

# OPINION

by Assoc. Prof. Ivanka Mitkova Zheleva, PhD, DSc.  
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on the doctoral thesis for the award of the educational and scientific degree of "**Doctor**" from Plovdiv University "Paisii Hilendarski" in the field of higher education **4. Natural Sciences, Mathematics, and Informatics**; professional direction **4.5. Mathematics**; doctoral program **Mathematical Modeling and Application of Mathematics**

Author: **Ivaylo Vladimirov Boyukliev**

Topic: "**MODELING AND RESEARCH OF FOREIGN EXCHANGE FINANCIAL MARKETS**"

Supervisors: Prof. D.Sc. Snezhana Georgieva Gocheva-Ilieva  
Assoc. Prof. Dr. Hristina Nikolova Kulina  
from Plovdiv University "Paisii Hilendarski"

## 1. General presentation of the procedure and the candidate

By order of the rector of Plovdiv University "Paisii Hilendarski" (PU) No. RD-21-238 dated January 29, 2024, I have been appointed as a member of the scientific jury to ensure the procedure for the defense of the doctoral thesis on the topic: "Modeling and Research of Foreign Exchange Financial Markets" by Ivaylo Vladimirov Boyukliev, a regular doctoral student at PU, with scientific supervisors Prof. D.Sc. Snezhana Georgieva Gocheva-Ilieva and Assoc. Prof. Dr. Hristina Nikolova Kulina, for the acquisition of the educational and scientific degree "**Doctor**" in the field of higher education **4. Natural Sciences, Mathematics, and Informatics**, professional direction **4.5. Mathematics**, doctoral program **Mathematical Modeling and Application of Mathematics** at the Department of Mathematical Analysis of the Faculty of Mathematics and Informatics. During the period since January 31, 2024, to February 1, 2024, a remote meeting of the scientific jury (SJ) was held, during which I was designated to prepare an opinion on the doctoral thesis of Ivaylo Vladimirov Boyukliev. The set of materials presented by the doctoral student is in accordance with Article 36 (1) of the Regulations for the Development of the Academic Staff of PU, with the Law on the Development of the Academic Staff in the Republic of Bulgaria (LDASRB), and with the specific requirements of the Faculty of Mathematics and Informatics at PU. It includes all required documents. The presented documents are meticulously prepared and make a very good impression.

## 2. General Characteristics of the Candidate's Dissertation

The doctoral thesis was developed at the Department of Mathematical Analysis of the Faculty of Mathematics and Informatics at Plovdiv University "Paisii Hilendarski" during the period 2020-2023. The dissertation includes an introduction, 4 chapters, conclusion, declaration, and bibliography, with a total of 160 printed pages. The bibliography comprises 135 sources.

The main goal of the dissertation is to develop and apply both classical and state-of-the-art intelligent methods with machine learning (ML) for statistical modeling of time series to analyze and forecast currency financial markets.

The research focuses on real historical data from financial markets and systems, used as a basis for predicting their future movements, values, and dynamics, as well as for determining effective investment strategies in current financial systems and software.

To achieve the set goal, the dissertation formulates and solves five specific tasks.

The scientific and applied results obtained from the dissertation can be categorized as follows:

1. A general framework for statistical modeling of univariate and multivariate time series in the field of currency and financial markets has been developed and applied. The framework includes an approach to identifying predictors and the application of underexplored intelligent machine learning methods for prediction and short-term forecasting.
2. Effective predictive models for univariate time series of deposits in foreign currency for Bulgarian citizens have been constructed and analyzed. For the first time in this field, the ensemble method CART Ensembles and Bagging (EBag) has been applied and studied. It has been found that models without data transformation are more accurate, reaching a match with real values of up to 97.7%. The models are applied to obtain forecasts for deposits three months ahead, showing significantly better results than the reference ARIMA model.
3. Highly effective predictive models for multivariate time series of the EUR/USD exchange rate, depending on macroeconomic factors, have been constructed and analyzed using three methods - EBag, Arcing, and Random Forests. For the first time in the field of financial and currency markets, the ensemble method Arcing from the gradient boosting class has been applied and studied. The influence of individual macroeconomic factors on the exchange rate has been determined. The modeling results show the accuracy advantage of Arcing models with an average absolute percentage error (MAPE) of 1% and a match with the data reaching 99.1%. The forecasts for one month ahead for all three methods are comparable to the accuracy of observations.
4. An approach to hybrid Arcing-ARIMA modeling of data on deposits for Bulgarian citizens with transformed and non-transformed data has been developed and applied. It has been found that the obtained hybrid models with non-transformed data are more accurate, achieving statistical indicators with MAPE=12.9%, a match with the data up to 99.6%, and the most accurate forecasts for the three test "future" months not included in the modeling. It has been demonstrated that these results outperform the predictive capabilities of standard ARIMA and Random Forests methods.

The majority of the obtained results in the dissertation have been published in English in 4 scientific articles, indexed in SCOPUS and WoS, co-authored by the doctoral student and his scientific supervisors. One of them has an SJR of 0.164, while another has an impact factor (IF) of 1.2 and a rank (Q3). In Scopus, the same article has a rank (Q2) and an SJR of 0.464.

Some of the results have been tested in two scientific projects funded by PU and the Ministry of Education and Science, respectively. Five presentations on the dissertation topic have been delivered at international and national scientific forums and seminars.

It is clear that the results presented in the dissertation and published articles are the author's personal achievement, obtained under the general guidance of the scientific supervisors.

The scientific articles presented by the candidate have been published by reputable international publishers, which typically review submitted articles for plagiarism and accept them for publication if no plagiarism is found. Therefore, I accept the fact of the publication of the candidate's works as evidence that there is no plagiarism in them.

I believe that the goal of the doctoral thesis has been achieved, and the tasks set have been solved. The quantity and quality of the publications related to the dissertation correspond to the requirements for the award of the educational and scientific degree of "Doctor." I fully appreciate all the scientific and applied contributions of the dissertation, considering them highly valuable.

### 3. Critical Comments and Recommendations

I have no critical comments or recommendations for the dissertation. I endorse the directions and perspectives for the candidate's future work.

#### CONCLUSION

The doctoral thesis and the results obtained therein meet and exceed the recommended requirements of LDASRB, its application regulations, and the regulations of Plovdiv University regarding the acquisition of the educational and scientific degree "Doctor."

I express my high positive evaluation for the doctoral thesis and the results obtained, which contribute both scientifically and practically. I confidently recommend to the esteemed scientific jury to award Ivaylo Vladimirov Boyukliev the educational and scientific degree of "DOCTOR" in the field of higher education: 4. Natural Sciences, Mathematics, and Informatics; Professional direction 4.5. Mathematics and the doctoral program Mathematical Modeling and Application of Mathematics.

Date:  
March 20, 2024

Prepared by: .....  
(Signature)

Assoc. Prof. Ivanka Zheleva, PhD, DSc.