REPORT

by Prof. Dr.Sci. Lyuben Radoslavov Mutafchiev, Emeritus Professor at the American University in Bulgaria on the competition for the academic position "Associate Professor" serving the needs of the Institute of Mathematics and Informatics – BAS (IMI-BAS) in the area of higher education 4. *Natural Sciences, Mathematics and Informatics, Professional field 4.5 Mathematics, Scientific specialty "Probability Theory and Mathematical Statistics",* announced in the State Gazette, issue 8, dated on 01/26/2024.

I present my opinion-report on this competition as a member of the Scientific Jury, appointed by Order № 64. 03/21/2024, by the Director of IMI-BAS Prof. Dr. Sci. P. Boyvalenkov. It is prepared in accordance with the requirements of:

- Law on the Development of the Academic Staff in the Republic of Bulgaria (LDASRB);
- Regulation for the implementation of LDASRB;
- Regulation on the conditions and procedures for acquiring scientific degrees and occupying academic positions in BAS;
- Regulation on the conditions and procedures for acquiring scientific degrees and occupying academic positions in IMI-BAS.

1. **General description of the submitted materials**

For the participation in the announced competition, a single candidate – Assistant Prof. Dr. Asen Georgiev Chorbadzhiev from section "Operations Research, Probability and Statistics" at IMI-BAS has submitted his documents. The materials that he presented in electronic format include: CV (professional autobiography), diplomas for higher education (educational qualification degree "Master of Science") from Sofia University, Faculty of Physics (SU-FF) and for the educational and scientific degree "Doctor" (PhD) in physical sciences from the Institute for Nuclear Research and Nuclear Energy – BAS (INRNE-BAS), a general list of publications, inventions, and other applied research results of the candidate, a list of publications for the competition, their abstracts and copies, a general list of citations, a list of citations for participation in the competition, and documents certifying the candidate's participation in research projects. The materials presented for the competition provide a clear overview of the candidate's research and applied activities.

2. **Brief biographical data of the candidate**:

Asen Chorbadzhiev was born on June 11, 1978. In the period 2004-2006, he was a student at SU-FF and participated in the master degree program 'Wireless Networks and Devices' in the general field 'Engineering Physics'. He successfully completed his master's degree with an excellently defended thesis. From 2008 to 2013, Ass. Prof. Chorbadzhiev was a doctoral student at INRNE-BAS. In 2013, he defended a Ph. D. thesis entitled "Studying the Influence and Correlation between Atmospheric Parameters and Cosmic Rays." From 2004 to 2009, Ass. Prof. Chorbadzhiev also worked as a programmer at Rila Solutions and Reflective Solutions, and from 2007 to May 2015, concurrently with his doctoral studies, he held the position of 'physicist' at INRNE-BAS. From May 2015 to present, he has been a main assistant professor at IMI-BAS.

3. General characteristic of the candidate's activities

Participation in scientific research projects

In his CV, Ass. Prof. Chorbadzhiev has provided data on participating in the teams of 3 research projects, 2 of which are funded by the "Scientific Investigations" fund (Bulgaria) and 1 by the Consortium 'National Center for High-Performance and Distributed Computing' (with principal – Bulgarian Ministry of Education and Science).

Ranking scientific data

Ass. Prof. Chorbadzhiev has submitted 18 articles for the competition, which are not included in his Ph.D. thesis and in the materials from the previous competition for an assistant professorship. Two of them are published independently, and the others are co-authored with colleagues from Bulgaria (9 are with one co-author, 1 - with two, 3 - with three, 2 - with five, and 1 - with six). I consider the candidate's contribution in the joint articles to be at least equal to that of his co-authors.

From the articles submitted for the competition, 11 were published in scientific journals and 7 in thematic collections and conference proceedings. 4 articles were published In Bulgarian scientific journals: 3 in Comptes rendus de l'Academie bulgare des Sciences (IF: 0.233, 0.343, and 0.285) and 1 in the Journal of the Bulgarian Geographical Society. (The abbreviation IF stands for the impact factor of the publication.) The remaining 7 journal articles were published in international journals as follows: 3 in Modern Stochastics: Theory and Applications (IF: 0.261, 0.455, and 0.284), 1 in the European Journal of Geography (IF: 0.261), 2 in the Journal of Applied Statistics (IF: 1.404, 1.495), and 1 in the Lithuanian Mathematical Journal (IF: 0.248). From the articles published in thematic collections, 1 is in the Bulgarian series Pliska: Mathematical Studies, 1 - in a series by the American Institute of Physics Publishing, and 5 in series published by Springer.

Ass. Prof. Chorbadzhiev has presented a list of citations for the participation in the competition in which the number of cited publications is 11, and the number of citing sources is 15.

General characteristic of the candidate's scientific activity

In the 'Brief Description of the Originality of the Scientific Contributions' from the documentation given in the materials for the competition, Ass. Prof. Chorbadzhiev has clearly and correctly described his research and applied interests and his main contributions in the works presented there. He thematically classifies his publications into three directions. The scientific interests of Ass. Prof. Chorbadzhiev in the first direction are from the area of statistical modeling and data analysis of atmospheric and geomorphological processes. This includes:

- Participation in a team conducting a long-term experiment in order to analyze a large number of atmospheric parameters and dealing with large datasets which require assessment of the quality and reliability of the measurements.

- Using time series analysis, a comparison between the data describing the transfer of dust particles from Sahara received from the Basic Environmental Observatory on the Musala peak in the Rila Mountains and some satellite data on the dust index is provided. A software system for automatic prediction of the location and transport of atmospheric phenomena of this type, based on a large number of available satellite data, has been created.

- Studying arsenic and heavy metal pollutions in the Ogosta River valley (including also groundwater pollutions), using the K-means clustering method to group the observed areas and the GLM (Generalized Linear Models) method to establish regression dependencies within the clusters. The dependent regression variable in these cases has either Gaussian or gamma distribution.

- Use of ready-made statistical software to automatically detect a sharp reduction in the intensity of galactic cosmic rays (Forbush effect). An empirical correction has been found to potentially calibrate the statistical model. Applications with real data received from the Musala Peak Observatory have been demonstrated.

The above results are published in the articles [2,1,5,10,18,9,6] from the list of the publications for the competition.

The second thematic direction, in which Ass. Prof. Chorbadzhiev presents himself in the competition, is the area of branching random processes. I will note here his successful collaboration with Assoc. Prof. P. Maister. The main contributions are listed below.

- An overview on the cascade process describing the birth of secondary type particles after the penetration of cosmic rays into the atmosphere is presented in terms of the theory of branching random processes.

- Investigation of a supercritical Markov branching process with a random initial number of particles. It is assumed that this number may follow a shifted geometric, negative binomial, or Poisson-Aeppli distribution. It has been proven that the total number of particles until a fixed moment of time and the initial number of particles follow the same distribution law with different distribution parameters.

- Similar studies have been conducted for a critical linear birth and death process with a random initial number of particles. The same discrete distributions of the initial number of particles as those given above have been considered. It has been found that the random initial conditions do not change the critical parameter of the branching mechanism but affect the probability of extinction of the process. A numerical model has been proposed which allows the study of processes with more complex initial conditions. Its application has been demonstrated on a linear birth and death process with an initial condition depending on a given Polya urn scheme.

- A model of the spread of COVID-19 based on a linear birth and death process with randomly Poisson-distributed initial number of particles has been developed. The potential for changing the mode of disease spread has been considered. The results have been empirically verified for data from 38 countries and territories over a period of 26 months in 2020 – 2022.

- In a series of articles motivated by the idea of creating an adequate model for studying permanently repeating cascades of particles when cosmic rays enter the atmosphere, a Markov branching process has been considered in which the reproduction distribution of particles is geometric. The main object of study here is the generating function of the number of particles at a fixed time. It is a solution to a specific differential equation known as the Kolmogorov backward equation. Solutions have been found in terms of certain special functions for subcritical and critical cases. A limit theorem has been proven, and the probability of extinction of the process has been studied. Factorial moments of the process

have also been found. Detailed studies have also been conducted for a supercritical branching process.

- Similar studies have been carried out for a subcritical Markov branching process where the reproduction of particles follows a probability distribution that is a mixture of the logarithmic series distribution and the Dirac measure at zero. It has been shown that the distribution of the number of particles at a given moment follows a shifted generalized Sibuya distribution. A limit theorem has been obtained for convergence to the distribution of the logarithmic series.

- A computational software has been developed to simulate the aforementioned branching and birth and death processes.

The results from the candidate's second scientific area given above have been published in the articles [3,8,11-17].

In addition to the two main thematic directions, Ass. Prof. Chorbadzhiev has also submitted for the competition 2 more articles [7,4]. In [7], a Levy process with representative random variable having logarithmic series distribution is discussed. The probability of transition and the Levy measure of the process have been studied. Article [4] is dedicated to computer applications in anthropology. The aim is to compare the directly made linear measurements of skulls with measurements of 3D digital models obtained through laser scanning. Correlation analysis has been used to assess the reliability of the two measurement methods.

The above review shows the successful research activity of Ass. Prof. Chorbadzhiev in the scientific specialty 'Probability Theory and Mathematical Statistics.'

CONCLUSION

The materials presented for the competition show that Ass. Prof. Chorbadzhiev meets the requirements of LDASRB, the Regulation for the implementation of LDASRB, the Regulation on the conditions and procedures for acquiring scientific degrees and occupying academic positions in BAS, and the Regulation on the conditions and procedures for acquiring scientific degrees and occupying academic positions in IMI-BAS for the academic position of an "Associate Professor." There is no evidence of plagiarism. I positively assess the scientific and applied activities of Ass. Prof. Dr. Asen Georgiev Chorbadzhiev and confidently recommend to the esteemed Jury to propose to the Scientific Council of IMI-BAN to elect him as an 'Associate Professor' in the field of higher education 4. Natural Sciences, Mathematics and Informatics, Professional field 4.5 Mathematics, Scientific specialty "Probability Theory and Mathematical Statistics."

04/23/2024 Signature:

Prof. Dr.Sci. Lyuben Mutafchiev