REVIEW

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

APPLICATION OF STOCHASTIC AND OPTIMIZATION METHODS FOR

RISK MANAGEMENT AND FOR PRICING OF FINANCIAL

INSTRUMENTS

for the acquisition of the educational and scientific degree "Doctor"

by

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The review was prepared by: Prof. Dr. Ognyan Kunchev, IMI-BAS, in my capacity as a member of the scientific jury, in accordance with Order No. 90/18.11.2025 of the Director of IMI-BAS.

Let's start with a brief introduction to the importance of the issues treated in the Dissertation.

First of all, we should mention that over the past 40 years, crises in the financial and banking sector have caused an incredible increase in the requirements for risk minimization by regulators, in order to avoid future crises. In particular, this led to the creation of a number of new measures for measuring risk in financial markets, some of which were introduced as mandatory by regulators. These measures are now reflected in a synthesised form in the framework called Basel III of 2010 (and the improvement Basel IV of 2017), which are the result of the evolution of the Basel I and Basel II frameworks, and are the fruit of the work of the Basel Committee for Banking Supervision (BCBS). In short, Basel III is a global regulatory framework that strengthens the resilience of banks after the 2008 crisis, focusing on higher capital (minimum 4.5% CET1, total 8% plus buffers), leverage limits (3%) and liquidity (LCR, NSFR) to absorb shocks, improve risk management and increase transparency, introducing new standardized approaches for risk-weighted assets (RWA) and operational risk, with final

“Endgame” revisions adding more detailed RWA calculations and a lower limit on the leverage ratio.

The risk assessment of financial instruments is essentially a financial and economic discipline in the field of modeling. It requires, on the one hand, in-depth knowledge of the financial instruments included in the assessment (portfolio), and on the other hand, a good understanding of the dynamics of the portfolio itself. This area is an example of modeling, where the goal is to find such quantities that reflect the risk of the portfolio in the most relevant way possible.

This dissertation is an example of the fruitful interaction between practically oriented research in the field of risk management of financial instruments and their theoretical justification. We must emphasize that in this dissertation work, the role of the Institute of Mathematics and Informatics as a unique center in Bulgaria, where the presence of a tradition in the field of financial mathematics provides an opportunity to carry out such research, and the academic atmosphere acts as a connecting factor in this interaction.

1. Structure of the dissertation, general characteristics and presented materials

The main research in the dissertation is devoted to the application of stochastic models (Black-Scholes, Heston, Bates, a model based on the exponent of a modified stable process (exponential tempered stable model), a model with stochastic volatility and a modified stable process) to the calculation of various risk measures (Value at Risk, Expected Shortfall, Expectile Risk Measure, Entropic Value at Risk (Entropic VaR)).

The dissertation is written in English and contains 134 pages and consists of an introduction, 8 chapters presenting the author's contributions. The bibliography consists of 196 titles, including 4 publications by the author. An abstract of 40 pages in Bulgarian (38 in English) is also presented, which adequately reflects the content of the dissertation.

The dissertation has several introductory chapters: Chapter 1 is motivational; Chapters 2 and 3 define the considered risk measures and the corresponding stochastic processes that describe them. Chapter 4 contains a description of the risk measures VaR and ES, which are based on quantiles. Chapter 5 describes the expectation-based risk measure EvaR.

2. Data and personal impressions about the candidate

I have known the dissertation candidate personally since 2022, as an active worker in the interesting and very relevant field of risk analysis in finance. I have attended his reports at various conferences, where he reported results related to the topic of the dissertation, and I have talked with him repeatedly on the topic of the dissertation, as well as about his work. It should be noted that the results obtained in the dissertation are directly related to his daily work, which he has been doing for at least 15 years, according to his autobiographical reference.

3. Content analysis of the candidate's scientific and applied scientific achievements contained in the presented dissertation work

The main contributions of the dissertation work consist in the application of stochastic models to the calculation of the most popular risk measures such as VaR, ES, ERM, EvaR.

We will now turn to a more detailed analysis of the results obtained in Chapter 5 and the following chapters:

1. As mentioned, the main contributions of the dissertation work consist in the application of stochastic models (Black-Scholes model, Heston model, Bates model, exponential tempered stable model, stochastic volatility model and modified stable process) to the calculation of various risk measures (Value at Risk, Expected Shortfall, Expectile Risk Measure, Entropic VaR).

2. A central and important technical contribution is the proof of a formula for the (Truncated) Truncated Expectation, which is derived in Chapter 5 through the characteristic function of the process (Proposition 5.4). On this basis, formulas are given for calculating the Expected Shortfall and the Expected Risk Measure through the Truncated Expectation (Theorem 5.2).

3. In Chapter 6 of the dissertation, the logarithmized returns in the Heston model are presented as newly introduced (by Dragomir Nedelchev and Tsvetelin Zaevski) random variables (Theorem 6.2) by averaging over the stationary distribution of the volatility process. Their convergence abscissae are defined as a subset of the abscissae of the initial process (Lemma 6.2, Theorem 6.1). All options for positioning the abscissae (Lemma 6.4, Theorem 6.2, Theorem 6.3, Theorem 6.4), which are found by solving algebraic equations, are considered. The approach is also applied to models that build on the Heston model, e.g. Bates model and a model with stochastic volatility and jumps, represented by a modified sustainable process.

4. Chapter 7 of the Dissertation also considers the Entropic Value at Risk (EvaR) in risk management. A formula for the Acceptance Set of the measure is derived (Theorem 7.2). A theorem is proved for calculating the value of the Entropic Value at Risk by minimizing a function related to the MGF (Theorem 7.1). Formulas for the Entropic Value at Risk are derived for the individual models: Black-Scholes model (formulas (7.18) and (7.19)), Heston model (Proposition 7.5), Bates model (Proposition 7.6), model based on the exponent of a modified

stable process (Proposition 7.4), model with stochastic volatility and modified stable process (Proposition 7.7).

5. In Chapter 8, the behavior of the risk measures in the five models for the S&P500 index for the last 23 years is empirically studied, including periods of normal market functioning and periods of financial crises. The main conclusion is the much better behavior of the Entropic Value at Risk in crisis conditions, as well as the better performance of models with stochastic volatility and spikes for the entire period studied, and the comparison is made with other established measures. From the available experiments, in the cases of market volatility, the delta-like behavior of the ESR is clearly visible, in contrast to the smoother behavior of the other risk indicators. This is one of the most interesting moments in the Dissertation, which is a practical confirmation of the theoretical results.

6. Chapter 9 is independent of the previous ones, but is in the subject of risk analysis of financial time series. Based on empirical data, the value of the popular in fractal and time series theory Hurst constant (index) is studied, by which memory in time series is measured. This index reflects the degree of regularity of the fractal Brownian motion, with the standard Brownian being at an index of 0.5.

It is calculated for the logarithmized instantaneous volatility for four leading market indices (S&P500, STOXX50E, FTSE, KSE). The calculations show that there is a linear relationship between the scaling factor and the value of the Hurst constant for the S&P500 index, which is the usual expectation. The surprise here is that there is a nonlinear relationship for the other indices, the most pronounced of which is the STOXX50E index. The results show that the Hurst constant has been less than 0.5 over the past 21 years, i.e. volatility is in a certain sense rough (rough volatility). It has been established that the value of this constant varies within certain limits and moves in packages (clusters). The value of the constant increases during financial crises, i.e. volatility becomes less rough.

4. Approbation of the results

The results of the dissertation have been published in 3 articles and one is in the process of peer review. The scientometric indicators of these articles are significantly higher than the minimum requirements for acquiring the educational and scientific degree "doctor" in the scientific field and professional direction (as defined in Decree No. 26 of 13.02.2019). The scientific publications fall into Group Q1 and Q4 in WoS and collect a total of 111 points, with a minimum requirement of 30 points for the respective field. In short, the 111 points obtained exceed the minimum requirements for a doctoral degree.

I declare that

a) the scientific works meet the minimum national requirements (under Art. 2b, para. 2 and 3 of the ZRASRB) and, respectively, the additional requirements of IMI-BAS, for acquiring the educational and scientific degree "doctor" in the scientific field and professional direction of the procedure;

b) the results presented by the candidate in the dissertation and scientific papers to it do not repeat those from previous procedures for acquiring a scientific title and academic position;

c) there is no plagiarism proven in accordance with the statutory procedure in the submitted dissertation and scientific papers under this procedure.

5. Qualities of the abstract

The abstract in Bulgarian contains 40 pages (38 in English) and meets all technical requirements. The presentation of the results in the abstract is adequate to the content of the dissertation.

6. Critical remarks and recommendations

I have no critical remarks on the substance. There are many questions and problems with the terminology: for example, the dissertation candidate uses the term “square optimization”, which should be quadratic optimization; “diapason”, which should be range; entropic, which in Bulgarian is accepted to be entropic.

In connection with the current interest in the topic of the dissertation, I would recommend publishing an expanded version of the text as a monograph.

7. Conclusion

After having familiarized myself with the dissertation work and the accompanying scientific papers presented in the procedure and based on the analysis of their significance and the scientific and applied scientific contributions contained therein, I confirm that the presented dissertation work and the scientific publications to it, as well as the quality and originality of the results and achievements presented therein, meet the requirements of the ZRASRB, the regulations for its implementation and the relevant regulations of IMI-BAS for the acquisition of the educational and scientific degree "doctor" in the scientific field: 4. Natural Sciences, Mathematics and Informatics, and professional field: 4.5. Mathematics, doctoral program, Probability Theory and Mathematical Statistics of IMI-BAS.

In particular, the candidate meets the minimum national requirements in the professional field and no plagiarism has been established in the scientific papers presented in the competition.

Based on the above, I confidently give a positive assessment and propose to the scientific jury to award Dragomir Kolev Nedelchev the educational and scientific degree "doctor" in the scientific field 4. Natural Sciences, Mathematics and Informatics, professional field 4.5. Mathematics.

8.1. 2025 г. **Review prepared by**:

Prof. DrSci Ognyan Kounchev