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DETERMINATION OF ORGANIZATIONAL RESILIENCE LEVEL WITHIN BUSINESS PROCESSES IN PRODUCTION COMPANIES

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Abstract Ongoing business activities need to adapt to market conditions in a continuous manner but sometimes significant disruptions (pandemic of covid 19, geopolitical instability, inflation, etc.) may occur. In that case, adaptation is not enough so organizations must demonstrate resilience-ability to overcome the unwell present state and continue to function as before or even better. The motivation for conducting this research and project comes from the fact that more knowledge is needed about organizational resilience, as well as conditions for its development and enhancement. The objective of this research is to propose a model for the assessment of organizational resilience at the level of the business process of product/service realization. The model is based on the fuzzy Delphi method, and it is verified on the real-life data obtained in one medium production company. Future research should cover the examination of the relationship between the assessed level of organizational resilience and the time needed for performance recovery after significant disruptions.

Keywords: Organizational resilience; fuzzy sets; fuzzy Delphi.

1. INTRODUCTION

From time to time, it may be considered that unpredicted events shape reality and business trends [1]. In the few past years, many of those manifested, such as covid 19 pandemic or unstable geopolitical situations in different parts of the world. In times of crisis and disruptions, organizational resilience (OR) is usually seen as a crucial feature of any organizational system such as enterprises and companies [2]. Although there is a significant number of papers in the literature, still there is no consensus on whether organizational resilience is a feature, ability, or capability of an organization, or something else [3]. In compliance with that, there are attempts to define it in a way that might be suitable for the assessment or even management. As a complex construct, organizational resilience is described through its indicators or resilience factors (RFs). Determining the level of the RFs value can be determined by using the Delphi technique, which has been extended with type 1 triangular fuzzy numbers (TFNs). The aggregation of the assessment of DMs into a single assessment can be obtained by applying the operator fuzzy geometric mean by analogy to existing research [4,5]. A referent literature analysis [6] indicates the existence of various research on the topic of determining if DMs have reached a consensus. One of the appropriate methods [7] suggests that it should be accomplished in the second round of the Delphi method. There are no suggestions if the obtained solution in the second iteration, without reaching a consensus, should be accepted, or rejected.

In the literature, there is a small number of works where the Delphi method with TFNs was developed, in which the determination of consensus is based on APMO [7]. At the same time, there are almost no papers that treat the resilience assessment at the business process level by using the fuzzy Delphi method. The motivation for this paper comes from those facts with a need to fully

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understand the condition of the organization regarding resilience since during a crisis or disruption, it can determine if an organization will survive in the market or not.

The wider objective of this research may be interpreted as a) introducing RFs according to the resilience literature [3], b) modeling the level value of the RFs at the level of business processes by the TFNs, c) modification of the method which is used for the reaching consensus developed by the management team, and d) definition of management actions which should lead to the enhancement of organizational resilience at the level of business processes.

The rest of the paper is organized as follows: Section 2 presents a relevant literature review. Section 3 presents the proposed model. A case study is presented in Section 4 and a conclusion is presented in Section 5.

2. LITERATURE REVIEW

This section presents a review of the literature that includes: (i) different models of resilience and performance evaluation systems, and (ii) the Delphi technique, which is extended with type 2 interval fuzzy numbers.

2.1. Organizational Resilience Models, Their Description and Assessment

From the period of conceptualization [8] until these days, OR has been a point of interest for many scholars. The brief explanation of the concept may be summarized as follows. While the performance of an organization has an ongoing trend over time, during the disruption its values rapidly go down. As each company has some level of OR, it should recover in a certain amount of time or it will terminate. If one company has a stronger OR, its performance will bounce back in a shorter period. However, there is still little consensus on its main features, assessment, and management [9]. Different scholars describe OR as an ability of an organization, the capability of an organization, process, capacity, or emergent property [3]. This research treats OR as a complex construct that can be decomposed into RFs and further assessed and managed [10].

2.2. Delphi Technique With Type 1 Fuzzy Numbers

The Delphi technique can be defined as a structured process for the collection and handling of data during several rounds of process execution. There are several decision-makers (DMs) with different specialties that participate in this process. There are numerous suggestions in the literature as to how much DMs should participate in the decision-making process. For instance, Somerville [11] believes that 5 to 10 experts should participate in the decision-making process. Other scholars believe that no more than 10 experts should participate in the decision-making process [12]. All scholars agree that there is the anonymity of DMs and that there should be no consultation between them during the evaluation process. In general, DMs express their assessments using precise numbers, interval ratings, measurement scales as well as linguistic expressions.

In the first round, a written questionnaire with precisely defined questions is sent to the DMs. They express their answers using a pre-defined measurement scale and return the completed questionnaire

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to the analyst in writing. Firstly, the analyst aggregates different assessments of DMs into a single assessment using one of the aggregation methods. In the Delphi technique, the key question is when consensus can be considered as reached. Then, it is checked whether a consensus has been reached. There are 15 developed methods for consensus checking defined by the literature [6]. Choosing a method for checking consensus can be seen as a task itself. If no consensus is reached, it is necessary to repeat the procedure in the second round. It is considered that DMs in the second round should correct their estimates respecting the aggregated value calculated in the first round. The evaluation and processing procedure is repeated as in the first round.

In practice, it is considered that the aggregated value obtained in the second round can be accepted as the final solution. Some scholars believe that a consensus [13] is reached definitely in the third round. In the literature, there are papers in which the procedures for checking consensus have been developed. Those are based on parametric hypothesis testing, the application of the variance test, and the student’s distribution test.

There are several papers where the Delphi technique is enhanced with TFNs [13-15], as in this research. In the analyzed papers, DMs based their assessments on different measurement scales. For instance, Kumar et al. [16] used a nine-point scale, as in this research. Domains of used fuzzy numbers are defined at different intervals. In this research, the domains of TFNs are defined on the common scale numbers [1-9], by respecting the suggestion of different authors [17]. The aggregation of the DM opinions into a unique assessment can be given by using: (i) fuzzy geometric operator [4,5], or (ii) fuzzy averaging operator [18].

3. THE PROPOSED MODEL

The business processes under consideration can be formally described as a set $\{1,\ldots,p,\ldots,P\}$. The total number of business processes is marked as P. The business processes are determined in compliance with the APQC framework [19]. The index of the business process is denoted as $p, p=1,..,P$. The level of each RF should be assessed at the level of each business process. This represents the essence of the proposed research since DMs should be aware of the RFs level so they could manage it and enhance it continuously. The set of RFs is defined according to the referent literature [10]. Formally, the list of proposed RFs is represented by a formal set $\{1,\ldots,j,..,J\}$. The number of analyzed RFs is marked with J and $j, j=1,..,J$ is index of RF. The level of each RF $j, j=1,..,J$ at the level of each identified business process $p, p=1,..,P$ is assessed by each DM. They can be presented by a set of indices $\{1,..,e,..,E\}$. Index of DM is marked as $e, e=1,\ldots,E$ and E is total number of DMs. In the treated problem, five DMs participate according to the recommendation provided by Somerville [11]. Those are the business owner, production manager, quality manager, logistic manager, human resource manager, and marketing and sale manager.

OR can be expressed by a certain value that is associated with a described level of activities that are implemented in a treated company [20]. Those levels could be examined to benchmark operational capacity, organizational resilience, and disaster risk reduction [21]. By analogy to Pescaroli et al. [21] which has employed a Likert scale to assess the level of OR, this research proposes a scale of seven pre-decided linguistic terms. It is worth mentioning that a company can be represented through a network of its business processes so the level of OR can be assessed can be determined for each

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business process. OR itself can be decomposed to the finite set of RFs, so each RFs can be assessed to be at a certain level within the company's business processes which is described in table 1. It is considered that DMs can express their assessments in a sufficiently good way using the pre-decided linguistic terms proposed within the proposed research. These linguistic expressions are modeled by TFNs.

Table 1. The linguistic expressions defining the level of OR for each RFs.

The description of the OR level for each RFs	The corresponding values of RFs
There are no blueprints or plans for the construction of the OR, there is no awareness of the OR (B1)	(1,1,1.5)
There are drafts of activities for securing the OR (B2)	(1,2.5,4)
There are clear plans and activities for securing OR (B3)	(2.5,4,5.5)
Competencies of all employees in the field of OR management are ensured (B4)	(3.5,5,6.5)
Competencies of all employees in the field of OR management are ensured and there is a partially developed awareness of OR (B5)	(4.5,6,7.5)
Competencies of all employees in the field of OR management are ensured and there is a fully developed awareness of OR (B6)	(6,7.5,9)
All needed competences are ensured and there is the absolute commitment of management and all employees regarding OR management (B7)	(8.5,9,9)

Furthermore, the proposed Algorithm for determining the value is presented RF j,j=1,..,J at the level of each business process p,p=1,..,P.
The proposed Algorithm can be realized through the following steps.

Step 1. Each DM e,e=1,…,E is assessing the value of each RF j,j=1,..,J at the level of each identified business process p,p=1,..,P by using one of seven pre-defined linguistic expressions that have been modeled by TFNs, $\tilde{b}_{jp}^{1e}$.

Step 2. Let us determine the "Average Percent of Majority Opinions" (APMO) Cut off Rate [7] in the first round:

$$\widetilde{APMO}^1 = \frac{\tilde{b}_{jp}^{1min} + \tilde{b}_{jp}^{1max}}{\sum_{e=1,..,E} \tilde{b}_{jp}^{1e}} \quad (1)$$

It should be checked if a consensus is reached in the first round:

$$defuzz\left(\widetilde{APMO}^1\right) \leq 0.7 \quad (2)$$

Defuzzification is performed by applying the Graded Mean Integration Representation - GRIM [22]. if the consensus is reached in the first iteration, then the value of $\tilde{b}_{jp}^{1}$ should be calculated by applying

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the operator of the fuzzy geometric mean. This value is described by TFN based on the rules of fuzzy algebra [23].

Step 3. Let us determine the Hamming distance between $\tilde{b}_{jp}$ and TFNs that correspond to the pre-defined linguistic expressions $L_k, k = 1, .., K$, $d\left(\tilde{b}_{jp}, L_k\right)$. Each RF $j, j = 1, .., J$ at the level of process $p, p = 1, .., P$ should be adjoined with one of the pre-defined linguistic expressions $L_k, k = 1, .., K$ according to the expression:

$$\min_{k=1,..,K} d\left(\tilde{b}_{jp}, L_k\right) \tag{3}$$

Step 4. If the condition defined in Step 2 is not met, then the second round should be performed. DMs assess the level of each RF $j, j = 1, .., J$ at the level of business process $p, p = 1, .., P$ concerning $\tilde{b}_{jp}$. Fuzzy ratings of DMs in the second round are denoted as $\tilde{b}_{jp}^{2e}$.

Step 5. Let us check if the consensus is reached in the second iteration:

$$defuzz\left(\widetilde{APMO}^1\right) \leq 0.8 \tag{4}$$

The algorithm proceeds to Step 3.

Step 6. In case no consensus was reached in the second round, do not give recommendations on further execution of the Delphi technique. Here, the authors believe that the proposed procedure (Step 4 to Step 5) should be continuously performed until a consensus is reached.

Step 7. By applying GRIM, the representative scalar of aggregated RF fuzzy value is obtained at the level of each denoted sub-process, b_{ip}.

Step 8. By applying the Maxmin rule (Wald rule), the pessimistic approach is used to determine the rank of RFs:

$$\max_{j} \min_{p} b_{ip} \tag{5}$$

The RFs that are ranked last should be recognized as the most critical ones that should be improved immediately.

4. THE ILLUSTRATIVE EXAMPLE

The company that is used for the illustrative example is medium size company functioning as a part of a big supply chain producing scales and analytical instruments. For the purpose of calculations, the business processes are determined in compliance with the APQC framework [19]. The business processes under consideration can be formally described as a set {1,…,p,…,P}. The total number of business sub-processes is marked as P, and those are operating in the scope of a business process that embraces Produce/Assemble/Test product [19]: (1) Schedule production (subprocess - SP1), (2)

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Produce/Assemble product (subprocess - SP2), (3) Perform quality testing (subprocess - SP3), (4) Maintain production records and manage lot traceability (subprocess - SP 4).

The considered RFs which are significant for a production company are [10]: management commitment (1), reporting culture (2), learning (3), awareness (4), preparedness (5), flexibility (6), self-organization (7), teamwork (8), redundancy (9), and fault-tolerance (10).

According to the proposed Algorithm (Step 1) assessments of DMs are presented in Table 2.

Table 2. The assessments of DMs.

	SP1	SP2	SP3	SP4
RF1	B4, B3, B5, B5, B5	B5, B5, B5, B4, B5	B6, B5, B5, B5, B4	B6, B5, B6, B6, B4
RF2	B6, B5, B6, B5, B4	B6, B6, B5, B5, B5	B6, B5, B6, B5, B4	B6, B6, B5, B5, B5
RF3	B6, B6, B5, B5, B7	B6, B5, B5, B5, B5	B6, B4, B4, B4, B6	B4, B3, B3, B5, B4
RF4	B4, B4, B5, B6, B4	B5, B4, B4, B6, B5	B5, B5, B4, B4, B3	B5, B6, B4, B4, B4
RF5	B4, B5, B3, B4, B4	B5, B5, B4, B5, B5	B3, B4, B5, B4, B2	B5, B5, B6, B4, B4
RF6	B7, B6, B5, B6, B7	B6, B6, B5, B6, B6	B6, B6, B5, B5, B6	B6, B4, B4, B5, B6
RF7	B5, B5, B6, B4, B5	B6, B5, B5, B7, B7	B6, B5, B7, B5, B6	B5, B5, B4, B5, B4
RF8	B7, B7, B6, B7, B7	B6, B5, B6, B5, B6	B4, B3, B5, B5, B4	B6, B7, B4, B5, B6
RF9	B1, B3, B3, B3, B1	B2, B1, B1, B1, B1	B5, B6, B4, B4, B5	B5, B5, B6, B4, B5
RF10	B6, B4, B5, B5, B7	B6, B5, B6, B5, B6	B7, B6, B7, B6, B6	B7, B7, B5, B6, B7

APMO, the aggregated values, and linguistic expressions are obtained by applying the proposed Algorithm (Step 2 to Step 7) and presented in Table 3.

Table 3. APMO, the aggregated values of RFs, and appropriate linguistic expressions.

	SP1 **APMO/the fuzzy aggregated values of RF/crisp**	**SP2** **APMO/ the fuzzy aggregated values of RF/crisp**	**SP3** **APMO/ the fuzzy aggregated values of RF/crisp**	**SP4** **APMO/ the fuzzy aggregated values of RF/crisp**
RF1	0.39/ (3.80,5.33,6.85)/5.33	0.40/ (4.28,5.79,6.85)/5.71	0.43/ (4.53,6.05,7.56)/6.05	0.39/ (5.09,6.61,8.13)/6.61
RF2	0.41/ (4.80,6.33,7.84)/6.33	0.42/ (5.05,6.56,8.07)/6.56	0.41/ (4.80,6.33,7.84)/6.33	0.42/ (5.05,6.56,8.07)/6.56
RF3	0.42/ (5.73,7.11,8.37)/7.09	0.45/ (4.77,6.27,7.78)/6.27	0.43/ (4.34,5.88,7.40)/5.88	0.45/ (3.22,4.74,6.26)/4.74
RF4	0.46/ (4.10,5.62,7.14)/5.62	0.44/ (4.31,5.83,7.35)/5.83	0.42/ (3.62,5.14,6.66)/5.14	0.46/ (4.10,5.62,7.14)/5.62
RF5	0.43/ (3.44,4.96,6.47)/4.96	0.40/ (4.28,5.79,7.29)/5.79	0.41/ (2.68,4.32,5.87)/4.30	0.44/ (4.31,5.83,7.35)/5.83
RF6	0.39/ (6.51,7.72,8.68)/7.68	0.39/ (5.66,7.17,8.68)/7.17	0.40/ (5.35,6.86,8.37)/6.86	0.42/ (4.57,6.10,7.62)/6.10
RF7	0.43/ (4.53,6.05,7.56)/6.05	0.40/ (6.15,7.38,8.37)/7.34	0.42/ (5.37,7.11,8.37)/7.03	0.41/ (4.07,5.58,7.08)/5.58
RF8	0.38/ (7.93,8.68,9)/8.61	0.40/ (5.35,6.86,8.37)/6.86	0.39/ (3.80,5.33,6.85)/5.33	0.40/ (5.45,6.86,8.13)/6.84
RF9	0.39/ (1.73,2.30,3.27)/2.37	0.58/ (1.00,1.20,1.83)/1.27	0.44/ (4.31,5.83,7.35)/5.83	0.43/ (4.53,6.05,7.56)/6.05
RF10	0.42/ (5.15,6.56,7.84)/6.54	0.40/ (5.35,6.86,8.37)/6.86	0.41/ (6.90,8.07,9)/8.03	0.40/ (6.98,8.00,8.68)/7.94

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By applying step 8 of the proposed algorithm, the max of the min values at the level of the sub-processes is:

Max (5.33,6.33,4.74,5.14,4.30,6.10,5.33,1.27,6.54) = 6.54 so RF10 is the first in the rank.

RF 9 is ranked in the last place so the management should consider actions to enhance it. The results comply with usual business practices but taking into consideration the global trends and ongoing energetic crisis, the company management should address redundancy lack in some of the critical activities that may impact the business continuity.

5. CONCLUSION

As there is an ongoing process of research in the domain of resilience, it may be noticed that it has been often treated as an outcome-when organization cope well during a crisis or bounce back from disruptions or interruptions. Over the few past years, many unpredicted events have occurred shaping the business in a way that could not be predicted. This means that companies oriented to business continuity will need to consider the analysis and enhancement of their organizational resilience.

The main contribution of the research is the proposed model for the assessment of the OR level of one production company to deliver a comprehensive analysis of it so it can be used as input for resilience enhancement.

The main constraint f the model is the need for a well-structured process of obtaining information during the sessions and a facilitator with the skills needed to deliver the fuzzy Delphi study. The main advantage of the proposed model is that it provides an answer to the assessed value of RFs in an exact manner. As such, it can be used for monitoring and managing organizational resilience over time.

Future research should be oriented to examining the relationship between the values of RFs and the time needed for performance recuperation after significant disruptions.

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