

OPINION

by procedure for the defense of a dissertation on the topic:

“Game Models and Time Series Modeling”

to acquire

educational and scientific degree “**Doctor**”

from

Author: **Vladislav Krasimirov Tanov**

Field of higher education: **3. Social, economic, and legal sciences**

Professional direction: **3.8. Economics**

Doctoral program: **“Data Science”**

Department: **“Statistics and Econometrics”**

Faculty of Economics, Sofia University "St. Kliment Ohridski" (SU)

The opinion has been prepared by Margarita Lyubenova Ruseva, PhD, University of Plovdiv “Paisii Hilendarski”, Faculty of Economics and Social Sciences, Department of “Management and Quantitative Methods in Economics” in my capacity as member of the scientific jury, according to Order No. RD 38-597/03.11.2023 of the Rector of Sofia University “St. Kliment Ohridski”. To prepare this opinion, as a member of the scientific jury, I have received all the necessary documents attached to the application from the doctoral student to the Rector of the University of St. Kliment Ohridski” regarding the opening of a procedure for the acquisition of the educational and scientific degree “Doctor”.

1. General characteristics of the dissertation work and the presented materials

The topic of the dissertation work is directly related to the dynamic development of one of the important directions in science. As part of behavioral economics, game theory attempts to predict how two or more parties will act in a given situation and thereby illuminate the path to decision making . Having in mind theoretical statements in the social sciences, this theory applies a mathematical model to predict the likely outcomes of a particular scenario. This is of utmost importance because it studies interactive decision-making, where the outcome for each participant or player depends on the actions of all. Therefore, it is justified to study different types of games and present a methodology for searching for equilibrium.

The presented dissertation *"Game models and time series modeling"* has a volume of 137 pages, of which: 1 page of content; 1 page list of abbreviations used; 4 page list of tables and figures; 108 pages of the main part, 6 pages of the list of used literary sources, 1 page

containing the publications of the dissertation work and 16 pages of appendices. The dissertation is structured according to generally accepted criteria and contains the following sections - introduction, exposition in three chapters and conclusion. The list of literary sources consists of 88 titles, of which 86 are in English and 2 in Bulgarian. The object of the study, the subject, the goals and tasks are highlighted in the individual parts of the dissertation work. The subject, scope and objectives of the dissertation are discussed in the context of developing game models with applications in big data analysis. The exposition is built logically and coherently, with a relatively good ratio between the individual parts.

Different goals are formulated in the work, and different tasks are specified in the process of realizing each of them in a specific sequence. The dissertation work has an integrative character, which is a reason to look for its innovative value in several directions. What is valuable in this scientific research is that through his work Vladislav Tanov seeks equilibrium in linear quadratic games by creating methods and algorithms for searching for stabilizing solutions of corresponding Riccati equations. It suggests that the obtained results can be used to develop game models with applications in big data analysis. A methodology was developed for considering a linear quadratic stochastic game, for which an iterative method was built to find a stabilizing solution of a system of four nonlinear matrix equations. Antagonistic games and game models on positive systems are discussed in an argumentative manner, and on this basis specific methods for finding a stabilizing non-negative solution of the corresponding Riccati equation are proposed. An approach for conducting classification analysis of big data is proposed and tested. An optimization model is formulated that searches for the best training subset for models performing classification analysis. An algorithm was used to solve the optimization task, which was applied to different sets of big data.

Based on the formulated main objectives of the dissertation work and the solved tasks, I accept that the work is rather well organized. In the main parts of the dissertation, theoretical and methodological questions are presented, which are bound in a logical sequence. The problem under consideration is relevant both in scientific and scientific-applied terms. In his dissertation, the author demonstrates an excellent degree of knowledge of the state of the problem, as well as of the existing literature on the subject. The presented analyzes highlight the author's ability to analyze the concept of game theory and its application as a decision-making tool in a competitive situation among players; to describe and propose methods and algorithms for searching for a stabilizing solution; to draw conclusions; to compare different principles and approaches. The results described in the work correspond to the originally set work plan. Based on theoretical analyzes and experiments, new iterative methods for finding

a solution and algorithms for conducting classification analysis are proposed, on which the author's contributions are also based.

2. Data and personal impressions about the candidate

The author of the dissertation, Vladislav Krasimirov Tanov, is a self-taught doctoral student at the Department of Statistics and Econometrics at Faculty of Economics of the University of Sofia “St. Kliment Ohridski” during the period 20.12.2018 - 20.12.2021. A prerequisite for the successful completion of this educational degree is its graduation with honors in the Bachelor of *Finance program* at George Mason University, Virginia, USA. The next step in the doctoral student's educational qualification is the successful defense of a master’s degree in *Data Analytics Engineering-Predictive Analytics* at the same university. Valuable steps in the professional growth and qualification of Vladislav Tanov are his realization as a member of the team of Microsoft , specializes in the development of monitoring, search and matching algorithms , as well as the development of a screening platform . Since September 2018, he is part of the Amazon Web Services team, where he continues his development in the field of data analysis technologies. From the autobiography of Vladislav Tanov, he has extensive experience gained from his work as a researcher and analyst in two serious companies, which is a prerequisite for the successful development and defense of the dissertation work.

I do not know the dissertation and have no personal impressions of him. For the first time, I became acquainted with the work of Vladislav Tanov after I received the materials for the preparation of this opinion.

2. Content analysis of the candidate's scientific and scientific-applied achievements, contained in the submitted dissertation and the publications to it, included in the procedure

The contributions of the dissertation work are undoubted. They are worded meaningfully and build a good idea of the success of the author's experimental strategy. The achieved results are substantial and are the result of diligent work on the topic of the dissertation work. The specified contributions can be evaluated as contributions of a scientific nature.

3. Approbation of the results

Six publications are presented about the dissertation work, one of which is an independent publication. Five of the publications, including the stand-alone article, are in editions visible in Scopus.

All presented scientific works are on the topic of the dissertation work and prove the author's abilities and skills for conducting scientific research. I believe that the attached

publications provide the necessary publicity of the results of the dissertation research to the scientific community. I accept that the conducted dissertation research was carried out entirely by the doctoral student, and the results obtained and the conclusions formulated are his personal contribution.

The scientific works presented by Vladislav Tanov - dissertation work and publications on the subject of the dissertation meet the minimum national requirements (according to Art. 2b, paras. 2 and 3 of *the Law on the Academic Staff Development in the Republic of Bulgaria – LASDRB*) and the additional requirements of SU “St. Kliment Ohridski” for the acquisition of an educational and scientific degree "doctor" in the scientific field and the professional direction of the procedure. The results in the dissertation and the scientific works related to it do not repeat those of previous procedures for acquiring a scientific title and academic position. No plagiarism was found in the submitted dissertation and scientific works.

4. Qualities of the Abstract

The abstract reflects the essence of the dissertation work and the achieved results of the conducted research. All sections of the dissertation are presented correctly, and a sufficient number of numerical expressions, tables and graphic images have been selected to illustrate the main results.

5. Critical notes and recommendations

Notes and recommendations regarding structure, style, and formatting may be made to the submitted dissertation. It is expedient for the introduction to have a more overview character and in it to highlight more clearly the relevance and significance of the problem under consideration, the main goal of the dissertation work, the object, the subject, the research thesis, hypotheses and the resulting tasks. Inaccuracies, repetitions and some stylistic and technical inaccuracies and errors are noticeable in the design of the dissertation work and the auto-reference to it.

Of course, the notes made do not completely change my positive assessment of the substantive nature and presence of substantial contributions in the dissertation work. They have the meaning of a proposal to improve its qualities.

6. Conclusion

Having familiarized myself with the dissertation work and the accompanying scientific works presented in the procedure and based on the analysis of their significance and the scientific and scientific-applied contributions contained in them, I confirm that the dissertation work

and the scientific publications to it, as well as the quality and the originality of the results presented in them, meet the requirements *Law on the Academic Staff Development in the Republic of Bulgaria (LASDRB), the Regulations for the Implementation of LASDRB and the relevant Regulations of the SU "St. Kliment Ohridski"* for the candidate's acquisition of the educational and scientific degree "Doctor" in the specific field of higher education and professional direction. Vladislav Tanov satisfies the minimum national requirements and no plagiarism has been found in the scientific works submitted for the competition.

The dissertation is the basis for the fact that the doctoral student has in-depth theoretical knowledge and practical skills in the scientific specialty of *Data Science* by demonstrating an ability to independent planning and conducting of scientific research.

Based on the above, **I give my positive assessment** of the conducted research, presented in the dissertation work, the abstract, the achieved results and contributions, and **I propose to the respected scientific jury to award the educational and scientific degree "Doctor"** to Vladislav Krasimirov Tanov in the field of higher education 3. Social, economic, and legal sciences; professional direction 3.8 Economics; PhD program "Data Science".

03.12.2023

Opinion prepared by:

(Assoc. prof. Margarita Lyubenova Ruseva, PhD)