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FACULTY OF MECHANICAL ENGINEERING IN NIŠ

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THE 6th INTERNATIONAL CONFERENCE
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ENHANCEMENT OF THE ORGANIZATIONAL RESILIENCE IN TERMS OF REDUNDANCY FACTORS

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Abstract: *Enhancing organizational resilience through redundancy factors involves implementing strategies and measures to ensure that a business or institution can continue to function effectively in the face of disruptions or crises. Redundancy factors help organizations minimize the impact of unexpected events, such as natural disasters, economic downturns, or cyberattacks. In this paper, the external redundancy factors are analyzed and ranked according to the criteria of potential improvement so the company can enhance overall organizational resilience. It is shown that the analyzed company should improve interconnectedness and interdependence with different stakeholders in their environment, especially relationship with customers. In practice, enhancing organizational resilience through redundancy factors is an ongoing process that requires a proactive and holistic approach to risk management. By implementing measures for the improvement of different factors and continuously refining them, organizations can better prepare for and respond to various disruptions and crises.*

Keywords*: organizational resilience, optimization, linear programming*

1. INTRODUCTION

Organizational resilience enhancement involves strengthening an organization's ability to withstand, adapt to, and recover from disruptions and crises. It is a proactive approach to minimize the impact of unexpected events and maintain operational continuity. As there is no official scientific consensus on what consists organizational resilience, it may be assumed that these features are formed inside and outside the company. A motivation for conducting this research is to provide an answer to the question on what are the external main features of organizational resilience that need to be improved in a manufacturing company.

A company should regularly conduct risk assessment and risk management practices [1]. In compliance with that, a company should develop and regularly update business continuity plans (BCPs) to ensure critical functions can continue in the face of disruptions [2]. One more important measure is to implement redundancy in critical systems, resources, and processes to ensure that there are backups in case of failures [3]. As it is common for companies to operate in supply chain, they should assess and enhance supply chain resilience by diversifying suppliers, building relationships, and having contingency plans [4].

A number of research indicates that redundancy is one of the main resilience factors that should be enhanced in the long term to enable a stable function of a company and quick recover in a time of crisis [5]. In compliance with that, the goal of this research is to determine which external redundancy factor in company should be first improved to enhance overall organizational resilience.

Linear programming was applied to solve the considered problem. Using this methodology, the significance of the external redundancy factor was determined, specifically the percentage of confidence that enhancing the chosen external redundancy factor would impact the improvement of the overall organizational resilience. Linear programming is a mathematical tool widely applicable and well-known in literature. This methodology is based on finding the optimal feasible solution, which is determined based on the defined objective function and linear constraints. Linear programming finds its application in various fields today, such as engineering, economics, management, etc. Enhancing organizational resilience is an ongoing process that requires careful planning, implementation, and continuous improvement. Section 2 contains the literature review and methodology, while section 3 provides a case study from one production company that operates in Central Serbia. The discussion and conclusion are presented in section 4.

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2. LITERATURE REVIEW AND METHODOLOGY

External redundancy, in the context of organizational resilience, refers to the ability of an organization to mitigate disruptions and ensure continuity by relying on external sources, partners, or backup systems. Several factors impact organizational resilience in terms of external redundancy. Their enhancement should be used to improve overall organizational resilience, so the main task is to assess their level in the company and decide which are supposed to be improved.

The literature review suggest the following external redundancy factors to be further examined: **Supplier Diversification ($i = 1$) -** Relying on a single supplier for critical inputs or components can create vulnerabilities [6]. Organizations can enhance resilience by diversifying their

supplier base; **Alternative Distribution Channels ($i = 2$) -** Organizations can establish alternative distribution channels or partners to ensure products or services reach customers even if one channel is disrupted [7]; **Cross-Industry Collaboration ($i = 3$) -** Collaborating with organizations in related industries can provide access to resources, expertise, and support during crises [8]; **Interconnectedness and Interdependence ($i = 4$) -** Understanding and managing the interdependencies between an organization and its external stakeholders, such as suppliers, customers, and regulators, is crucial for resilience [9]; **Government and Regulatory Support ($i = 5$) -** Collaboration with government agencies and regulatory bodies can provide access to resources, information, and assistance during crises [10]; **Insurance and Risk Transfer ($i = 6$)** - Utilizing insurance and risk transfer mechanisms can provide financial support in the event of disruptions, reducing the financial impact on the organization [11]; **Redundant Communication Networks ($i = 7$)** - Maintaining multiple communication networks and providers can ensure that an organization has reliable communication channels during disruptions [12]; **Globalization Considerations ($i = 8$)** - Organizations with global operations must consider geopolitical stability and economic conditions in various regions to reduce vulnerability to external disruptions [13]; **Supply Chain Resilience Strategies ($i = 9$)** - Implementing supply chain strategies such as just-in-time (JIT), vendor-managed inventory (VMI), and safety stock can provide external redundancy by buffering against supply disruptions [4]; **Financial Contingency Plans ($i = 10$)** - Maintaining access to financial resources, including lines of credit and contingency funds, can provide external financial redundancy during economic crises [14].

These factors highlight the importance of external redundancy measures in organizational resilience. In practice, all the analyzed factors are important for the company although they should be ranked in order to be continuously improved over time.

Organizations that strategically plan for external redundancy can better adapt to disruptions and ensure the continuity of critical operations.

2.1. The algorithm for the ranking of the denoted external redundancy factors

To make a selection which redundancy factor is supposed to be improved in the first place, company management should make an appropriate assessment. The algorithm for this assessment is presented as follows:

Step 1. Assessment of criteria weights at the level of each decision-maker, W_c^e.

Step 2. Determining the aggregate value of criteria weight using the geometric mean operator, W_c.

Step 3. Generating a decision-making matrix based on decision-makers' assessments. The aggregated value of the assessments was obtained using the geometric mean operator, $[m_{ic}]_{I\times C}$.

Step 4. Defining the objective function and linear constraints of the considered model.

Step 5. Application of Lingo 20.0 software for solving stated Linear Programming problem.

Step 6. Determining the most crucial external redundancy factor.

The application of the proposed steps is illustrated and explained gradually in the following section.

3. CASE STUDY

To make a realistic assessment, a company should employ a decision machining team consisting of experienced and highly ranked individuals. In the treated case, those are the top manager of the company, the quality manager, and the financial manager. The decision makers use the direct assessment of the criteria values for each considered factor, so their opinion is aggregated for the rest of the algorithm calculations.

Within this case study, an analysis of factors of external redundancy that may impact organizational resilience is conducted. The decision-makers participating in this research are the top manager of the company, the quality manager, and the financial manager. The task for decision-makers was to respond to the provided questionnaires in two iterations. In the first questionnaire, decision-makers performed a direct assessment of the weights of the considered criteria, which are: 1) the time of activity improvement factor ($c = 1$), the cost of activity ($c = 2$), the level of belief that improving this factor absolutely influences the improvement of external redundancy ($c = 3$).

Assessment of the weights of the considered criteria, W_c^e according to decision maker $e = 1$:

$$W_1^1 = 0.2; W_2^1 = 0.45; W_3^1 = 0.35$$

Assessment of the weights of the considered criteria, W_c^e according to decision maker $e = 2$:

$$W_1^2 = 0.3; W_2^2 = 0.4; W_3^2 = 0.3$$

Assessment of the weights of the considered criteria, W_c^e according to by decision maker $e = 3$:

$$W_1^3 = 0.2; W_2^3 = 0.35; W_3^3 = 0.45$$

The estimated weights of the criteria were aggregated using the geometric mean operator, followed by linear normalization to ensure that the sum of criterion weights equals 1. The aggregated values of criteria weights are:

$$W_1 = 0{,}23; W_2 = 0{,}40; W_3 = 0{,}37$$

In the second questionnaire, decision-makers were tasked with individually assessing the value of each external redundancy factor, $i, i = 1, \dots, 10$, according to each of the considered criteria, $c, c = 1, \dots, 3$, using a scale of [1-9] (Saaty's measurement scale).

The case study is conducted in one production company that operates in Central Serbia. For the purpose of assessment, the decision makers were interviewed. The following table was presented to them with appropriate explanations and guidelines on how to make an assessment. Each decision-maker conducted their assessments independently. Table 1 the used measurement scale is presented.

Table 1. The measurement scale used for assessing external redundancy factors

The time of activity improvement factor ($c = 1$)	**The cost of activity ($c = 2$)**	**The level of belief that improving this factor absolutely influences the improvement of external redundancy ($c = 3$)**	**Value**
Very long time frame (more than 6 months)	Very High Cost (more than 10% of annual company budget for the overall business improvement)	The belief that improving this factor will have negligible influence on the improvement of organizational resilience	1
Long time frame (between 2 and 6 months)	High Cost (between 8% and 10% of annual company budget for the overall business improvement)	The belief that improving this factor will have low influence on the improvement of organizational resilience	3
Medium time frame (between 3 to 8 weeks)	Medium Cost (between 5% and 8% of annual company budget for the overall business improvement)	The belief that improving this factor will have moderate influence on the improvement of organizational resilience	5
Short time frame (between 1 to 3 weeks)	Low Cost (between 2% and 5% of annual company budget for the overall business improvement)	The belief that improving this factor will have high influence on the improvement of organizational resilience	7
Negligible time frame (up to one week)	Almost Negligible Cost (less than 2% of annual company budget for the overall business improvement)	The belief that improving this factor absolutely influences improvement of organizational resilience	9
Intermediate value (the decision-maker cannot define the value precisely)			2, 4, 6, 8

The estimated values of the redundancy factor according to the considered criteria by all three decision-makers are shown in Table 2. The aggregated value of their assessments is provided in brackets.

Table 2. The decision-making matrix

	$c = 1$	$c = 2$	$c = 3$
$i = 1$	5, 6, 8 (6.21)	6, 5, 6 (5.65)	6, 6, 8 (6.60)
$i = 2$	3, 4, 4 (3.63)	5, 5, 6 (5.31)	4, 7, 4 (4.82)
$i = 3$	6, 5, 5 (5.31)	4, 5, 4 (4.31)	2, 3, 3 (2.62)
$i = 4$	6, 7, 7 (6.65)	5, 7, 6 (5.94)	8, 6, 9 (7.56)
$i = 5$	2, 5, 4 (3.42)	4, 2, 6 (3.63)	5, 2, 3 (3.11)
$i = 6$	4, 2, 6 (3.63)	2, 2, 2 (2.00)	2, 2, 3 (2.29)
$i = 7$	5, 3, 3 (3.56)	3, 3, 2 (2.62)	1, 2, 2 (1.59)
$i = 8$	5, 2, 2 (2.71)	2, 4, 4 (3.17)	6, 2, 4 (3.63)
$i = 9$	4, 5, 2 (3.42)	5, 3, 6 (4.48)	6, 3, 5 (4.48)
$i = 10$	8, 6, 6 (6.60)	6, 7, 7 (6.65)	5, 7, 7 (6.26)

In order to determine the most important redundancy factor based on the displayed values and calculated criteria weights, the problem can be formulated as a Linear programming task:

Objective function:

$$\max\{y\}$$

subject to:

$$\frac{x_{ic}}{m_{ic} \cdot W_c} \geq y \quad (1)$$

$$x_i = \sum_{c=1}^{3} x_{ic} \quad (2)$$

$$\frac{x_{i2}}{x_{i1}} \leq 1 \quad (3)$$

$$\frac{x_{i3}}{x_{i2}} \leq 1 \quad (4)$$

$$\sum_{i=1}^{10} x_i = 100\% \quad (5)$$

$$x_i \geq 0\% \quad (6)$$

where:

m_{ic} is the value of the considered factor according to criterion c (value from the decision-making matrix).

x_{ic} is the percentage of belief that factor i is the best according to criterion c;

W_c is the weight of the considered criterion;

x_i is the sum of weighted values for i; is the percentage of belief that factor i is the best according to all criteria; the total sum of x_i amounts to 100%;

$\frac{x_{i2}}{x_{i1}}$ is the ratio between weighted values of i according to criteria $c = 2$ and $c = 1$;

$\frac{x_{i3}}{x_{i2}}$ is the ratio between weighted values of i according to criteria $c = 3$ and $c = 2$;

Defined optimization task can be solved using Lingo 20.0 software. The values obtained in the software are shown in Figure 1.

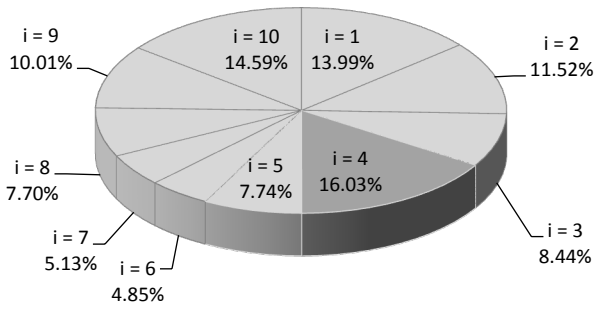

Fig.1. The percentage of belief that factor i is the best according to all criteria

The obtained results clearly indicate that the analysed company should improve interconnectedness and Interdependence (i=4) at the first place in rank.

4. DISCUSSION AND CONCLUSION

The main issue that needs to be addressed here is enhancement of the company interconnectedness and interdependence. Due to the occurrence of unpredictable events during the last few years (e.g., COVID 19 pandemic), one of the most important external factors is customers. Satisfied customers may exhibit more patience and understanding during disruptions, which can be vital

for an organization's ability to recover [15]. Organizations with a diverse and satisfied customer base are less vulnerable to disruptions caused by the decline of a single market segment or customer group [16]. Many studies have shown that satisfied customers are more likely to become loyal customers [17]. Organizations that actively gather and act upon customer feedback tend to be more adaptable and responsive [18]. This can contribute to their overall resilience. A strong and trusted brand, often built on customer satisfaction, can be more resilient in times of crisis. Trust can mitigate the negative impact of adverse events [19]. As a measure to be taken in the presented case, a company should develop a reliable tool for customer satisfaction assessment and management.

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