij}$ are set as L^{pf}_{ij}, U^{pf}_{ij}, M^{pf}_{ij}, respectively.

The values in the fuzzy triangular domain, $\tilde{v}^{pf}_{ij}$ belongs to the interval [1-9] and they have the same meaning and values as a standard scale which is defined by AHP [15].

In this paper, we use seven linguistic expressions for describing the fuzzy rating of indicators value, which are defined by triangular fuzzy numbers in the following way:

- *very low value*- $(y;1,1,2)$
- *low value* - $(y;1.5,3,4.5)$

- *fairly medium value*- $(y;2.5,4,5.5)$
- *medium value* - $(y;3.5,5,6.5)$
- *fairly high value*- $(y;5.5,7,8.5)$
- *high value* - $(y;7.5,8,9)$
- *very high value* - $(y;8,9,9)$

3.3.The proposed fuzzy algorithm

The proposed fuzzy model is realized in the following steps:

Step 1. Setting the matrix pair of comparing the relative process importance in enterprise f, $\left[\tilde{w}_{pp'}^{f} \right]$, $p,p' = 1,..,P_f; f = 1,..,F$. The weight of process p, $p = 1,..,P_f$ is calculated as:

$$\tilde{w}_p = \frac{1}{P_f} \cdot \sum_{1}^{P_f} \tilde{w}_{pp'}^{f}$$

Step 2. Setting the matrix pair of comparing indicators importance in enterprise f, $\left[\tilde{w}_{ii'}^{f} \right]$, $i,i' = 1,..,I; p = 1,..,P_f; f = 1,..,F$. The weight of indicators i , i=1,..,I is calculated as:

$$\tilde{w}_i^{f} = \frac{1}{I} \cdot \sum_{1}^{I} \tilde{w}_{ii'}^{f}$$

Step 3. The weight of indicator i, i=1,..,I on the level of process p, in enterprise f is calculated:

$$\tilde{w}_{ip}^{f} = \cup(\tilde{w}_p^{f}, \tilde{w}_i^{f}) = \left(x;\mu_{\tilde{w}_{ip}^{f}} \right)$$

Step 4. Determining of the scalar value of fuzzy number $\tilde{w}_{ip}^{f}$, w_{ip}^{f} by applying moment method [16].

Step 5. In general, the parameters can have cost and benefit nature. The value of every parameter can be described through the fuzzy number $\tilde{v}_i^{pf}$ by management team. Applying the normalization process, domain of the triangular fuzzy numbers, $\tilde{v}_i^{pf}$ are mapped into a set of real numbers on the interval [0-1] and in that way they are becoming comparable, $\tilde{r}_i^{pf} = \left(z;a_i^{pf}, b_i^{pf}, c_i^{pf} \right)$. The value 0, and the value 1 denote that treated parameter indicator i, i=1,..,I on the level of process p, in the enterprise f , $p = 1,..,P_f; f = 1,..,F$ has the lowest or the highest value, respectively. In this paper, a linear normalization procedure is applied [17].

Step 6. Weighted value of indicator i, on the level of each process p of enterprise f can be calculated:

$$\tilde{d}_i^{pf} = w_{ip}^{f} \cdot \tilde{r}_i^{pf}$$

Step 7. The vorst ranked indicator on the level of process p in the enterprise f $p = 1,..,P_f; f = 1,..,F$ can be calculated as follows, i^*:

$$i^* = \min_{p=1,..,P_f} \tilde{d}_i^{pf}$$

Step 8. The value of adaptive capacity of process p in the enterprise f can be calculated:

$$\tilde{AC}_p^f = \frac{1}{I} \cdot \sum_{i=1}^{I} \tilde{d}_{ip}^f$$

Step 9. The processes on the enterprise level f, f=1,..,F can be ranked by using method defined by Dubos and Prade [18].

Step 10. The degree of belief that indicator i' (or process p') which is on the second ranked place is worse than the first ranked indicator (process) can be determined by applying appropriate method [18,19].

4. ILUSTRATIVE EXAMPLE

The relevance of this type of enterprise can be illustrated through the data of Republic Statistical Office of Serbia: (1) 99.4% of all enterprises belong to SMP in 2010, and (2) the most of employees work in the production sector of industry. The data from EU claims that 80 million workers are employees of SME which gives approximately 60% of total GBP of EU [20]. From the perspective of joining EU, SMEs are very important for Serbian economy.

Developed fuzzy model and its corresponding software are tested on the real data which are gained from SME of Central Serbia production sector. The procedure of developed software testing can be described as follows:

By using the proposed fuzzy algorithm and the coresponding software, the rank of processes and the rank of indicators on the process level is determined procesa in Table 1 and Table 2, respectively.

Table 1 Rank of adaptive capacity indicators

i	The lowest value of indicator on the process level	Rank of indicators
i=1	0.1939,0.3102,0.4266	5
i=2	0.1239,0.1394,0.1487	2
i=3	0.1449,0.1449,0.2898	3
i=4	0.1472,0.1472,0.2944	4
i=5	0.125,0.125,0.25	1

In the treated enterprise, the indicator which has the lowest value of overall adaptive capacity is i=5. Since indicator 5 is defined as Inovation and creativity, management should take steps in order to increase this value. Management should be more oriented to encouraging employees to create ideas and to solve raising problems. The indicator Silo mentality is calculated to be on the second place. The measure of belief that Silo mentality is more critical to business compared to the overall adaptive capacity of enterprise is 0.9. This indicates that management should take actions that will lead to decrease of Silo mentality. This can be achieved through the team building activities and increased interprocess cooperation. The best ranked indicator is proactive management approach.

Table 2 The rank of business processes with respects to adaptive capacity

	The values of adaptive capacity on the process level	Rank
$\tilde{AC}_1$	0.4572,0.7679,1.0857	5
$\tilde{AC}_2$	0.2986,0.4289,0.5579	4
$\tilde{AC}_3$	0.1991,0.3202,0.4402	3
$\tilde{AC}_4$	0.1953,0.3124,0.4569	2
$\tilde{AC}_5$	0.4406,0.5134,0.6918	6
$\tilde{AC}_6$	0.1917,0.2447,0.4049	1

The worst ranked process in the treated enterprise is the process of support (p=6). On the second place is presented the process of purchase (p=4). The measure of

belief that process of purchase is worse than support processes from the perspective of adaptive capacity is 0.76. The process of support is not managed through the top management and that is why adaptive capacity is low. Increasing of adaptive capacity of support process can be achieved through the decentralized hierarchy and improved knowledge management. The measures that can improve purchase process are improving information system as well as improving the relations with suppliers and partners.

5. CONCLUSION

The industrial management practice shows that in almost every enterprise, adaptive capacity represents the most relevant strength of organizational resilience. Indicators that show adaptive capacity level must be treated permanently because in the time of crisis decreased level of it may lead to catastrophe. In this paper, a new fuzzy model for evaluation and ranking of adaptive capacity on the process level and on the enterprise level is proposed. The proposed model was tested on a selected eneterprice of production sector in Central Serbia. The following conclusions are made: (1) it is possible to describe the considered problem by formal language that enables to look for the solution by exact method, (2) all uncertainties such as relative importance of adaptive capacity indicators, relative importance of processes and the parameter values are modelled by fuzzy sets theory, (3) the developed fuzzy method gives the possibilities through simulation to get the answer if there would be the result change if the input data change, and (4) the illustrated numerical example is given.

The further research will cover the scope of process improvement measures as well as improving overall organizational resilience.

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