Deyan Radev, Ph.D.
Associate Professor of FinTech and Banking
Director of CEE Centre for Digital Finance

Faculty of Economics and Business
Administration
Sofia University
125 Tsarigradsko Shose Blvd., bl.3

Evaluation

By Assoc. Prof. Dr. Deyan Radev
Department of Statistics and Econometrics
Faculty of Economics and Business Administration
Sofia University "St. Kliment Ohridski"

Subject: Doctoral dissertation for the award of the educational and scientific degree "Doctor" in the professional field 3.8. Economics (Analytical Data Studies /Data Science/)
Title: "Game Theoretical Models and Time Series Modeling"
Author: Vladislav Krasimirov Tanov
Supervisor: Assoc. Prof. Dr. Nikolay Netov, Department of Statistics and Econometrics, Sofia University "St. Kliment Ohridski"
Basis for the assessment: Order No. RD 38-597/03.11.2023 of the Rector of Sofia University "St. Kliment Ohridski" Prof. D.Sc. Anastas Gerdjikov

Author Information

Vladislav Krasimirov Tanov graduated from George Mason University in Fairfax, Virginia, where he obtained a bachelor's degree in finance between 2008 and 2012. Between January 2015 and December 2016, he pursued a master's degree in the same university, defending a master's degree in data analysis with a focus on predictive analytics. Between February and December 2016, Vladislav Tanov was a data science intern at George Mason University. Between September 2017 and September 2018, he worked as a data analyst at Microsoft, and from September 2018 to the present, he has been an employee at Amazon Web Services (AWS), holding various positions: Business Intelligence Engineer II (September 2018 - May 2019), Data Engineer II (June 2019 - May 2021), and Applied Scientist II (May 2021 to the present).

In 2019, he was admitted as a doctoral student to the Department of Statistics and Econometrics at the Faculty of Economics and Business Administration at Sofia University „St. Kliment Ohridski". The doctoral student has successfully passed all exams within the doctoral program. He was dismissed with the right to defend his thesis in 2023.

The total number of points earned from the educational program, the validation of the scientific results of the doctoral student, and the publications cover the required number according to the internal regulations of Sofia University and the Faculty of Economics and Business Administration.

General Characteristics of the Dissertation and Evaluation of the Results

The presented dissertation includes an introduction, three chapters, conclusion, and a list of references, with a volume of 138 pages. To visualize the content, over 30 figures and 15 tables have been used. Eighty-eight literary sources have been cited, a significant portion of which were published in the last ten years.

The introduction discusses the relevance of the topic, the object and subject, the goals and tasks of the research, the research thesis and hypotheses, the methodology, and the limitations of the study. The researched problem is extremely relevant both scientifically and scientifically-applied. The object and subject of the study are clearly and correctly formulated. The chosen research methodology fully corresponds to the set goals and tasks.

The first and second chapters of the dissertation are dedicated to finding equilibrium in linear-quadratic games by creating methods and algorithms to search for stabilizing solutions to respective Riccati equations. These studies could form the basis for the development of game models with applications in the analysis of big data (machine learning). Research in this direction emerges when applying the concept of finding optimal Nash strategies in the conditions of a classification task.

In the first chapter, we examine a linear-quadratic stochastic game analyzed by Zhu and Zhang, for which we construct an iterative method to find a stabilizing solution to a system of four nonlinear matrix equations. The methods, algorithms, and examples from (Ivan Ivanov, 2012; Ivelin Ivanov, 2016) are used in the first chapter. At the same time, the proposed methods complement the research in (Ivelin Ivanov, 2016). The results have been published in **1 article in Scopus**.

The second chapter deals with antagonistic games and game models on positive systems. Methods for finding a stabilizing nonnegative solution to the respective Riccati equation are proposed. The results have been published in **3 articles, two of which are indexed in Scopus**.

The aim of the third chapter is to develop data-oriented approaches to conducting classification analysis of big data. We formulate an optimization model that seeks the best training set, in a specific sense, for models conducting classification analysis. To solve the optimization task, we propose an algorithm applied to different sets of big data. The results have been reported at an international conference and are supported by **2 publications indexed in Scopus** (https://www.scopus.com/authid/detail.uri?authorId=57208207140)

Evaluation of Scientific and Scientific-Applied Contributions

Scientific Contributions in the First Chapter

The proposed iterative method through equations (1.6) - (1.8) is novel and finds a solution to the system of nonlinear matrix equations (1.4). The solution to the equations leads to a Nash equilibrium for a linear-quadratic stochastic game, as studied by (Zhu, Zhang, 2013). The proposed iterative method has been published in (Ivelin Ivanov and V. Tanov, 2018, "An Iterative Method for an Equilibrium Point of Linear Quadratic Stochastic Differential Games with State and Control-Dependent Noise," Ann. Acad. Rom. Sci., 2018).

Scientific Contributions in the Second Chapter

The contributions in the second chapter are the two proposed new iterative methods for finding a solution to the cell Riccati equation with special coefficients:
- Iterative method (2.31) -(2.34),
- Iterative method (2.35) -(2.38).

For both iterative methods, their convergence properties have been theoretically derived. Both methods are characterized by a clear execution scheme and easy computer implementation. Experiments demonstrate their effectiveness. The research on both iterative methods has been published in two articles (Ivelin Ivanov, Vladislav Tanov, 2018; Ivelin Ivanov, Vladislav Tanov, 2020).

Scientific Contributions in the Third Chapter

The contributions in the third chapter are the two algorithms proposed for conducting classification analysis, mainly on unbalanced sets: Algorithm for sets with two classes of observations, Algorithm for sets with more than two classes of observations. The algorithms have been tested with various public datasets, and the results have been compared with the research of other authors in the scientific literature. The research has been published in two scientific publications.

I accept all contributions formulated by the author.

Publications Related to the Dissertation

As part of the public defense procedure, the doctoral student has presented six publications in English, five of which are in journals or conferences indexed in Scopus. The publications analyze the issues developed in the dissertation.

Evaluation of the Abstract

The abstract of the dissertation by the doctoral student meets the requirements.

Notes and Recommendations

The chapters of the dissertation have undergone several rounds of review and have been published in editions indexed in global databases. For this reason, I have no suggestions regarding the content, and my recommendations are related to finalizing the dissertation draft:

1. The dissertation can be used as a basis for the development of educational content, contributing to the understanding of theoretical and empirical approaches, as well as the current state in the researched area by students in specialized master's programs in the country.

Conclusion

I positively evaluate the presented dissertation. The achieved results and the realized publications demonstrate the preparation and skills of the author to conduct independent scientific research of very high quality. The dissertation corresponds to the requirements for obtaining the educational and scientific degree of "Doctor" in the Law on the Development of the Academic Staff in the Republic of Bulgaria, the Regulations for its Application, and the Regulations on the Conditions and Procedure for Obtaining Scientific Degrees and Taking Academic Positions at Sofia University "St. Kliment Ohridski." **I recommend that the scientific jury award the educational and scientific degree of "Doctor" in the professional field 3.8. Economics (Analytical Data Studies /Data Science/) to the doctoral student Vladislav Krasimirov Tanov.**

Date, place: Signature:

29.11.2023 г., Sofia   / Assoc. Prof. Deyan Radev, PhD /