REVIEW

from professor D.Sc. Ivan Garvanov – University of Library Studies and Information Technologies

Member of the Scientific Jury appointed by the Director of IICT-BAS via Order № 170/11 July 2019

SUBJECT: Dissertation of **Dilian Chavdarov Korsemov** with title "**Models and Algorithms to Support Group Decision-Making**", presented for the acquisition of educational and scientific degree "doctor" in a doctoral program "Application of the principles and methods of cybernetics in different fields of science)", Professional field 5.2. "Electrical engineering, electronics and automation"

1. General description

A meeting of the Scientific Jury was held on 12 of July, 2019 where I was selected as a reviewer and the following documents were provided:

- Dissertation
- Abstract in Bulgarian and abstract in English
- information (2018 attestation) for taken exams and received credits
- a list of printed scientific publications on the dissertation topic
- a list of observed citations
- information about the fulfillment of the minimum requirements of IICT

The duration of Dilian Korsemov education start from 01.01.2016 until 01.01.2020 with supervisor Prof. Daniela Borissova.

2. Actuality

Today in many different areas it is necessary to take group decisions. Due to the globalization and the constantly growing competition, today is difficult to make successful decisions without the assistance of experts from different fields. Each of these experts must have proven capability to provide convincing information about their assessments of existing alternative solutions with respect to predetermined criteria. It should be noted that experts' opinions should not be considered as equal as they have different competencies, knowledge and experience. The essence of decision-making process includes booth of quantitative and qualitative indicators that define this multi-criteria problem non-trivial and complex.

Consequently, conducting of scientific research related with development of models and algorithms to support decision-making and in particular, group decision-making, is a current research area.

3. Knowing the problem

Chapter 1 provides an in-depth analysis of the decision-making process as well as existing techniques and mathematical models to support the process of group decision-making. From this overview it could be concluded that the PhD student is well aware of the nature of the investigated problem. Evidence for this is the number of 136 references used in a bibliographic. All references sources are in English.

4. Analytical characterization of PhD dissertation

The dissertation consist of total 121 pages, including 21 figures, 22 tables and is structured in introduction, 3 chapters, conclusion, contributions, list of publications, list of citations, declaration for originality and bibliography. The overview of the present state of the scientific research in the subject area are presented in Chapter 1. Prospective research directions, the purpose of the dissertation work and the tasks for its realization have been identified are also given in the end of **Chapter 1**.

Chapter 2 describes proposed models for supporting group decision-making and the algorithms for their implementation, namely: modified simple additive weighting, modified weighted product model, and a modified model based on the SMART. For each of the proposed modified models to support group decision making, corresponding algorithms for their performance are also proposed. The essence of the formulated models is expressed by the introduced weighted coefficients for each group member depending on his experience and expertise. This fact makes allow more accurately aggregation of final group decision. A generalized algorithm with three different strategies (for choosing of one best alternative; for choosing of several good alternatives; or for ranking of all alternatives to their degree of preference) is also proposed. Four different group decision making models for selection of alternative(s) under uncertainty conditions considering principles of Wald, Laplace, Hurvitz and Savage are also proposed.

Chapter 3 describes the numerical experiments with the proposed modified models for group decision making and the algorithms for their implementation. The provided results of numerical experiments show the practical applicability of the proposed modifications of simple additive weighting model, the weighted product model, and the SMART-based model for choice of alternative(s) via group decision-making are presented. There exists description of the conducted experiments using the proposed algorithm for group decision making with three different strategies. The provided results of numerical testing, demonstrate the practical applicability of the proposed group decision making models under uncertainty conditions using of Wald, Laplace, Hurvitz and Savage criteria. Part of the proposed modifications is implemented in the MS Excel environment as a tool to support group decision-making.

5. Purpose and tasks of PhD dissertation

On page 39 of the dissertation thesis is defined the aim as "to propose mathematical models to support the group decision making and algorithms for their realization, taking into account the differences in the expertise of the group' members". To accomplish this goal, the following tasks are formulated:

- to analyze existing models and techniques for group decision making;
- to propose models for group decision-making and algorithms their implementation, taking into account the expertise of each member of the group, using 1) weighted sum model, 2) weighted product model, and 3) SMART model;
- to propose a generalized algorithm for group decision-making with integrated different strategies – for selection of one best alternative, for choice of several good alternatives and rank of all alternatives;
- to propose models for group decision-making under uncertainty conditions using criteria Wald, Laplace, Hurvitz and Savage.

6. Methodology of the study

Research methodology includes both the formulation of adequate mathematical models and algorithms, as well as assessment of their practical applicability through numerical testing based on data about real problems. In solving the formulated optimization tasks, the author is used specialized optimization software Lingo. Some of the proposed models are also implemented in the MS Excel environment. The obtained results by using of Lingo software and MS Excel show identical values that prove the correctness of the formulation and their adequacy.

7. Abstract and author' declaration

The presented two versions of the abstracts in Bulgarian and English correctly reflect the content of the dissertation and correspond to the requirements of Bulgarian legislation. From the presented declaration of originality, as well as from the presented papers on the dissertation theme, it can be judged that the described results are a personal work of the author.

8. Contributions

From the presented 4 contributions in the dissertation, I accept the following 3 contributions as scientific-applied:

1. Modifications of weighted sum model, weighted product model and SMART model for selection of alternative(s) under group decision-making are formulated. The proposed modifications take into account the differences in the experience and knowledge of the group members by using of weighted coefficients to express the level of expertise. Modifications of the models allow to select one the best alternative or to select several good alternatives. The proposed models allow formulation of combinatorial optimization tasks, whose solutions determine the

optimal preferred alternative(s). The corresponding algorithms for practical application of these models are proposed.

2. A generalized algorithm for group decision making with three different strategies is proposed: 1) for choice one best alternative, 2) for selection of several good alternatives, 3) for ranking of all alternatives). For each strategy, appropriate optimization models for group decision making are formulated, taking into account the expertise of each member of the group.
3. Modified models for group decision making under uncertainty conditions using the criteria of Wald, Laplace, Hurvitz and Savage are proposed. The proposed modifications take into account the differences in the experience and knowledge of the group experts by introducing corresponding weighted coefficients for each expert. Appropriate optimization tasks have been formulated to determine the optimal alternative for each of these criteria.

9. Assessment of compliance with the minimum national requirements

There are total 7 presented publications on the dissertation theme and all of them are in English. It should be noted that 4 of the publications are visible in the Web of Science and Scopus databases. Three of the publications have SJR (No 2, No 3, and No 6) and 3 publications are in specialized international journals. Four citations for 3 of the publications are given – one for No 7, one for No 6 and two for No 4.

According to the minimum national requirements for obtaining of the educational and scientific degree „Doctor in the professional field 5.2 "Electrical engineering, electronics and automation", the required scores are to be at least 30 for the group of indicators G. The same number of scores is required by the Regulations on the Conditions and Procedures for Acquisition of Academic Degrees and Occupation of Academic Positions in BAS and the Regulations on Specific Conditions for Acquisition of Academic Degrees and Occupation of Academic Positions in IICT-BAS. The presented publications on the dissertation form a total 73.33 scores for the indicators from G group, which is significantly higher than the required minimum of 30 scores.

10. Critical remarks and recommendations

Some of the described results in the dissertation are not reflected in publications and it is recommended to be published.

The obtained results strongly show that the PhD student **Dilian Korsemov** have the necessary theoretical knowledge and practical skills in the specialty, as well as proven ability for independent scientific research.

I have the following questions:

How to explain the differences in results shown on page 87, Fig. 3.9?

How the coefficients that express the expertise of each group member are determined in the performed numerical experiments?

11. Conclusion

The presented dissertation meets the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria, the Rules for its implementation, the Rules for the conditions for the acquisition of academic degrees and for the occupation of academic positions in the Bulgarian Academy of Sciences and the Rules for the specific conditions for the acquisition of scientific degrees and for academic positions at IICT-BAS.

The described results in the dissertation, along with the fulfillment of the national minimum requirements, give me enough reason to give a positive assessment of the dissertation work and **I suggest to the honorable scientific jury to award to Dilian Chavdarov Korsemov the educational and scientific degree „Doctor" in doctoral program "Application of the principles and methods of cybernetics in different fields of science (technical)", professional field 5.2 "Electrical Engineering, Electronics and Automation".**

26 August 2019

/Prof. D.Sc. Ivan Garvanov/