Review

By: ***Prof. D.Sc. Roumen Mladenov Georgiev***, external member of the Scientific Jury; Scientific field: "Economics and management (industry)" and "Organization and management outside the field of material production".

Regarding: Dissertation for the award of the scientific degree "Doctor of Science", professional field 3.8 Economics; Economics and Management (Industry)

Legal basis for the review: participation in the scientific jury according to ordinance № RD 38-232 / 24.06.2020 of the Rector of Sofia University “St. Kliment Ohridski ”

Author of the dissertation: **Assoc. Prof. Dr. Anton Antonov Gerunov**

Dissertation topic: "Automated approaches to operational risk management"

1. Overview of research results and practical experience of the author

1.1 Compliance with minimum national requirements

The dissertation presented for review and related publications are dedicated to the study of the possibilities for automation of operational risk management processes with a view to achieving a unified approach to risk management in different situations, as part of the efforts for digital transformation of economic systems. The reference submitted by the candidate under Art. 1a, para 1 of PPZRASRB for compliance with the national econometric requirements shows that the total number of points required for awarding the scientific degree "Doctor of Science" is significantly exceeded, while meeting all specific requirements by sections. At the same time, from the very beginning I want to emphasize, from a content point of view, the exceptional relevance of the author's works. The application of big data analysis for automation of current processes in organizations and the introduction of new innovative approaches to customer and citizen service is a basic problem of the Fourth Industrial Revolution

1.2 Experience and key competences of the authors

From the attached documents and from my personal observations I can conclude that the candidate Anton Gerunov, after graduating from the First English Language High School in Sofia, in 2006. (language and mathematical profile), purposefully and consistently develops his professional competencies and achieves results in scientific and scientific-applied terms in the economic fields of risk management, digital technologies and universal innovations. This is also reflected in the dissertation he wrote.

- After graduating with honors from high school, the candidate graduated from Jacobs University (Germany), Sofia University and Stockholm University with a focus on computer and systems sciences and data analysis; he has also worked as a researcher and manager of many projects in data analysis, automated decision making and information systems
- He defended a dissertation for the degree Doctor of Philosophy (Ph.D.) and has won an academic competition for the position of associate professor. Dr. Gerunov currently

teaches at Sofia University, lecturing on risk management, digital business strategies and quantitative methods for analysis of public policies

- Assoc. Prof. Gerunov performs governance functions in the Management Board of the European Institute of Public Administration 2015-2017 (Maastricht, The Netherlands) and has had responsibilities for financial process management, risk management and IT business analysis at LogSentinel (2017 till now), and is also Chairman of the Board of the Institute of Ethics and Data Analytics (IDEA) leading their research program on artificial intelligence and automation decision making
- Actively and regularly participates in prestigious scientific and scientifically applied seminars on digital transformation, risk management and statistical and econometric methods for analysis of large data sets

The developed problems in the present interdisciplinary dissertation can be considered as a logical conclusion (synthesis) of the accumulated knowledge and experience of the candidate and correspond to the objective need to increase the scope of business process automation by including key operational risk management activities.

2. Overview of the dissertation

- The dissertation consists of an introduction, 5 chapters, a conclusion, a list of referenced literature and information sources, and 3 appendices: lists of "tried and tested classification algorithms" and "tried and tested regression algorithms", "summary of the distribution of samples according to the calculated models"
- The dissertation is structured in 364 pages, of which the main text is 337 pages. The structure of the dissertation is balanced and corresponds to the goals and research tasks, it uses over 400 literary and statistical sources in Bulgarian, English and German. The referenced literature and statistical sources are on the topic of the dissertation and support the depth and objectivity of the analysis.
- The dissertation developed by Assoc. Prof. Anton Gerunov has an interdisciplinary character and is a novel and relevant topic for the Bulgarian economy and economics.

The completion of the research tasks fully corresponds to the objectives of the research and makes it possible to defend the main author's theses. The testing of the hypotheses is performed in accordance with their specifics. The aim, tasks and theses completely correspond to the subject of the dissertation.

3. Evaluation of the research methodology

In his research, Assoc. Prof. Anton Gerunov applies classification and regression algorithms in the field of machine learning to problems in the field of economics and the science of risk management, business management and implementation of management information systems. Therefore, the research methodology largely predetermines the possibility to connect, to integrate the existing methods and research from machine learning with real situations in the economy, described in relevant data sets, in order to perform the research tasks:

a. The general methodology is based on a systematic approach and follows the general scientific principles: objectivity, transition from the concrete to the abstract and vice versa, concretization and unity between theory and practice
b. In the literature review and critical assessment of the existing typologies of risk and its management, the methods of analysis and synthesis, as well as inductive and deductive methods for reaching the main conclusions are used. This allowed the author to review and summarize a wide range of literature sources, to extract new scientific results from the analysis of existing research and to achieve an integrated understanding of the results coming from different disciplines and applied fields - economics, risk management, econometric and statistical methods and management and information systems.
c. An important element of the research methodology are the approaches and methods of design science, with special attention being paid to the methods of prototyping and classification. This approach has made it possible to build new useful artifacts of high scientific value based on a set of specific requirements. In this sense, the proposed general algorithm for operational risk management and reference architecture of the information system are the result of a combination of general scientific and specialized methodology of design science.
d. In modeling the situations of operational risk the author uses both known and relatively standard econometric models (correlations, linear and logistic regressions, etc.) and a set of advanced methods in the field of machine learning (neural networks, random forests, Bayesian methods, support vector machines, etc.). To assess the importance of certain variables to the models, statistical hypotheses are derived, and they are formally tested by calculating test statistics and exact levels of significance. For the evaluation of the algorithms, statistical criteria for forecast accuracy are defined and applied, and they are compared quantitatively. All calculations are made using the statistical programming language R and its packages.

The methodological approach and the results achieved in its implementation are a novelty for the Bulgarian economic science. They can be used as a basis for future research in the field of risk management and digital transformation, as well as in an applied context in the implementation of a solution in real situations of operational risk in the private and public sector.

4. Evaluation of the scientific and applied contributions

I concur with the assertions of the summary that the dissertation has made the following contributions that are have both scientific, as well as practical value.

Scientific contributions:

- Deriving a general algorithm for automated management of operational risks through analysis and synthesis of the existing literature and author's extensions by the method of design science
- Based on testing of 136 classification algorithms from the field of machine learning outlining those with the highest forecast accuracy in solving operational risk management tasks with a discrete choice;
- Based on testing of 109 regression algorithms from the field of machine learning outlining those with the highest forecast accuracy in solving problems for managing operational risks with a continuous target variable;

- A reference architecture for a management information system is proposed, which fully automates the activities of the derived general algorithm for operational risk management and can integrate the tested statistical algorithms.

Scientific and applied contributions:

- The concept of operational risk has been operationalized in such a way that it is directly applicable to databases;
- A consensus criterion has been proposed for defining an observation as potentially risky, which relies on the agreement of four different individual criteria in the field of statistics and machine self-learning;
- Ethical criteria are developed for the analysis of systems or digital agents with autonomous decision-making and are applied to the proposed management information system.

The combination of insights has allowed the author to achieve both new results in the field of operational risk management and to create a specific digital artifact (management information system architecture) that can be used in practice.

5. Evaluation of the publications based on the dissertation's results

The dissertation of Assoc. Prof. Anton Gerunov has been tested through publications in Bulgaria and abroad, presenting reports at specialized scientific conferences, as well as through informal discussions with experts working in the field of risk management, economic decision making, economic and business modeling.

The publications are as follows:

College Textbook:

1. Gerunov, A. (2017). *Notes on Risk Management*. Sofia University "St. Kliment Ohridski", Faculty of Economics and Business Administration. ISBN: 978-954-9399-45-5.

Chapter in a Book:

2. Gerunov, A. (2020). Financial and business aspects of the investment in data protection. Chapter 7 in Gerunov, et al. (Eds.), *Privacy by Design: Principles, practices, and technologies*. Sofia University "St. Kliment Ohridski", Faculty of Economics and Business Administration. ISBN: 978-954-9399-59-2.

Studies:

3. Gerunov, A. (2020). Classification algorithms for modeling economic choice. *Economic Thought*, 2, 45-67.
4. Gerunov, A. (2020). Binary Classification Problems in Economics and 136 Different Ways to Solve Them. *Bulgarian Economic Papers,* 2/2020, 1-31.
5. Gerunov, A. (2019). Risk management: typologies, principles and approaches. *Entrepreneurship*, 7(2), 205-244.

Articles:

6. Gerunov, A. (2020). Machine Learning Algorithms for Forecasting Asset Prices: An Application to the Housing Market. *Economics and Management*, 1, 27-42.
7. Gerunov, A. (2020). Quantitavie approaches to operational risk management in the financial sector. *Annual of the Faculty of Economics and Business Administration, Sofia Univeristy "St. Kliment Ohridski".* (*in print*)
8. Gerunov, A. (2020). Analysis and evaluation of operational risk. *Economic and Social Alternatives*, 2, 24-42.
9. Gerunov, A. (2019). Modelling economic choice under radical uncertainty: machine learning approaches. *International Journal of Business Intelligence and Data Mining*, 14(1-2), 238-253.
10. Gerunov, A. (2016). Automating Analytics: Forecasting Time Series in Economics and Business. *Journal of Economics and Political Economy*, 3(2), 340-349.

First, the submitted publications meet the requirements of Art. 12 of the Act for Development of the Academic Staff in the Republic of Bulgaria (ZRASRB), art. 35 of the Regulations for application of ZRASRB (PPZRASRB) and fulfill the national scientometric requirements under Art. 1a, para. 1 of PPZRASRB for Area 3: Social, economic and legal sciences, Professional field 3.8 Economics.

Second, in the publications on the topic, the author popularizes a large part of the approach and conclusions of the research. It is commendable that the publications were made through the most renowned specialized scientific journals, which are a high platform for the author's theses. At the same time, they have the potential to deepen students' knowledge of operational risk management processes and digital transformation. New in-depth knowledge is created, which will be particularly useful for experts working on digital transformation and operational risk management in organizations of the private and public sector.

6. Evaluation of the Dissertation Summary

The summary accurately presents the content of the dissertation and has the obligatory requisites for a dissertation summary for the scientific degree "Doctor of Sciences". It presents the approach, content and results of the 5 chapters and the conclusion set out in the dissertation. The most important contributions from the research are formulated in detail.

7. Critical comments and recommendations

My main recommendation is mainly focused on the future research of Assoc. Prof. Anton Gerunov - he could now be more focused on expanding the scope of the module for business management - rules (business logic) to perform certain activities in identifying potential risk and creating opportunities in the development of technology. It may be possible to replace this module with a more complete version of specific artificial intelligence, so that some of the rules are generated automatically and address the problem of distinguishing risk from systematic, epistemic uncertainty.

Conclusion

The reviewed dissertation and scientific publications on the topic **"Automated approaches to operational risk management"** present sufficient scientific, practical and methodological contributions and deserve high praise. All national minimum requirements and the requirements of Sofia University "St. Kliment Ohridski" are fulfilled by the candidate.

Based on the documentary evidence presented and on the reviewed dissertation and accompanying publications, their significance, the scientific, applied and methodological contributions contained in them, I find it reasonable to propose to the esteemed Scientific Jury that Assoc. Prof. Anton Antonov Gerunov be awarded the scientific degree "Doctor of Science" in the professional field 3.8 Economics; Economics and management (Industry). My personal decision is to vote "FOR" the award of the scientific degree "Doctor of Science" to Assoc. Prof. Anton Antonov Gerunov.

Date: 30.08.2020

Member of the Scientific Jury:

Prof. D.Sc. Roumen Georgiev