

FORM 6

UNIVERSITET KRAGUJEVAC  
FACULTY OF ENGINEERING  
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02.09.24  
KRAGUJEVAC

**TEACHING-SCIENTIFIC COUNCIL**

Teaching-scientific council of Faculty of Engineering, Kragujevac

and

**COUNCIL FOR TECHNICAL-TECHNOLOGICAL SCIENCES**

**UNIVERSITY OF KRAGUJEVAC**

At the meeting of the Council **TECHNICAL-TECHNOLOGICAL SCIENCES** of the University of Kragujevac held on 10.7.2024. године (decision number: IV-04-559/16) we have been appointed as members of the Committee for the evaluation and defense of the doctoral dissertation entitled: **"Assessment and enhancement of organizational resilience in complex industrial enterprises in uncertain environment"**, of the candidate **Michael Huber**, student of doctoral academic studies Industrial engineering and Engineering management, for which a mentor has been appointed **Aleksandar Aleksić**, associate professor.

Based on the data at our disposal, we submit the following:

**EVALUATION REPORT**

**OF THE FINISHED DOCTORAL DISSERTATION**

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| <b>1. Doctoral dissertation data</b>  |
| 1.1. Doctoral dissertation title:   |
| Assessment and enhancement of organizational resilience in complex industrial enterprises in uncertain environment.   |
| 1.2. Description of the doctoral dissertation (provide a short content with the page number indication, chapters, figures, graphs, equations and references) (up to 500 characters):  |
| The doctoral dissertation contains 189 pages divided into 9 chapters, Introduction; Problem definition; Literature review; Research methodology; The case study in a complex industrial company; Discussion and implication; Conclusion; Appendix; Literature. The doctoral dissertation contains 30 figures, 42 tables, 48 equations, and 342 references.  |
| 1.3. Description of the research subject (up to 500 characters):  |
| The dissertation presents a comprehensive analysis of the organizational resilience of complex systems integrated into one international company.<br>Here, organizational resilience is conceptualized through a set of resilience factors (RFs) that may be assessed by the decision makers applying Delphi method expanded with fuzzy sets. The input data for the case study is obtained in the international company.<br>Detailed analysis has revealed that there is a significant correlation between the resilience factors and the time needed for recovery of each measured key performance indicators (KPIs). |

#### 1.4. Analysis of initial hypothesis fulfilment:

Regarding the proof of hypotheses defines at the beginning of this PhD dissertation:

Hypothesis A: By using the hybrid fuzzy model, the aggregate value of the resilience factors affecting each identified KPI can be precisely determined.

Hypothesis B: A negative correlation exists between the aggregate value of the resilience factors and the recovery time of the key performance indicators.

Hypothesis C: The application of heuristic methods enables the identification of the optimal set of strategies to improve RFs in a complex enterprise environment

Hypothesis D: A dynamic approach to resilience management that integrates cross-phase activities is shown to be more effective in managing disruptions and uncertainties compared to static resilience models.

Hypothesis E: The normative implementation of corporate resilience can be permanently anchored and improved in the company through sustainable management systems.

Hypothesis A aligns with the study's findings, affirming its validity. Notably, the application of fuzzy logic allows for the incorporation of uncertainties through fuzzy sets and linguistic variables. This methodology facilitates a nuanced representation and thus a more accurate assessment of ambiguous terms. Consequently, it suggests that a hybrid fuzzy model can be utilized to determine precise values for each identified KPI. Chapter 5.2 substantiates and corroborates this hypothesis. The consistency of the scores is validated through a recognized procedure, and the correlation coefficient between the first and second round scores by the decision makers (DMs) demonstrates a strong positive correlation. This confirms that the ratings are consistent and, therefore, reliable. The fact that the values obtained in the second round are considered final further supports the premise that the fuzzy model delivers accurate values for this purpose.

Hypothesis B is also supported by the study's findings, confirming its accuracy. The study examines the relationship between the weighted aggregated value of each resilience factor (RF) and the recovery time of each key performance indicator (KPI). The performed calculations and correlation analysis validate the hypothesized negative correlation: there is a statistically significant negative relationship between the RF values and the time required to restore the KPIs. The correlation coefficient indicates that higher RF values are associated with shorter KPI recovery times. This result is detailed in Table 5-4.

Hypothesis C at the model level posits that heuristic methods can identify optimal strategies to enhance risk factors (RFs) within a complex business environment (refer to Table 7-3). The study explores the application of heuristic methods to pinpoint strategies for improving RFs in intricate organizational settings. Key RFs deemed essential for industrial companies are defined based on literature (refer to Chapter 4.1.2). Various management methods can enhance organizational resilience factors, though their implementation is influenced by constraints such as budget and execution time. The hypothesis suggests that an optimal set of management methods can be determined using heuristic methods. However, the candidate tried to apply exact methods also, since their application is faster and does not demand complex mathematical operations. The empirical validation highlights the effectiveness of the Branch-and-Bound algorithm approach. This approach facilitates informed decision-making through optimized resource allocation. The use of Branch-and-Bound heuristics to optimize organizational RFs has yielded precise insights into this approach's performance. Consequently, Hypothesis C is supported by the study's results, confirming its validity.

Hypothesis D at a holistic level posits that a dynamic approach to resilience management, integrating cross-phase activities, is more effective in managing disruptions and uncertainties than static resilience models (refer to Table 7-4). The study's findings confirm Hypothesis D, demonstrating its accuracy in the context of entrepreneurial resilience.

In companies, the need for a dynamic and adaptable corporate culture is evident (refer to Chapters 3.3.2 and 3.3.3). Essential elements include transparent communication, targeted employee support, and investment in effective leadership. A dynamic resilience management approach, which encompasses various activities and phases, allows organizations to flexibly respond to changes and crises, continually adapting as illustrated in the case study. This contrasts with static models, which are less effective in a rapidly evolving environment. Additionally, the case study highlights the importance of organizational

structure. The complexity of decentralized matrix organizations, where autonomous business units are part of a global supply chain, is particularly emphasized.

Hypothesis E posits that the normative implementation of corporate resilience can be permanently embedded and enhanced in organizations through sustainable management systems (refer to Table 7-5). The study's findings, alongside the case study, support this hypothesis, confirming its accuracy.

Implementing resilience in organizations necessitates the adoption of standards and norms, as well as their integration into management systems (refer to Chapter 3.4.3). These standards and norms (refer to Chapter 3.4.1) provide clear guidelines for implementation and can alleviate external pressures on organizations. Integrated management systems highlight the importance of sustainability and foster innovations that strengthen resilience.

Standards and models such as the SGMM and the AQMM facilitate the introduction of resilience in companies, shape corporate culture, and enhance the understanding of resilience. However, embedding corporate resilience is not automatic. It demands clear objectives, appropriate resources, and the revision of existing practices. Additionally, developing indicators and metrics is essential for evaluating organizational impact and preparing for future challenges.

In line with Hypothesis E, the study confirms that the normative implementation of corporate resilience can indeed be permanently anchored and improved through sustainable management systems, thus validating the hypothesis.

#### 1.5. Analysis of applied research methods:

The core of this research lies in the implementation of a two-stage fuzzy model.

In the initial phase, the candidate determined the level of resilience factors (RFs) within the product delivery process of the analyzed company by employing the Fuzzy Delphi Technique. The conventional Delphi technique was enhanced with triangular fuzzy numbers that were described with linguistic expressions. This approach was chosen to make the task for decision makers less complex and adapted to everyday communication.

This stage involved identifying the subprocesses within the production process, their corresponding performances, and the key performance indicators (KPIs). This is executed through the employment of the APQC Process Classification Framework (PCF), which provides a hierarchical taxonomy of business processes. This framework is adaptable across various industries, sizes, and geographical locations, enabling organizations to benchmark their processes effectively. However, the dissertation notes the importance of tailoring processes to specific business contexts to achieve meaningful and relevant results. The input data for this phase was gathered from the company's documentation and surveys filled out by the company's managers. The candidate established the KPI levels for each subprocess and quantified the RFs.

In the second phase, the candidate calculated the weighted aggregated fuzzy value of RFs for each KPI and analyzed the relationship between RFs and KPIs using scatter plots. The candidate determined the recovery time required for each KPI value and assessed how resilience factors impact KPIs. This allowed the candidate to establish resilience index values for each KPI. Organizational resilience was shown to significantly contribute to addressing issues arising from market disruptions and improving future business operations. Additionally, the candidate tested the correlation between the resilience index and the time needed for KPI recovery after sudden disruptions.

The model is based on real data from a complex industrial enterprise, and the findings indicate a significant negative correlation between the variables, thus proving our initial assumptions. This innovative approach fills a notable gap in empirical research on corporate resilience, offering a practical and structured methodology for industrial enterprises.

To enhance overall organizational resilience, the candidate analyzed the application of heuristic and exact methods. Considering the complexity of the problem, the branch and bound algorithm was selected as the most suitable tool. This algorithm was applied with a defined goal function and constraints regarding the proposed budget and time. The results reveal which management methods should be applied to improve the identified resilience factors in the analyzed company.

#### 1.6. Analysis of research objective fulfilment:

The dissertation highlights that a significant number of organizations have recently adopted a comprehensive, system-wide approach to resilience. This trend is crucial, as it signifies a shift from isolated resilience efforts to integrated strategies that encompass the entire organizational structure. Such an approach ensures that companies are better prepared for disruptions, thereby enhancing their ability to sustain operations and achieve long-term success.

The research objective fulfilment can be assessed through the comparative analysis of the planned scientific contribution and the achieved results. The plan included the following contributions:

*The conceptualization of the new model for organizational resilience.*

*The methodology for the assessment of organizational RFs is defined by the proposed model.*

*The proposal of a finite set of KPIs that are monitored at the level of subprocesses of a generic process in a complex company.*

*The analysis of the relationship between RFs values and the time needed for KPIs recovery.*

*The developed new optimization model for the selection of methods for RFs level enhancement.*

The comparative analysis indicates the following.

*The conceptualization of the new model for organizational resilience* is based on resilience indicators that are suitable for complex manufacturing organizations. The unique list of organizational RFs in compliance with GRI guidelines is defined for complex manufacturing organizations and their supply chain. The candidate analyzed the RFs at three levels (generic, industry branch-specific, and subprocess-specific ones).

The assessment of RFs values was conducted during a business-as-usual period, and the time needed for recovery was measured when business processes were (a) exposed to an assumed emerging risk or threat (e.g. a disruption in the supply chain) and (b) over the operating time. The assessment was done at the level of the identified subprocess.

*The methodology for the assessment of organizational RFs is defined by the proposed model.* The research was executed at the level of each identified subprocess in the scope of realization of physical products by applying fuzzy Delphi technique. This means that the traditional Delphi technique was enhanced with the triangular fuzzy numbers.

*The proposal of a finite set of KPIs that are monitored at the level of subprocesses of a generic process in a complex company.* The selection of KPIs was executed at the level of a realization of physical products. The variable of interest for the dissertation is the time needed for recovery of KPIs after a significant disruption.

*The analysis of the relationship between RFs values and the time needed for KPIs recovery.* The scatterplot analysis of RFs' aggregated value at the level of each KPI and the time needed to recover each KPI is presented by applying regression and correlation analysis.

*The developed new optimization model for the selection of methods for RFs level enhancement.* After analysis of the relationship between RFs values and the time needed for KPIs recovery, the RFs with the lowest value were appointed for enhancement by different management methods. The chosen tool for the RFs enhancement was branch and bound algorithm.

The Commission is of the opinion that the research objectives were successfully met.

#### 1.7. Analysis of the obtained research results and the list of candidate's published scientific papers from the doctoral dissertation (authors, paper title, journal title, volume, year of publication, pages from-to, DOI number, category):

A part of the candidate's research results from the doctoral dissertation was presented to an international scientific audience by publishing the work in international journals of category M21a and international conferences (M33).

The validation of the proposed two stage model in the dissertation is presented in the international journal paper while optimization of the obtained results and the improvement of RFs is presented in the papers from international conferences.



International journal (M21a):

1. Huber, M., Komatina, N., Paunović, V., Nestić, S. (2023). Analysis of the Relationship between the Organizational Resilience Factors and Key Performance Indicators' Recovery Time in Uncertain Environments in Industrial Enterprises. Mathematics, 11(14), 3075. URL: <https://www.mdpi.com/2227-7390/11/14/3075>

International conferences (M33):

1. Aleksić, A., Huber, M. Tadić, D., Nestić, S. (2024). Advanced Risk Management Practices - The Application of the Exact Solutions Methods for Resilience Factors Improvement. 3rd Serbian International Conference on Applied Artificial Intelligence (SICAAI). Kragujevac. May 23rd – 24th, 2024.

2. Tadic, D., Huber, M., Aleksić, A. (2024). Application of Exact Methods for Finding the Optimal Solution of Organizational Resilience Improvement. SymOrg. XIX International Symposium, Unlocking the hidden potentials of organization through merging of humans and digitals. Zlatibor, June 12-15, 2024. (hybrid) URL: <https://symorg.fon.bg.ac.rs/wp-content/uploads/2024/06/Zbornik-SymOrg-2024.pdf>

1.8. Assessment of the completed doctoral dissertation as the candidate's original scientific work in the appropriate scientific field and analysis of the plagiarism report (up to 1000 characters):

The Committee has determined that the doctoral dissertation "Assessment and enhancement of organizational resilience in complex industrial enterprises in uncertain environment" is the result of the candidate's original scientific work in the field of Engineering management.

In adherence to the University of Kragujevac's procedures, the dissertation underwent a thorough plagiarism detection process. In the Report on the verification of the originality of the doctoral dissertation no. IV-04-496/5 dated June 24th, 2024, indicates that the dissertation, written in English, has matched content with three sources. The majority of these matches pertain to the candidate's own previously published work in scientific journals and international conferences, where the candidate is listed as the first or corresponding author, so the work represents the result of the completed doctoral dissertation. Additionally, a minor match was identified with the document titled Report on the assessment of the scientific basis of the topic and the fulfilment of the requirements of the candidate and the proposed mentor. Therefore, the report on the originality check of the doctoral dissertation (plagiarism check) and the mentor's assessment on the originality check report of the doctoral dissertation "Assessment and enhancement of organizational resilience in complex industrial enterprises in uncertain environment " of candidate Michael Huber unequivocally indicate the originality of the doctoral dissertation.

1.9. The significance and impact of the doctoral dissertation in the current state of a specific scientific field:

Ongoing research in the domain of organizational resilience frequently treats it as an outcome, evidenced when an organization effectively manages a crisis or recovers from disruptions or interruptions.

The doctoral dissertation "Assessment and Enhancement of Organizational Resilience in Complex Industrial Enterprises in an Uncertain Environment" addresses a crucial issue in Engineering Management, especially highlighted by the market disruptions and other global crises. It emphasizes the necessity for organizations to adopt comprehensive, system-wide resilience strategies, which many still lack. The dissertation introduces a two-stage fuzzy model using the Fuzzy Delphi Technique to assess resilience factors and their impact on key performance indicators. This innovative methodology fills a gap in empirical research, offering practical insights for industrial enterprises. It also leverages the APQC Process Classification Framework to benchmark processes effectively. The research underscores the need for continuous development of resilience indicators and metrics, recommending future studies to refine the Delphi method and extend the model across industries.

The dissertation's findings have practical implications for organizations seeking to enhance their resilience. It recommends that companies select relevant KPIs that are independent of external influences and adapt these indicators to their specific context using proven methods such as the OECD method and the Value Chain Analysis (VCA). By integrating a backward chain into the extended VCA, organizations

can ensure a comprehensive business perspective essential for effective KPI development. This work significantly advances the understanding and application of corporate resilience in engineering management and provide a conceptual framework that defines and operationalizes procedures for achieving resilience. In the follow-up work of the candidate, this framework should be applied in the company that was used to conduct the case study.

1.10. Evaluation of the fulfilment of the requirements for the doctoral dissertation defence according to the study programme, faculty's general act, and university's general act (up to 1000 characters):

The candidate Michael Huber passed all the exams for the doctoral academic studies in Industrial Engineering and Engineering Management (according to the issued certificate of passed exams of the Service for Student affairs No. 2951 dated 08.12.2022), which satisfied the first of the requirements for the defense of the doctoral dissertation.

The doctoral dissertation of the candidate Michael Huber was written according to the instructions of the Regulations on application, preparation and defense of doctoral dissertations of the University of Kragujevac and in terms of content corresponds to the topic accepted by the Teaching and Scientific Council of the Faculty of Engineering University of Kragujevac and the Council for Technical and Technological Sciences of the University of Kragujevac. The candidate Michael Huber showed a complete understanding of the field of industrial engineering and engineering management and fully mastered all the principles of scientific and research work, from reviewing the literature, setting up hypotheses, designing and conducting experiments, analyzing and explaining the results, which is best demonstrated by published papers in scientific journals and international conferences as the first or the corresponding author. The candidate Michael Huber published a paper as the first author entitled "Analysis of the Relationship between the Organizational Resilience Factors and Key Performance Indicators' Recovery Time in Uncertain Environments in Industrial Enterprises" which satisfied another requirement for the defense of the doctoral dissertation.

Bearing in mind the mentioned facts, the Committee believes that the research objectives have been met and that all the scientific, professional and administrative requirements for the defense of the doctoral dissertation of the candidate Michael Huber have been met.

## 2. CONCLUSION

Based on the analysis of the doctoral dissertation and the submitted documentation, the Committee for the evaluation and defense of the doctoral dissertation, entitled "**Assessment and enhancement of organizational resilience in complex industrial enterprises in uncertain environment**", by the candidate **Michael Huber**, recommends the competent authorities to accept the doctoral dissertation and approve its defense.

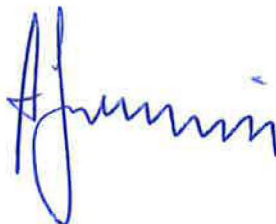
### Committee members:



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**Committee president**



Aleksandar S. Jovanović, full professor

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