REVIEW

of dissertation for awarding the scientific degree "Doctor of Science" in Area 3: Social, economic and legal sciences, professional field 3.8. "Economics"

Author of the dissertation: Assoc. Prof. Dr. Anton Antonov Gerunov - Department of Industrial Economics at the Faculty of Economics and Business Administration, Sofia University "St. Kliment Ohridski"

Topic: "Automated approaches to operational risk management"

This review is pursuant an Order of the Rector of Sofia University "St. Kl. Ohridski" № RD 38-232 / 24.06.2020, with which I was appointed a member of the scientific jury in the competition for awarding the scientific degree "Doctor of Science" in Area 3: Social, economic and legal sciences, professional field 3.8. "Economics", specialization "Economics and Management (Industry)".

1. General overview of the candidate

Assoc. Prof. Dr. Anton Gerunov holds a Bachelor's degree in Integrated Social Sciences from Jacobs University, Bremen, Germany. He holds a master's degree in Economics with a focus on data analysis from Sofia University "St. Kliment Ohridski," and a master's degree in Computer and Systems Sciences with a focus on open e-government from Stockholm University. In 2010 and 2011 Assoc. Prof. A. Gerunov was a research fellow at the Bulgarian National Bank. In 2015 he defended a PhD in economics with a focus on data analysis.

Anton Gerunov's academic development began in 2009 as a researcher in the field of statistical and econometric modeling in the Department of Statistics and Methods (Jacobs University, Bremen, Germany). Since 2011 he has been initially an Assistant, and then Associate Professor of Risk Management and Quantitative Methods for Public Policy Analysis at the Faculty of Economics at Sofia University "St. Kliment Ohridski ", where he lectures on data analysis, digital business strategies, management in a digital environment and more. The candidate has a rich professional biography - he has worked as a consultant in business analysis and modeling - in various scientific and practical projects in the field of market analysis and financial planning, as an IT and innovation advisor at the Council of Ministers of Bulgaria - in business and economics. analyzes; Monitoring OP "Competitiveness" in the field of innovation, as a project manager and senior business consultant at "GemSeek Consulting" in the field of market and financial analysis, statistical modeling, etc. From 2014 to 2017 he was Head of the Office of the Deputy Prime Minister of the Republic of Bulgaria with main departments: e-government, administrative reform, strategic coordination of OP "Good Governance". From 2015 to 2017 he was a Member of the Management Board of the European Institute of Public Administration (Maastricht, the Netherlands) with main responsibilities for budget approval and strategic development. Since 2017 he is a Consultant in analytics and e-government mainly on projects in Bulgaria and Norway in the field of data analysis, automated decision making and information systems. For the same period, he is an operational director of Log Sentinel, with departments of process and financial flow management, risk management

and IT business analysis. Since 2019 he is a Chairman of the Management Board of the Institute of Ethics and Data Analytics (IDEA), where he leads the research program of the institute in the field of personal data protection and ethical aspects in the use of artificial intelligence and automated decision making.

Assoc. Prof. Dr. Anton Gerunov actively participates in various working groups and meetings organized by the Ministry of Education to build a Strategy for the implementation of artificial intelligence in education, in a working group to build an architectural framework for e-government in Bulgaria / subgroup "New Technologies" /. He was a process management consultant in the project "Vision for Sofia" with a focus: automation of processes and decision making, participated in the International Leadership Program (IVLP) at the US Department of State (Washington, Philadelphia , New York) on "Good Governance", at a summit organized by Google on "Data-driven innovation," Zagreb (Croatia), in an annual meeting with Nobel Laureates in Economics, Lindau (Germany). Assoc. Prof. Gerunov has participated in a series of scientific and applied seminars - a course on "Fundamentals of Project Management in PMI methodology", Sofia (Bulgaria), a course in methodology at the Institute of Project Management, "Cisco" Institute for Entrepreneurs (Bulgaria) - Business Modeling Seminar, Economic Seminar organized by the Institute for Economic Research (France), Summer Seminar: Economics and Philosophy, organized by the Neuwaldegg Institute (Vienna, Austria) and others.

2. Assessment of compliance with the requirements for obtaining the scientific degree "Doctor of Sciences" by the candidate

The presented dissertation of Assoc. Prof. Dr. Anton Gerunov meets the requirements of the Law on the Development of Academic Staff in the Republic of Bulgaria (ZRASRB) and the Regulations for its application, as well as the Regulations for the requirements and conditions for acquiring scientific degrees and holding academic positions at Sofia University. The required documents are part of the submitted materials for the competition together with the diploma for the educational and scientific degree "Doctor of Philosophy, Ph.D." and the acquired academic position "Associate Professor". Ten publications in peer-reviewed journals on the topic of the dissertation are presented as part of the procedure. Those are either already published or accepted for publication scientific papers related to the topic of the dissertation as per Article 78, paragraph 5, item 6 of the PURPNSZADSU, including a monographic textbook, a chapter of a collective monograph, three studies and 5 articles, one of which is in an indexed journal in the Scopus database. Five of these publications are in English and the rest - in Bulgarian. The candidate also meets the requirements of the Law on the Development of Academic Staff in the Republic of Bulgaria and the Regulations for its implementation in terms of teaching experience.

3. Relevance and significance of the scientific problem

The dissertation is dedicated to an undoubtedly significant problem given the recent global trends that make the world increasingly uncertain, complex, interconnected and unstable. At the forefront is the need for sound corporate governance, analysis and risk management in general. This extends to operational risks in the context of uncertainty, market volatility, cyclical crises leading to an "explosion" of operational risks caused by subjective and objective errors in the activity of people, processes, systems and external events. The issue is relatively poorly studied and becomes a priority in connection with the rapidly evolving technological processes, the need to manage large data sets in almost all spheres of public life, as well as insufficient research related to the implementation of automated control and the

ability to algorithmically describe processes and their successful integration into the overall management process.

The author makes a successful attempt for a comprehensive analysis of the topic, which is based on an in-depth study of the requirements of applicable general scientific and specialized methods, as well as the growing needs for practical application, critical analysis of approaches and methods of risk management, research, incorporating the points of view other authors on parts of the subject, statistics and individual opinions, as well as the knowledge acquired by the doctoral student in the course of his work. Based on the analysis and study of different views, a number of solutions to current and future problems in the field of operational risk management are proposed in order to achieve organizational efficiency and obtain higher value added for organizations while reducing the costs associated with this activity.

4. General evaluation of the dissertation

The dissertation consists of an introduction, an exposition in five chapters, a conclusion and three appendices, containing a list of tested classification and regression algorithms / with a total volume of 364 pages /. The bibliography contains 412 Bulgarian and foreign sources in the field of risk typology, standard and new approaches and practices for risk management and, in particular operational risk, the possibilities for implementing algorithms for operational risk management, as well as automation of the management process. The study aims to offer an automated process for managing operational risks, including a wide range of quantitative methods for assessment and the use of a specialized information system, which creates the potential for additional organizational efficiency in management decisions.

For the realization of the set goals, as well as the tasks of the dissertation research, Assoc. Prof. Dr. Anton Gerunov thoroughly analyzes the problems related to the existing approaches and methods of risk management with a focus on the management of operational risks. Building upon an analysis of the main economic, social and technological trends related to the automation of the management process, the dissertation presents a review of novel methods for operational risk assessment in classification and regression tasks, as well as a general algorithm for automated operational risk management. The proposal to build a reference architecture of a management information system in order to ensure its smooth integration into business processes is of special interest. The author also pays attention to the social and ethical aspects of the implementation of an information system for operational risk management. Emphasis is placed on the possibility of automated application of classification and regression algorithms for operational risk management in different hypotheses. On this basis, it is proposed to apply automation of the management process using appropriate information and data support, as well as the creation of a unified architecture of an automated information system with different modules.

The dissertation is appropriately structured, and in its opening chapter the author dwells on the theoretical foundations / incl. and the different concepts of the typology of risks /, as well as makes an in-depth analytical review of economic risks and approaches to their management. Special attention is paid to existing approaches and practices of risk management with a particular focus on operational risk. The author has also reported the research limitations, namely that the study covers a large but still limited set of situations involving operational risk. The second chapter examines in detail the new approaches and opportunities for managing operational risks based on current trends in this area. In the third chapter the author proposes finding possibilities for automated application of classification algorithms of operational risk management, based on criteria for selection of optimal algorithm in direct marketing, in credit card operations and in granting loans, as well as in managing the relations with external partners, and the operations stemming from the expanding volume of e-commerce. This approach seeks to improve the

predictive accuracy of various analytical tasks and systems and thus ultimately improve organizational decision making. The algorithms for operational risk management proposed in Chapter Four on the basis of optimal selection criteria are particular of interest. In the fifth chapter the dissertation proposes the introduction of an automated system for operational risk management based on the automation of the management process and outlines the general reference architecture of the automated information system, including various modules. In conclusion, the dissertation successfully realizes the goals and objectives of the study, justifying the need to create a common algorithm for automated management in order to apply an unified management approach to all situations where operational risk may be present.

5. Characteristics of the scientific and applied contributions in the dissertation

The dissertation presents the dissertation author as a conscientious researcher who approaches the dissertation research responsibly. A. Gerunov's knowledge in various fields of scientific knowledge - macroeconomics, risk theory, information processing and the application of modern mathematical methods and algorithms for risk management turns the dissertation into a work characterized by high awareness, depth and critical view of trends in the area under study. The dissertation is a result of conscientious research of an author with theoretical and specialized knowledge in this field, acquired as a result of extensive scientific research and sizable practical experience.

The contributions of the dissertation are found in a number of areas:

➢ The research of Assoc. Prof. A. Gerunov is an in-depth analysis of the conceptual framework and the prerequisites related to the analysis and management of risk and in particular of operational risk. The problems related to the application of algorithms for operational risk management and the creation of an automated system for its management are presented as a completely new concept with a view to solving economic problems of an interdisciplinary nature. In general, the dissertation is an original, very serious and in-depth analysis of the state and prospects of risk management. The dissertation very precisely and reasonably states the objective reasons that make the topic so modern and significant, as well as the degree of development in the context of changes on a global and national scale. Apart from being important and topical, the issue of the dissertation is useful in a purely practical aspect as a solution to minimize losses to organizations resulting from inadequate systems or controls, human error or management problems. The referenced literature forms a good basis for solving the research tasks.
➢ The research conducted presented the dissertation shows / in agreement with the first hypothesis / that the process of operational risk management is a subject to automation by applying an algorithmic management approach, a set of algorithms suitable for analysis of large data sets and the creation of an appropriate information system, building on reference architectures known in the literature. In this way, the forecast accuracy can be improved compared to the traditionally used econometric methods and hence higher quality results can be obtained, unlocking new value added.
➢ The logical structure of the research, as well as the realization of the research goals, tasks and the test of assumptions also contribute to an in-depth and comprehensive treatment of the chosen topic. The study of the contemporary aspects in issues under consideration is very well substantiated. To this end an interdisciplinary approach is used, which leverages numerous publications, information-analytical materials and other sources. The approach chosen by the author allows him to explore in depth the application of new approaches and algorithms for the assessment and management of operational risks. The work also displays a solution to overcome

some problems associated with building a comprehensive automated management system for operational risk.

➢ The presentation is very well structured, and a logical unity of facts, analyses, conclusions and recommendations is obtained. There is an in-depth reading of what has been achieved in this area. The style of presentation is both scientific and understandable, which allows for appreciating the author's position, as well as those of other authors. For the first time in the specialized scientific literature on the problem the advantages, disadvantages and forecast accuracy of the approaches and algorithms used for operational risk management are thoroughly studied and contribution are made to this body of knowledge by leveraging the design science paradigm.

➢ Of interest to the specialized audience is the reference architecture of the management information system proposed by the dissertation author, allowing automation of the activities of the general algorithm for operational risk management.

➢ The scientific contributions of the author can be found in all three main areas required of such a dissertation: novelty in science, enrichment of existing knowledge, application of scientific knowledge in practice. Definitely, the results of the study are of practical interest. I fully agree with the main scientific contributions formulated by the dissertation author.

The dissertation is a complete research, which gives me the reason to believe that it complies with the Law on the Development of Academic Staff and the Regulations for its implementation. The abstract reflects the main points and scientific contributions of the dissertation. It is made according to the requirements of ZRASRB. The results of the research are practically applicable as lecture and teaching materials.

In addition to the positive considerations, some recommendations can be made to research presented in this dissertation in order to improve the work of the author in his future research activity:

• The dissertation describes the three approaches of operational risk management set out in the Basel Accords and integrated in citations on prudential requirements for banks (Regulation (EU) № 575/2013 of the European Parliament and of the Council of 26 June 2013 on prudential requirements) for credit institutions and investment firms and amending Regulation (EU), namely: Basic Indicator Approach, Standardized Approach and Advanced Measurement Approache. It should be borne in mind that the introduction of Basel IV (2022) eliminates These approaches and introduces a single, risk-sensitive approach to be used by all banks. The change is dictated by comparability, and the fact that it is difficult to estimate operating losses covering events such as misconduct and inadequate systems and controls, using internal models.

• The classification algorithms discussed in Chapter 3 and regression algorithms in Chapter 4 are applied to basic situations, which, however, cannot always be defined as situations related to operational risk: 1. Conducting a direct marketing campaign; 2. Conducting credit card operations - a typical scoring model task is considered - credit card debt is repaid (class 0) or not (class 1). Without investigating the cause (e.g. fraud), such a task is entirely in the field of credit risk. The thesis that, "From the point of view of the organization, this is secondary" (fraud risk, or liquidity risk of the counterparty, which represents credit risk for the financing institution) is true insofar as the institution would realize losses, but the correct classification - credit or operational risk (fraud) is necessary not only for regulatory purposes, but also for proper control and specific actions that can be taken to manage one or the other risk; 3. Granting of loans - the situation in the field of credit risk is again considered, as it is necessary to distinguish whether the non-repayment of the loan is due to insolvency or fraud; 4. Management of relations with external

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partners - the task under consideration is essentially building a rating model on counterparties and the possibility of their assessment, which is also in the field of credit risk; 5. E-commerce activities; 6. Excessive absences from the workplace - in the context of operational risk such an indicator should be considered as a parameter / predictor of an operational event and should be analyzed as an indicator of increased operational risk.

- Despite the high empirical correlation between operational and financial risks, the need for separate management, reporting and treatment, especially in the banking sector, is conditioned by the regulations to which the institutions are subject (Regulation 575), therefore solving the tasks related to scoring models (in essence) and / or rating models can hardly be linked to operational risk management.

- The review of a wide range of popular algorithms in the field of machine learning on different operational situations allows one to draw some conclusions. First of all, the best algorithms for each of the considered tasks do not overlap - in each of the individual classifications there are differences in the best algorithms for its solution. For example, the models for credit cards and for granting loans give different top 10 classification methods. Different results regarding the models with the best forecast accuracy are also observed in the regression algorithms for forecasting in relatively similar situations. In practice, such results may complicate the risk management of an organization, and additional highly qualified expert staff will be needed to build, validate and maintain the relevant models.

- It would be useful for the dissertation author to address risk management issues as part of overall corporate governance, as long as it is necessary to focus on the contribution of risk management both to achieving goals and creating value, and to "protecting" and preserving value. In this sense, analyses that reflect current practices for successful management of organizational behavior, decisions and activities could be useful in order to assist organizations in building structures and processes that facilitate the management and administration of operational risk. A good example in this regard is the updated model of the "Three Lines of Defense" of the Global Institute of Internal Auditors (The IIA), which is enshrined as a principle in the management of operational risk in a number of organizations.

- Some minor errors that are noticed in the dissertation: on page 305 - Table 45, and on page 238 - Table 19, on page 281 - Table 50. In the abstract - on page 31 the description refers to Chapter 4 rather than Chapter 3 – as it describes risk management algorithms in cases of long-term values of the target variable, indicating five main situations of operational risks - modeling of absences from the workplace, the popularity of online communication of the organization, incident management in the process of maintenance, to assess the real estate of the organization, as well as to assess adverse changes in the external environment.

- I believe that certain disparities in volume and composition can be overcome, such as the size of individual chapters and paragraphs. The latter, of course, is up to the author.

These considerations do not diminish in any way the value of the study. Evaluating the proposed dissertation gives me a reason to express my positive consideration of the results, which show the author as an accomplished and creative scientist, a highly competent and sophisticated researcher. In view of the above, I give a positive evaluation of the dissertation of Assoc. Prof. Dr. Anton Gerunov and propose to the highly respected scientific jury to award him the degree of "Doctor of Science" in Area 3: Social, Economic and Legal Sciences, professional field 3.8. "Economics".

Sofia, 14 August 2020   Prof. Dr. Maria Vidolova