Organizational resilience assessment from the perspective of process realization and key performance indicators

Nikola Komatina
University of Kragujevac
Faculty of Engineering
Kragujevac, Serbia
nkomatina@kg.ac.rs

Nastasija Nikolic
University of Kragujevac
Faculty of Engineering
Kragujevac, Serbia
nastasija.mijovic.fink@gmail.com

Vladan Paunovic
University of Kragujevac
Faculty of Technical Sciences
Cacak, Serbia
vladan.paunovic@ftn.kg.ac.rs

Abstract - **It may be considered that organizations that are operating in various markets, whether local or global, are highly vulnerable to turbulence and different market conditions. To succeed, every organization must not only adapt to such conditions but also demonstrate organizational resilience. Organizational resilience contributes to the adequate resolution of problems that arise as a result of market disruptions, as well as to the future improvement of the business.**

The purpose of this study is to evaluate organizational resilience at the delivery physical products process level. The proposed model analyzes organizational resilience as well as the time required to return to or improve performance levels associated with significant disruptions.

Keywords: Organizational resilience, key performance indicators, aggregation

I. Introduction

Different disruptions that an organization is dealing with may come from both inside and outside enterprise boundaries. Some examples of disruptions that can occur are economic recession, natural disasters, and human errors [1]. The ability to respond to internal or external disruptions is called "resilience" [2]. Over time, the concept of organizational resilience expanded and now refers to recovery ability, recovery times, and costs of recovery [3].

Organizational resilience can be described through resilience factors (RFs). RFs can be used to determine an organization's overall level of resilience, which indicates its ability to recover after a crisis. In recent years, there has been an unprecedented level of exposure of organizations to various disturbances and unplanned events, which significantly influenced the increased interest in directing research toward organizational resilience.

As is well known, decision makers (DMs) express their opinions using linguistic statements rather than numbers. Many authors believe that the theory of fuzzy sets [4] is an excellent tool for quantifying linguistic variables. The effect of RFs on key performance indicators (KPIs) is described in this paper using linguistic expressions modeled by triangular phase numbers (TFNs). These phase numbers adequately describe the existing uncertainties while requiring little computational complexity.

The current organizational resilience is determined based on the value of RFs, as well as the time required for performance to return to the level before the disruption. The goal of the research is to determine how each of the RFs affects KPI recovery. Based on the obtained results, the organization will be able to improve its resilience primarily by improving the worst-ranked RF within each KPI.

The wider objective of this research may be interpreted as introducing RFs according to the resilience literature [5]; introducing KPIs according to the relevant literature [6,7]; modeling the influence of RFs at the level of KPI by the TFNs; determining the aggregate value of the impact of RFs at the level of KPI and; definition of main actions which should lead to the enhancement of KPIs.

The motivation for this research stems from the fact that the organization must understand how each of the RFs affects the KPIs so that, in the event of a disruption, it can recover in the shortest amount of time.

In Section 2, the material and methods are presented. Section 3 refers to the proposed Algorithm and Section 4 contains a case study. The conclusion is presented in Section 5.

II. Material and Methods

This section presents a review of the literature that includes: (A) Organizational resilience models, their description and assessment, (B) KPIs in process of the physical products process, and (C) Linguistic expression used to describe the impact of RFs on KPIs.

A. Organizational resilience models, their description, and assessment

Because of the consequences of increasingly frequent market disruptions, the concept of organizational resilience has recently received increased attention [8]. Although there is a lot

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of interest in this topic, there is no agreement on what exactly organizational resilience is and how to improve it. Some authors point out that, despite the term's growing importance, there isn't always agreement on a common definition even in the same field [9]. However, several common factors contribute to organizational resilience, such as resilient individuals [10], resilient supply chains [11], and resilient engineering principles [12]. Even when there is a low risk of disruption, an organization must be resilient [13]. It is necessary to comprehend the organization's current resilience and forecast the organization's potential progress [3].

Organizational resilience should be maintained by restoring the system to its pre-disruption state using effective methods. RFs that have been identified as having an impact on organizational resilience in process of physical products delivery are shown in Table I [14, 15]:

TABLE I – RFS THAT HAVE AN IMPACT ON ORGANIZATIONAL RESILIENCE IN THE PROCESS OF PHYSICAL PRODUCT DELIVERY

No.	[14, 15]	
	Identified RFs	***Description***
j = 1	Management commitment	Recognizing human performance problems and effort to solve them
j = 2	Reporting culture	Reporting problems through an organization
j = 3	Learning	From normal work as well as from accidents
j = 4	Awareness	Understanding the quality of performance
j = 5	Preparedness	Anticipating the problems of human-machine systems
j = 6	Flexibility	Ability to adapt to new problems and solve it
j = 7	Self-organization	Generating results from multiple independent entities
j = 8	Teamwork	Achieving better results in a team than an individual might
j = 9	Redundancy	Absence of critical components
j = 10	Fault-tolerant	Maintain system performance in case of errors

B. KPIs in process of the product/service realization process

To maintain the level of business that existed before the disruption, KPIs for each sub-process (SPs) of product/service realization process (schedule production – SP1; produce – SP2; perform quality testing – SP3; and maintain production records and manage lot traceability – SP4). The following KPIs have been identified:

- The total cost of quality per $100,000 revenue (SP1),
- Employee retention rate (SP1),
- Total cost to perform the procurement process group per purchase order (SP2),
- Average procure-to-pay cycle time in days (SP2),
- Percentage of unique suppliers who are active suppliers (SP2),
- Scrap and rework costs as a percentage of the cost of goods sold (SP3),
- Total cost to manufacture per $1,000 revenue (SP3),
- Percentage of defective parts per million (SP3),
- Average cycle time in calendar days from delivery order to successful completion of delivery and disposal of back-hauled goods (SP4),
- The perfect order performance (SP4),
- Percentage of supplies on-time delivery (SP4).

C. The linguistic expression used to describe the impact of RFs on KPIs

It is assumed in this paper that evaluating the impact of RFs on KPIs can be adequately realized using seven linguistic terms. TFNs model these linguistic terms as it is presented in Table II. The TFNs domains are defined in the range [0-10]. The value 0, i.e. 10, indicates that RF does not impact, whereas it has a full impact.

TABLE II - LINGUISTIC TERMS MODELLED BY TFNS

	Linguistic term	**Domain**
L1	Almost does not impact at all	0, 0.5, 1
L2	Very little impact	0.5, 2, 3.5
L3	Little impact	2, 3.5, 5
L4	Medium impact	3, 5, 7
L5	High impact	5, 6.5, 8
L6	Very high impact	6.5, 8, 9.5
L7	Amongst full impact	9, 9.5, 10

III. METHODOLOGY

The evaluation of the value of RFs at the sub-process level can be expressed as a fuzzy group decision-making problem. According to [16], the following DMs evaluate the value of RFs at the level of each sub-process: the business owner, production manager, quality manager, logistic manager, human resource manager, and marketing and sales manager. Their values are described by seven linguistic expressions, which are represented by seven TFNs. TFN domains are defined on a common measurement scale [17]. The aggregated values of RFs values, $\tilde{v}_{jp}$ is determined by the proposed fuzzy Delphi technique. All KPIs defined within the sub-process are thought to be associated with RFs values determined at the sub-process level.

A. The proposed Algorithm

The proposed Algorithm can be realized through the following steps.

The proposed Algorithm can be realized through the following steps.

Step 1. The impact of RF ***j, j = 1, ..., 1***1 on each KPI ***i, i = 1, ..., 10***, DM is assessed using one of the pre-defined linguistic expressions which have been modeled by $\tilde{x}_{ji}$.

Step 2. Determine the weighted value of RF influence ***j, j = 1, ..., 11*** for each KPI ***i, i = 1, ..., 10:*** $\tilde{z}_{ji} = \tilde{x}_{ji} \cdot \tilde{v}_{jp}$.

Where:

$\widetilde{v}_{jp}$ is value RD ***j, j = 1, ..., 11*** at the level of sub-process ***p, p = 1, ..., 4*** for which are defined considered KPIs.

Step 3. Determine the aggregated weighted impact value of RFs ***j, j = 1, ..., 11*** impact, for each KPI ***i, i = 1, ..., 10:***

$$\widetilde{\varphi}_i = \sum_{j=1,...,11} \widetilde{z}_{ji}$$

Step 4. The representative scalar of TFN, $\tilde{\varphi}_i$ is denoted as φ_i and it is given by using the defuzzification procedure.

Step 5. Sort z_i into non-descending order.

Step 6. According to Pareto analysis, the first 20% of KPIs are those that should be further analysed for improvement. In this analysis, those would be the first and the second in the rank.

IV. CASE STUDY

The illustrative company is a medium-sized company that produces scales and analytical instruments as part of a large supply chain.

Step 1. The assessment of the impact of RFs on KPIs is presented in Table III.

TABLE III - THE ASSESSMENT OF THE IMPACT OF RFS ON KPIS

	i=1	**i=2**	**i=3**	**i=4**	**i=5**	**i=6**	**i=7**	**i=8**	**i=9**	**i=10**	**i=11**
	p=1		p=2			p=3			p=4		
j=1	L5	L7	L5	L4	L7	L4	L7	L3	L6	L7	L7
j=2	L7	L1	L7	L4	L2	L4	L7	L4	L6	L5	L7
j=3	L5	L7	L5	L1	L1	L7	L5	L6	L4	L7	L5
j=4	L6	L7	L6	L7	L5	L6	L7	L6	L5	L4	L7
j=5	L5	L6	L5	L6	L3	L4	L5	L5	L6	L6	L5
j=6	L4	L2	L6	L6	L3	L4	L6	L1	L4	L3	L6
j=7	L3	L5	L4	L3	L3	L4	L3	L3	L4	L4	L5
j=8	L4	L7	L5	L4	L5	L4	L4	L4	L5	L5	L5
j=9	L6	L2	L2	L2	L1	L6	L7	L7	L6	L5	L3
j=10	L7	L3	L4	L4	L5	L5	L5	L5	L4	L5	L6

The weighted impact value RFs are presented in Table IV and Table V (Step 2).

TABLE IV - THE WEIGHTED IMPACT VALUE OF RFS (PART 1)

	i=1	**i=2**	**i=3**	**i=4**	**i=5**
	p=1		p=2		
j=1	(0, 2.67, 6.85)	(34.20, 50.63, 68.50)	(21.40, 37.64, 54.80)	(12.84, 28.95, 47.95)	(38.52, 55.01, 68.50)
j=2	(2.40, 12.66, 27.44)	(0, 3.17, 7.84)	(45.45, 62.32, 80.70)	(15.15, 32.80, 56.49)	(2.53, 13.12, 28.25)
j=3	(28.65, 46.22, 66.96)	(51.57, 67.55, 83.70)	(23.85, 40.76, 62.42)	(0, 3.14, 7.78)	(0, 3.14, 7.78)
j=4	(26.65, 44.96, 67.83)	(36.90, 53.39, 71.40)	(28.02, 46.64, 69.83)	(38.79, 55.39, 73.50)	(21.55, 37.90, 58.80)
j=5	(17.20, 32.24, 51.76)	(22.36, 39.68, 61.47)	(21.40, 37.64, 58.32)	(27.82, 46.32, 69.26)	(8.56, 20.27, 36.45)
j=6	(19.53, 38.60, 60.76)	(3.26, 15.44, 30.38)	(36.79, 57.36, 82.46)	(36.79, 57.36, 82.46)	(11.32, 25.10, 43.40)
j=7	(9.06, 21.18, 37.80)	(22.65, 39.33, 60.48)	(18.45, 36.90, 58.59)	(12.30, 25.83, 41.85)	(12.30, 25.83, 41.85)
j=8	(23.73, 43.40, 63)	(71.19, 82.46, 90)	(26.75, 44.59, 66.96)	(16.05, 34.30, 58.59)	(26.75, 44.59, 66.96)
j=9	(11.25, 18.40, 31.07)	(0.87, 4.60, 11.45)	(0.50, 2.40, 6.41)	(0.50, 2.40, 6.41)	(0, 0.60, 1.83)
j=10	(46.35, 62.61, 78,40)	(10.30, 23.07, 39.20)	(16.05, 34.30, 58.59)	(16.05, 34.30, 58.59)	(26.75, 44.59, 66.96)

TABLE V - THE WEIGHTED IMPACT VALUE OF RFS (PART 2)

	i=6	**i=7**	**i=8**	**i=9**	**i=10**	**i=11**
	p=3			p=4		
j=1	(13.59, 30.25, 52.92)	(40.77, 57.48, 75.60)	(9.06, 21.18, 37.80)	(33.09, 52.88, 77.24)	(45.71, 62.80, 81.30)	(45.71, 62.80, 81.30)
j=2	(14.40, 31.65, 54.88)	(43.20, 60.14, 78.40)	(14.40, 31.65, 54.88)	(32.83, 52.48, 76.67)	(25.25, 42.64, 64.56)	(45.45, 62.32, 80.70)
j=3	(39.06, 55.86, 74)	(21.70, 38.22, 59.20)	(28.21, 47.04, 70.30)	(9.66, 23.70, 43.82)	(28.98, 45.03, 62.60)	(16.10, 30.81, 50.08)
j=4	(23.53, 41.12, 63.27)	(32.58, 48.83, 66.60)	(23.53, 41.12, 63.27)	(20.50, 36.53, 57.12)	(12.30, 28.10, 49.98)	(36.90, 53.39, 71.40)
j=5	(8.04, 21.60, 41.09)	(13.40, 28.08, 46.96)	(13.40, 28.08, 46.96)	(28.02, 46.64, 69.83)	(28.02, 46.64, 69.83)	(21.55, 37.90, 58.80)
j=6	(16.05, 34.30, 58.59)	(34.78, 54.88, 79.52)	(0, 3.43, 8.37)	(13.71, 30.0, 53.34)	(9.14, 21.35, 38.10)	(29.71, 48.80, 72.39)
j=7	(16.11, 35.55, 58.59)	(10.74, 24.89, 41.85)	(10.74, 24.89, 41.85)	(12.21, 27.90, 49.56)	(12.21, 27.90, 49.56)	(20.35, 36.27, 56.64)
j=8	(11.40, 26.65, 47.95)	(11.40, 26.65, 47.95)	(11.40, 26.65, 47.95)	(27.25, 44.59, 65.04)	(27.25, 27.90, 49.56)	(27.25, 44.59, 65.04)
j=9	(28.02, 46.64, 69.83)	(38.79, 55.39, 73.50)	(38.79, 55.39, 73.50)	(29.45, 48.40, 71.82)	(22.65, 39.33, 60.48)	(9.06, 21.18, 37.80)
j=10	(34.50, 52.46, 72)	(34.50, 52.46, 72)	(34.50, 52.46, 72)	(20.94, 40, 60.76)	(34.90, 52, 69.44)	(45.37, 64, 82.46)

According to the proposed Algorithm, (Step 3 to Step 4) the aggregated weighted impact of all RFs at the level of each KPI is presented in Table VI.

TABLE VI - THE AGGREGATED WEIGHTED IMPACT OF ALL RFS AT THE LEVEL OF EACH KPI

	$\tilde{\varphi}_i$	φ_i		$\tilde{\varphi}_i$	φ_i
i=1	(184.82, 322.92, 491.87)	332.20	i=7	(281.86, 447, 641.58)	456.81
i=2	(253.29, 379.31, 524.41)	385.67	i=8	(184.03, 331.87, 516.88)	344.26
i=3	(238.66, 400.54, 598.89)	412.69	i=9	(227.64, 403.62, 625.19)	418.82
i=4	(176.29, 320.78, 502.87)	333.31	i=10	(246.51, 410.37, 610.89)	422.59
i=5	(148.28, 270.13, 420.78)	279.73	i=11	(297.55, 462.05, 656.61)	472.09
i=6	(204.70, 376.08, 593.12)	391.30			

The obtained results by applying the proposed Algorithm (Step 5 to Step 6) is presented in Table VII.

TABLE VII - THE OBTAINED RESULTS BY APPLYING THE PROPOSED ALGORITHM

	φ_i	rank		φ_i	rank		φ_i	rank
i=5	279.73	**1**	i=2	385.67	**5**	i=10	422.59	**9**
i=1	332.20	**2**	i=6	391.30	**6**	i=7	456.81	**10**
i=4	333.31	**3**	i=3	412.69	**7**	i=11	472.09	**11**
i=8	344.26	**4**	i=9	418.82	**8**			

The first and second in the rank are RFs denoted as Management commitment and Preparedness which are very important in any company. The company management should put effort to propose actions for the enhancement of those RFs values. In a presence of serious disruption, the analysed company in its present state may face serious problems and a decrease in KPIs' value for a certain period. Also, bouncing back to a normal operating state may be challenging.

V. CONCLUSION

Resilience is a dynamic concept. The degree of resilience of an organization evolves. The resilience of an organization directly affects how long it takes for its performance to return to pre-disturbance levels after a disruption. The occurrence of such disorders has been on the rise in recent years. This has a direct impact on the organization's need to consider its resilience daily.

The primary contribution of this research is a model for estimating the time required for an organization to return to its pre-disruption state. The model takes into account specific KPIs within each sub-process of the physical product delivery process. The model takes into account the impact of each RFs on each of the KPIs. The model can be used to improve organizational resilience.

The main limitation of the model could be the inability of the experts involved in the study to obtain appropriate linguistic terms. The model's main advantage is that it can identify which RFs need to be improved and which have the greatest impact on organizational resilience, allowing it to be improved most effectively.

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