REVIEW

from professor Daniela Borissova, D.Sc.
Member of the Scientific Jury appointed by the Director of IICT-BAS via
Order № 262/31 October2019

ABOUT: Dissertation thesis of Veselin Lazarov Shahpazov with title „RESEARCH ON NEURAL NETWORKS BASED CAPITAL MARKETS FORECASTING MODELS", presented for the acquisition of educational and scientific degree "doctor" in a doctoral program "Informatics", Professional field 4.6. "Informatics and Computer Science"

At the first meeting of the scientific jury, held on 4.11.2019, I was selected as a reviewer, and as a member of the scientific jury I received the following materials: dissertation, abstract in Bulgarian, abstract in English, reference for meeting the minimum requirements of IICT-BAS, 6 full-text publications, and a professional biography.

1. Analytical characteristic

The presented dissertation with title "*Research on neural networks based capital markets forecasting models*" by Veselin Lazarov Shahpazov contains total of 148 pages including 21 figures and 12 tables, and is structured as follows: introduction and 8 chapters. The last 5 chapters refer to guidelines for future research, conclusion - summary of the achieved results with a declaration of originality of the dissertation, publications on the topic of the dissertation, participation in projects and bibliography. The presented bibliography contains a total of 139 literature sources, of which 10 are Internet addresses, 4 in Bulgarian and the rest are in English.

Chapter 1 contains description of traditional analytical methods (fundamental analysis, technical analysis, time series forecasting, efficient market hypothesis, chaos theory, and other techniques) as well as some methods for predicting capital markets with artificial intelligence approaches.

In Chapter 2 the methods based on neural networks to forecast capital markets are analyzed. Neural network characteristics, artificial neural network training, neural network organizations are described, and neural network usage and capital market forecasting over the years are demonstrated.

Chapter 3 presents description of the results from the investigation of neural network capital markets forecasting models. A hybrid model of neural networks and systems based on rules for capital market forecasting is presented.

Chapter 4 presents the guidelines for future research directions related with: 1) refining neural network based capital market forecasting models using other types of networks, architectures, training techniques, and 2) further developing the proposed neural network and systems hybrid model, based on rules for forecasting underdeveloped and low liquid capital markets by including an additional element for the subjective quantitative factor that evaluates stock liquidity.

The conclusion, which represents summary of the achieved results and declaration of originality of the dissertation, are given in Chapter 5.

Chapter 6 contains a list of publications on the topic of dissertation work and a list of citations, Chapter 7 contains a list of participation in projects, and bibliography is given in Chapter 8.

2. Aim and tasks

On page 10 is written "*The main purpose of this dissertation, defined and in its title is to investigate models for forecasting of capital market by neural network*". Six tasks have been formulated, the solution of which would lead to the realization of the set goal, namely:

- Investigation of the formation, development and ability of neural networks to forecast the capital market
- Analysis of methods for forecasting capital markets with neural networks
- Research on the Bulgarian stock market as a subject of forecasting
- Formation of a hybrid model for capital market forecasting
- Conducting experiments with the hybrid model in the real conditions on the Bulgarian capital market
- Summary of results achieved and future development of the model.

3. Evaluation of publications

The results of the dissertation are published in overall 6 publications, 5 of them are in English and 1 in Bulgarian. Only 3 of the publications are referenced and indexed in World Databases as IEEE Xplore and Scopus. One publication (this in Bulgarian) is prepared by Veselin Shahpazov and all others are co-authored.

A good impression is made of the 6 citations for one of the publications, which is co-authored.

The minimum national requirements have been fulfilled according to the Decree of the Council of Ministers 26 of 13.02.2019 for amendment and supplementation of

the Rules for the Implementation of the Law on the Development of the Academic Staff in the Republic of Bulgaria, as well as the specific conditions of BAS and respectively IICT for the acquisition of the educational and doctoral degree "doctor" in field 4 "Natural Sciences, Mathematics and Informatics", 4.6. "Informatics and computer sciences". For indicator 1 the points are 50, and for the sum of indicators from 5 to 10 - the total number of points is equal to 36 with a minimum of 30 points.

Veselin Shahpazov has also participated in two research projects.

4. Abstract and contributions

The abstract accurately reflects the content of the dissertation and it is presented in both Bulgarian and English. A declaration of originality is also attached as part of the dissertation.

The main scientific and applied contributions can be summarized as follows:

1. The main qualitative and quantitative differences between the Bulgarian regulated capital market with a representative of BSE – Sofia and the developed exchanges around the world are determined

2. A hybrid model of neural networks and systems based on rules for forecasting weakly developed and low liquid capital markets is proposed

3. Experimental tests are carried out with the proposed hybrid model using historical data.

5. Critical notes and questions

In general, the dissertation submitted for review is not well balanced. The reasons for this statement are the very extensive first and second chapters, which are essentially represent description of other authors results.

I have the following questions:

1. With which purpose is made this study of models for capital market forecasting with neural networks?

2. Is it possible to use other models for capital market forecasting? If so, with what?

3. What are the advantages of neural networks in capital market forecasting?

4. How many cycles are required to train a neural system for capital market forecasting and what is the required computational time?

5. Is there a relationship between the time window used and the mean square error?

6. Is it possible to use the proposed hybrid model in real time? What are the advantages of this model?

7. Conclusion

The dissertation complies with the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria and Rules for its application, the Rules of the BAS, as well as the Rules on the specific conditions for acquiring academic degrees and for occupying academic positions at IICT-BAS. Therefore, I give a positive assessment and suggest to the honourable Scientific Jury to award Veselin Lazarov Shahpazov the educational and scientific degree "Doctor" in Doctoral Program "Informatics", professional field 4.6 "Informatics and Computer Science".

27.11.2019

Reviewer: ....

(Prof. Daniela Borissova, DSc)