REVIEW

by **acad. Ivan P. Popchev**
of dissertation for scientific degree
"Doctor of Science"
in professional direction **4.5 Mathematics,**
scientific specialty "Probability theory and mathematical statistics"
Title **"An approach for pricing American-style derivatives"**
by **Tsvetelin Stefanov Zaevski**

By order №457/29.11.2024 of corr.-member P. Boyvalenkov – the Director of IMI-BAS, in accordance with art. 30 of the Regulation on the Implementation of the Development of Academic Staff in Republic of Bulgaria Act and by decision of Scientific Council of IMI-BAS (protocol No 15/29.11.2024) in connecting with the procedure of acquiring the scientific degree "Doctor of Science" in professional direction 4.5 Mathematics, scientific specialty "Probability theory and mathematical statistics" by Tsvetelin Stefanov Zaevski with dissertation "An approach for pricing American-style derivatives", I am appointed as a member of the Scientific Jury.

For evaluation of the dissertation paper, the conditions of the Act of Development of the Academic Staff in the Republic of Bulgaria (ADASRB), the Regulation on the Implementation of the Development of Academic Staff in Republic of Bulgaria Act (RIDASRBA) (Decree No 202 of 10.09.2010 amend and supl. SG 15/19.02.2019) and the Regulation in the IMI-BAS for the implementation of the law are defined and will therefore be accurately reported.

1. According to Art 12(4). The dissertation paper must contain theoretical conclusions and solutions of major scientific and applied scientific problems, which correspond to the up-to-date achievements and can be regarded as a considerable and original contribution to science.

2. According to the Regulation in the IMI-BAS art 3(1).1. At least 7 of the publications submitted in the procedure for acquiring the scientific degree "Doctor of Science" must have IF or SJR. (supl. 25.03.2022) For professional field 4.5, at least 4 of the publications must have IF.

On page 1 in the introduction is the point 1.1 **Aim of the dissertation is** "to investigate the American-stye financial instruments and to construct a fast and accurate method for their analysis and evaluation".

The dissertation has a volume of 511 pages and includes:

1. Introduction. (**Chapter 1**, 1–12).

2. First hitting time properties. (**Chapter 2**, 13–52).

3. Preliminaries. (**Chapter 3**, 53–68).
4. A new approach for pricing discounted American options. (**Chapter 4**, 69–100).
5. Pricing discounted American capped options. (**Chapter 5**, 101–130).
6. On some generalized American style derivatives. (**Chapter 6**, 131–160).
7. American strangle strategies with arbitrary strikes. (**Chapter 7**, 161–192).
8. Quadratic American strangles in the light of two-sided optimal stopping problems. (**Chapter 8**, 193–226).
9. Cancellable call options under perpetual assumptions. (**Chapter 9**, 227–250).
10. Cancellable put options without maturities. (**Chapter 10**, 251–270).
11. Perpetual cancellable options with a proportional penalty. (**Chapter 11**, 271–302).
12. Perpetual cancellable options with convertible features. (**Chapter 12**, 303–334).
13. Pricing cancellable American put options on the finite time horizon (**Chapter 13**, 335–358).
14. MATLAB codes (**Chapter 14**, 359–470).
15. Concluding remarks and further works (**Chapter 15**, 471–474).
16. Scientific Contributions (**Chapter 16**, 475–478).
17. References (479–510).
18. Index (511).

The abstracts are in Bulgarian (52 p.) and English (63 p.), respectively, and present the dissertation.

The presented list of "All publications related to the dissertation" includes **13 publications** in English. The analysis of these publications shows the following:

– **7 of the publications are in journals with IF,** Q_1 (No 4, 5, 6, 8, 9,10,11);

– 1 publication is in a journal with IF, Q_2 (No 7);

– 1 publication is in a journal with IF, Q_3 (No 13)

– 3 of the publications are in journals with IF, Q_4 (No 1, 2, 12);

– 1 publication is in Serdica Mathematical Journal (No 3).

All 13 publications are independent.

In the list "All citations of publications on the dissertation", **35 citations** are reported, whereas there are **29 citations** in the list **"All citations in WoS and/or Scopus of publications on the dissertation"**.

The analysis of the publication activity and the citations of the publications **confirm that the requirements of Art. 3(1).1. of the Regulations of IMI-BAS and the minimal national requirements for the scientific degree "Doctor of Sciences" are met.**

Critical notes on the dissertation:

1. In the "References" (pp. 479–510), as well as in the abstracts, the publications are not numbered that makes the text difficult to read.
2. Some of the publications in the "References" are bibliographically incomplete – without: ISBN/ISSN, publisher, pages, etc.
3. The publication

   I. Popchev, I. Radeva, and V. Velichkova. Blockchains in enterprise global risk management. In 2021 International Conference Automatics and Informatics (ICAI), pages 282-287. IEEE, 2021c.
   doi: 10.1109/ICAI52893.2021.9639500.

   is given twice – on pages 509 and 510, in "References". The publication above is given twice also in the

   – Abstract of dissertation in Bulgarian 50 p., and
   – Abstract of dissertation in English – 59 p.

Questions and recommendations on the dissertation:

1. Which of the scientific contributions obtained in Chapter 12 are **"theoretical generalizations"** (Art. 12(4) of the ADASRB)?
2. Which **"solutions of major scientific or applied scientific problems" in the dissertation are significant and original contributions to science** (Art. 12(4) of the ADASRB)? What are the criteria for **"original contribution to science"**?
3. Is it possible to be given preliminary forecast information about the future work (Chapter 15) over time and the necessary financial and research resources?

4. I would recommend considering the future implementation of a software product based on the theoretical and practical findings of the dissertation. The resulting package could be either part of one of the popular software platforms or a separate module for the valuation and analysis of American-style financial derivatives.

Contributions of the dissertation:

Chapter 16 (pp. 475–478) provides "Scientific Contributions". They can be briefly systematized by giving each contribution the number of the corresponding publication(s) together with the number of citations:

1. A method for pricing American-style financial instruments issued on an underlying asset modeled by a log-normal process. An alternative approach is proposed based on some properties of the Brownian motion's first hitting moment to a (piecewise) linear boundary or exiting such a strip [1] (2 total citations, 1 in WoS and/or Scopus), [2] (2 total citations, 1 in WoS and/or Scopus) and [3].

2. An approach for approximating optimal boundaries through maximizing the financial result of the derivative's holder and closed and semi-closed form formulas are derived. This method is applied to classical American options as well as their capped versions – a call option cannot be exercised above a predetermined level, respectively below it for a put. Articles [4] (4 total citations, 4 in WoS and/or Scopus) and [5] (4 total citations, 3 in WoS and/or Scopus).

3. An approach for determining when a payoff leads to a problem whose state space can be divided into two connected parts (by analogy with the classical American options) – the optimal and continuation sets. Article [6].

4. An algorithm for evaluating derivatives that lead to the first exit from a strip as an optimal strategy – strangle combinations between put and call options. A finite difference method is applied to determine the fair price. Article [7] (2 total citations, 2 in WoS and/or Scopus).

   A sufficient condition for a derivative to lead to such a task has been proven. As a consequence, a new financial instrument, called by the author a quadratic strangle, has been defined and studied. Article [8].

5. A method for characterizing the cancellable American options (also known as game or Israeli) – the writer has the right to cancel the contract prematurely, paying a penalty. An approach to maximizing the utility of both the holder and the writer is applied.

Classical call and put options in the absence of maturity are in articles [9] (6 total citations, 5 in WoS and/or Scopus) and [10] (5 total citations, 4 in WoS and/or Scopus); in the case of finite maturities – [13] (5 total citations, 4 in WoS and/or Scopus).

6. A new class of cancellable options with convertible and multiplyable features are defined and investigated – [11] (4 total citations, 4 in WoS and/or Scopus) and [12] (1 total citation, 1 in WoS and/or Scopus).

7. Implementation of the obtained theoretical results through the mathematical platform MATLAB.

The **"summarized scientometric profile"** of Assoc. Prof. Tsvetelin Zaevski can be constructed from the world bases as follows

– **Web of Sciense:** 32 publications, 143 sum of times cited, h-index 7;

– **Scopus:** 32 documents, 167 citations, h-index 8;

– **Google Scholar:** 238 citations, h-index 9; i10-index 7;

– **Reserch Gate:** 1 119 Research interest score, 211 citations, h-index 9;

– **zb MATOpen:** 18 publications since 2007;

– **MATHSCINET:** 21 publications, citations 5 in 1 publication;

– **orcid:** 22 validated works, 6 self-asserted works.

The "summarized scientometric profile" of Tsvetelin S. Zaevski shows sustainable development, convincing effectiveness, and recognition in the international scientific community.

I know the candidate as a student in the master's program of the FMI-SU "St. Kliment Ohridski" and as his reviewer for associate professor (2021) in the professional direction 4.5 Mathematics, scientific specialty "Probability Theory and Mathematical Statistics" (stochastic models in finance). I have presented publications No. 1 and 2 from the dissertation in Comptes rendus de l'Académie bulgare des Sciences (2020, 2021). With a written opinion dated 21.10.2024, I have proposed to proceed with an official procedure for the defense of the scientific degree "Doctor of Sciences".

Assoc. Prof. Tsvetelin Zaevski, PhD, is an accomplished, thorough, searching and effective researcher.

Conclusion

The dissertation paper meets the conditions of ADASRB, RIDASRBA, and Regulation of IMI-BAS.

I give a **positive conclusion** for acquisition of the scientific degree **"Doctor of Science"** of Assoc. prof. **Tsvetelin Stefanov Zaevski**, Ph.D.

I propose to the Scientific Jury to vote unanimously for Assoc. prof. Tsvetelin Stefanov Zaevski, Ph.D the scientific degree "Doctor of Science" on professional direction 4.5 Mathematics, scientific specialty "Probability theory and mathematical statistics".

Sofia, 15.01.2025

Reviewer:

/acad. Ivan P. Popchev/