POSITION

from Assoc. Prof. Dr. Eng. Ivan Prodanov, Mining-Geological University "St. Ivan Rilski", Department of Industrial Automation, Professional field 5.2 "Electrical Engineering, Electronics, and Automation"

Subject: Acquisition of the academic and scientific degree "Doctor", professional field 5.2 "Electrical Engineering, Electronics, and Automation", with a scientific specialty "Application of principles and methods of cybernetics in various fields of science", following Order No. 137/22.11.2023 of the Director of the Institute of Robotics at the Bulgarian Academy of Sciences (IR-BAS) and Protocol No. 1 of 28.11.2023 of the scientific jury.
Author of the dissertation: M.Eng. Ekaterina Popovska, Institute of Robotics at BAS.
Topic of the dissertation: "Mathematical Methods for Research Modeling, Analysis, and Forecasting in the Energy Sector and Energy Markets."

1. General Overview of the Dissertation:

The dissertation by M.Eng. Ekaterina Popovska spans 183 pages, including an introduction, four chapters, a conclusion, a list of contributions, a bibliography, 9 tables, and 37 figures. The bibliography comprises 139 titles and 2 web addresses. The appendices, formatted within 22 pages, include a citation list and software program codes. Chapter 1 provides an extensive literature review covering various methods for forecasting and analyzing electricity prices. It delves into short-term and long-term time series analysis methods, concepts, and techniques, emphasizing application and modeling in complex energy systems. Chapter 2 focuses on methods for analyzing long-term stability through fractal analysis and fluctuation analysis. The chapter presents a methodology for investigating long-term time series stability, including the R/S and DFA methods. A methodology for long-term electricity price forecasting is developed, encompassing several steps. Chapter 3 employs a comprehensive approach to studying and forecasting electricity prices, combining SARIMA and LSTM methods. The work analyzes the effectiveness of SARIMA for analyzing and forecasting values on time series with seasonal effects and noise. Additionally, an LSTM-based algorithm focusing on time series processing and analysis is presented. Chapter 4 summarizes and analyzes the results of empirical research in electricity price forecasting. The work includes a comparative analysis of SARIMA, LSTM, ARIMA, and Hurst and DFA methods. The study emphasizes the importance of selecting an appropriate method based on data characteristics across different time intervals.

In summary, the dissertation by M.Eng. Ekaterina Popovska is detailed and comprehensive, presenting a complex analysis and application of various mathematical methods in the field of energy sector and energy markets. The structure of the dissertation is clear and meets the requirements for volume and content. The methods and models discussed are extensively explored, encompassing both theoretical aspects and specific applications in addressing issues in the energy sector. The appropriate number of citations and publications lead to the conclusion that doctoral candidate Ekaterina Popovska has actively participated in scientific research and successfully presented her scientific contributions in the dissertation.

2. Relevance and Significance of the Problems Addressed in the Dissertation:

The research conducted by the doctoral candidate in the field of energy sector and energy markets represents a significant and timely contribution to understanding key issues related to the volatile nature of electricity market prices. The dissertation offers innovative methods and models for forecasting that not only reflect the instability of energy markets but also provide valuable tools for optimizing trading portfolios and enabling sustainable management of energy systems. The combination of various mathematical methods for time series analysis presents a new approach and important opportunities for enhancing solutions in the energy sector and energy markets. The results obtained can assist in the formulation of strategies for sustainable energy management.

3. Appropriateness of the Set Goals and Objectives. Understanding of the Problem. Analysis of the Results.

M.Eng. Ekaterina Popovska demonstrates an excellent understanding of the issues in the field of energy sector and energy markets. The dissertation represents a careful and thorough analysis of the goals and objectives set by the author in the context of researching mathematical methods for analysis, modeling, and forecasting in energy sector and energy markets. The objectives of the dissertation are formulated and focused on investigating methods for analyzing time series of hourly electricity prices. The set tasks are described in detail and correspond to the overall direction of the work. The author chooses an appropriate approach by combining various mathematical methods such as R/S analysis, DFA, ARIMA, and LSTM models. This approach proves to be appropriate as it allows for the evaluation of different aspects of time series and identifies the optimal method for specific conditions. The doctoral candidate demonstrates a high level of understanding of the problem by analyzing the impact of various methods on the time series of electricity prices. The application of these methods not only illustrates the scope of the author's knowledge but also adds value to the achieved results in the context of understanding long-term and short-term dependencies in price signals. A comprehensive presentation of the obtained results is provided, including values of the Hurst exponent, correlation properties, and forecast accuracy coefficients. The analysis is systematic and provides a comprehensive overview, allowing the reader to understand the relationship between the applied methods and the achieved results.

In summary, the goals and objectives presented in the dissertation are aligned with the current needs in the field of energy and successfully extract important information through the application of various mathematical methods.

4. Evaluation of the Achieved Contributions and Their Significance:

The dissertation represents a significant scientific contribution to the field of the energy sector. The author proposes innovative mathematical methods and models that support the forecasting of electricity prices. The contributions made are highly significant, particularly in the context of evolving energy markets, while also enriching the theoretical foundation of the field. The dissertation successfully identifies the main challenges faced by mathematical methods in analyzing energy markets and addresses them with a strategic approach, recognizing the importance of mathematical models in coping with the complexity of modern energy systems.

Various methods are examined in the work, including R/S analysis, DFA, ARIMA, and LSTM, which are successfully applied to analyze and forecast time series of electricity prices.

The dissertation focuses on both short-term and long-term forecasts, providing a detailed analysis of the advantages and limitations of each methodology. The conclusions drawn from the research emphasize the potential for improving forecast accuracy, offering clear recommendations for selecting an appropriate method depending on specific conditions and data characteristics. The summarized results and scientific contributions in the conclusion provide a comprehensive synthesis of the achievements of the study.

5. Abstract:

The abstract provides a clear overview of the dissertation, including the main ideas, methods, and results. It is sufficiently informative and reproduces the content of the work with the necessary depth.

6. Critical notes and recommendations

Despite my positive assessment of the dissertation work, I would suggest the inclusion of more specific examples that illustrate the applicability of the results achieved. These examples should be chosen so that they do not affect company interests, but contribute to a better understanding and application of the acquired knowledge in real scenarios. This will strengthen the applicability and practical value of the research, making it more accessible and valuable to the general public.

CONCLUSION

After having familiarized with the presented dissertation work and the scientific and applied contributions contained in it, I consider that the presented material of the dissertation work fully meets the requirements of the Development of Academic Staff in the Republic of Bulgaria Act (DASRBA), the Regulations for the Implementation of DASRBA and the Internal Regulations of the IR-BAS. All requirements for obtaining the educational and scientific degree "doctor" have been met. Given this, I give my positive assessment of the conducted research, presented by the above-reviewed dissertation work, abstract, results achieved and contributions, and **I propose to the members of the Scientific Jury to award the educational and scientific degree "doctor" to Ekaterina Popovska in area 5 of higher education, professional direction 5.2. "Electrical engineering, electronics and automation" with a scientific specialty "Application of the principles and methods of cybernetics in various fields of science".**

Sofia, February 6, 2024

Signature:

Assoc. Prof. Dr. Eng. Ivan Prodanov