**ANNOTATION OF THE SCIENTIFIC PAPERS
AND SELF-ASSESSMENT OF THE CONTRIBUTIONS**

to participate in the competition for the academic position of **"professor"**
Area of higher education: **3. Social, economic and legal sciences**,
Professional field: **3.8 Economics**
(Economics and Management – Information Systems and Technologies)

ASSOC. PROF. GALINA MIRCHEVA ILIEVA, PHD

**DEPARTMENT OF MANAGEMENT
AND QUANTITATIVE METHODS IN ECONOMICS, FESS OF PU**

For participation in this competition (see List of scientific papers for participation in the competition) are presented 24 scientific papers, including 1 monograph, 22 scientific publications and 1 textbook. All of them were published after acquiring the academic position of „associate professor".

I. MONOGRAPH

1. **Ilieva**, G. (2020) *Cloud Technologies: Multi-criteria selection.* Prof. Marin Drinov Academic Publishing House. 136 p. ISBN 978-619-245-079-3

This monograph examines the problems associated with the application of so-called cloud technologies for digitalization of modern business. After a thorough comparative analysis of research in the field and of different types, models and products for cloud services, their specific features have been identified. In order to develop a comprehensive methodology for evaluation, comparison and selection of an appropriate computing service in the cloud for digitalization of major economic activities, an analysis of modern algorithms for multicriteria analysis has been performed. The main scientific contribution is the proposed and tested methodology for choosing a cloud service, which best corresponds to the preferences and requirements of users and is based on fuzzy multi-criteria decision-making methods.

Chapter 1. 'Evolution of Information Technologies' discusses the main stages in business processes evolution that are related to automation (optimization), digitization (efficiency) and digital transformation (partnership). Special attention is paid to the digital business transformation and its advantages, as well as to the potential areas of application. The processes of digitalization are considered from different points of view – state of IT infrastructure, role of information systems and technologies for digitization, problems with the process of digitalization in a company or institution and others.

Chapter 2. 'Cloud Technology as a Digitalization Solution' is dedicated to modern business digitalization instruments such as artificial intelligence, big data, Internet of Things and cloud computing. The main characteristics of cloud technologies are analyzed, as well as their influence on improving organizations' competitive advantages. Some good business practices in recent years have been discussed. A comparison (in terms of capabilities, benefits, distribution and development prospects) of the most popular cloud services (IaaS, PaaS, SaaS. DaaS, XaaS, BPaaS, NaaS, DBaaS, TaaS

and many others) has been made, as modern alternatives to remote storage and information processing. Four models of cloud infrastructures (private, public, public and hybrid cloud) have been compared.

Chapter 3. 'Application of cloud technologies by business areas' presents and analyzes the relevant good practices in manufacturing enterprises, in e-commerce, finance and insurance, higher education, various economic activities and others.

Chapter 4. 'The problem of choosing a cloud technology and a multi-criteria approach to its solution' analyzes different ways to choosing a cloud computing service depending on: user requirements; ISO/IEC 25010 standard specifications for software product quality; indicators for evaluation of cloud services; financial models, and decision-making methods through multicriteria analysis. It is argued that many companies would prefer a hybrid cloud model that combines public and proprietary cloud services which raises the question of choosing the optimal computing infrastructure. Critically, some metrics for evaluating cloud services and methods for selecting appropriate cloud platform are considered. It is noted that there is a lack of research on the problem of group multicriteria choice of cloud platform. As a result, a methodology for selecting a cloud service based on mathematical methods for group multicriteria analysis with accurate and fuzzy estimates has been proposed. The new methodology has been tested through a practical example comparing ten popular cloud storage platforms.

In conclusion, the topicality of the issues in the field of information systems and technologies and the peculiarities of new methodology have been summarized.

II. SCIENTIFIC ARTICLES

2. **Ilieva**, G. (2012) Bidding Strategy Selection via Direct Aggregation of Fuzzy Numbers. *Management and Sustainable Development.* 33(2) p. 126–132. ISSN 1311-4506 http://oldweb.ltu.bg/jmsd/files/articles/33/33-24_G_Ilieva.pdf

This paper proposes a new method for bidding strategy selection in multi-agent systems for electronic auctions. The described method suggests the implementation of an algorithm for multi-criterion ordering with direct fuzzy numbers aggregation called ARAKRI2. In classical Decision Theory, alternative/criterion matrix and weighted coefficients both with real values are used in multi-criterion selection. In a software system of agent participants, however, it is difficult to find quantitative indicators of strategy evaluation criteria on individual level as well as on collective level. For this reason, in practice, in evaluating bidding strategies, fuzzy agent attitude matrices for each given strategy are used. Fuzzy logic enables agents to cope with uncertainty, inaccuracy and incompleteness of available information.

3. Ivanov, I., Veleva, A., **Ilieva**, G. and Yankova, T. (2012) Teaching by Using IST – a FESS primer. In: Proc. of the *International Conference on Information Technologies.* p. 226–233. ISSN: 1314-1023. http://web.uni-plovdiv.bg/gal-ili/Publ/IT%202012.pdf
http://infotech-bg.com/proceedings , All Proceedings, InfoTech-2012, e001.pdf

The goal of this paper is to analyze the process of incorporation of new training methods and technologies by the Faculty of Economics and Social Sciences (FESS). A variety of applications of the Information Systems and Technologies (IST) in education have been described. The students' opinions about the educational methods have been collected through a survey and the results are presented. Their analysis suggests that more than half of the students regard the current incorporation of electronic didactical methods as insufficient.

4. **Ilieva**, G. (2013) Aspects of applicability of GIS-technology in marketing. *Management and Sustainable Development*. 39(2). p. 42–46. ISSN 1311-4506 http://oldweb.ltu.bg/jmsd/files/articles/39/39-08_G_Ilieva.pdf

The development of mobile communications and the Internet has led to a growing demand in geo-information products. Geo-informatics' boom of recent years was also nurtured by fast convergence between mobile phones and personal computers. In 21-century economics, geo-spatial component of knowledge bolsters integrated management approach and is a prerequisite for sustainable company development. In this paper, the capabilities of geographic information system (GIS) technologies for solving marketing problems in retail and services have been analyzed. Two are the starting points of this research: marketing data are spatially localized and when studying consumer behaviour, spatial behaviour should be taken into consideration. The purpose of this paper is presenting an overview of GIS applications: determining the location of new retail sites; services, based on customer's location; sales representatives' management; in advertisement and target marketing, which are strongly dependent on spatial factors. The advantages of geomarketing in comparison with traditional one are: addition of spatial information in databases and implementation of mathematical calculations and visualization; access to special procedures for marketing research, etc. The analyzed applications are relevant for retail and service companies in planning and organizing marketing activities as a tool, enhancing decision-making process.

5. **Ilieva**, G., Yankova, T., Klisarova, S. (2014) Information technologies in the modern training of students majoring Finance. In the proceeding of the International Conference "*New perspectives in the teaching of statistics in the field of economic and social sciences*", Plovdiv University Publishing House "P. Hilendarski", p. 62–71. ISBN 978-954-423-952-7 http://web.uni-plovdiv.bg/galili/Publ/NPPS%202013.pdf.

In this study, we investigate the application of information technologies in the training of mathematics and computer science to financial professionals. The presented examples were employed in the training of bachelor's degree students in Finance major at Plovdiv University "Paisii Hilendarski" in the period 2012-2014.

6. **Ilieva**, G., Angelov, D. and Dimitrova, T. (2014) Geospatial Analysis of Tabular Data in Marketing Management. In: Proc. of the *International Conference 'Times of Uncertainty and Risks: Possibilities and Perspectives for Development'*, Vol. 2. p. 239–246. ISBN: 978-619-202-037-8 https://doi.org/10.13140/RG.2.1.4332.9763 http://web.uni-plovdiv.bg/galili/Publ/TURPPD%202014.pdf

In this paper, the capabilities of Geographical Information Systems (GIS) for geo-spatial analysis of tabular data in solving marketing problems are studied. This research has two starting points: marketing data are geographically localized and in their analysis, their behavior in space should be considered. The aim of the paper is presenting the possibilities GIS technologies offer in marketing business analysis of tabular data. Modern spreadsheet software includes built-in analysis functionality and allows navigation of data in 2D and 3D environments. Moreover, specialized GIS software contains a range of spatial modelling and analysis tools. Suggested methods for business analysis of tabular data enhance decision making during the planning and organization processes of various marketing activities.

7. **Ilieva**, G., Yankova, T., Klisarova-Belcheva, S. 2015. Cloud Business Intelligence: Contemporary Learning Opportunities in MIS training. In: *CEUR Workshop Proceedings* of the 7th Balkan Conference in Informatics. *1427*. p. 25–32. ISSN: 1613-0073.http://ceur-ws.org/Vol-1427/paper4.pdf.

The aim of this work is to present a possible way of teaching cloud-based Business Intelligence (BI) in Management Information Systems (MIS) course at Plovdiv University „Paisii Hilendarski". In training students to analyze and monitor business performance, create reports, and visualize dashboards, we apply active learning methodology. Presented practical examples of data analysis with MS Power BI for Office 365 and SAP Cloud Lumira are actual cases from the university's Business administration (undergraduate) program. The conducted experiment demonstrates that the application of active learning in teaching cloud-based BI improves the technological and professional competencies of future decision makers for intelligent analysis of organization data.

8. **Ilieva**, G., Yankova, T. and Klisarova-Belcheva, S. (2015) Big Data Based System Model of Electronic Commerce. *Trakia Journal of Sciences.* 13(1). p. 407–413. ISSN: 1313-7069 https://doi.org/10.15547/tjs.2015.s.01.070

The purpose of this paper is to systematically analyze the capabilities of big data technology to solve important problems in electronic commerce. The role of big data as one of the central priorities in modern information technologies for online sellers and buyers is underlined. Big data methods to improve the basic functional areas of e-commerce: marketing, payments, supply chain, and management are described. A new model for automation of key business processes in e-commerce through new technology is presented. The model is verified using practical examples of e-commerce activities. The process of e-commerce modernization requires additional infrastructure, new methods and modern software for better data organizing, customer personalization and improved decision making.

9. **Ilieva**, G. & Dimitrov, A. (2015) Inter-criteria Comparison of Bulgarian Construction Companies Using Fuzzy Relations. *Int. Journal of Engineering Science and Innovative Technologies*, 4(2), p. 290–299, ISSN: 2319-5967 http://www.ijesit.com/Volume%204/Issue%202/IJESIT201502_40.pdf

Financial analysis is a prerequisite for effective operating activities and successful long-term company's management. Various financial ratios are used for assessing the financial performance of a company and its ability to adapt to changes in its environment. The problem of the financial state comparison of construction companies can be solved by multiple-criteria decision making (MCDM) with fuzzy relations between important financial ratios. The inter-criteria ranking method called ARAKRI is in the basis of the proposed solution for comparing the competitiveness of nine leading Bulgarian construction companies.The described procedure can improve compliance with the principles of transparency, equal treatment and non-discrimination in Bulgarian public procurement and serve as an objective method of impartial winner determination.

10. **Ilieva**, G. (2017) Group Decision Analysis with Interval Type-2 Fuzzy Numbers. *Cybernetics and Information Technologies*. 17(1). p. 31–44. ISSN: 1311-9702 eISSN: 1314-4081 https://doi.org/10.1515/cait-2017-0003

This paper presents a group multi-criteria DEMATEL and VIKOR decision analysis method with interval type-2 fuzzy sets. In order to compare normal fuzzy trapezoidal

numbers, we convert them into crisp values using graded mean integration representation. By a case study for selection of business intelligence platform, we prove that the proposed combination is a feasible solution that can work with benefits and costs criteria, while also reducing uncertainty in experts' assessment.

11. Dimitrov, A., Slavenkov, B., **Ilieva**, G., Klisarova-Belcheva, S. (2017) School and university education should support the entrepreneurs of the future in Bulgaria. *Management and education.* 13(3). p. 31–39. ISSN: 1312-6121 http://conference-burgas.com/maevolumes/vol13/b3_v13.pdf

Entrepreneurship has a positive impact on countries' economic development and social systems. Do schools and universities offer the necessary training for future entrepreneurs in Bulgaria? How prepared are they to work in a dynamic, open and highly competitive environment? This paper presents some features of entrepreneurship education introduced in recent years and proposes measures to overcoming the challenges that face building entrepreneurial competence in Bulgarian high school and university students.

12. Klisarova-Belcheva, S., **Ilieva**, G., Yankova, T. (2017) Business Intelligence and Analytics – Contemporary System Model. *Trakia Journal of Sciences.* 15(1). p. 298–304. ISSN: 1313-7069 https://doi.org/10.15547/tjs.2017.s.01.053

This paper aims to analyze and evaluate the current state of business intelligence systems (BIS) market and outline the main trends in BI technologies development. The main research methods employed are studying BIS characteristics, analysis of market dynamics and the strengths and weaknesses of market participants, which is integrated in drawing conclusions regarding trends in BIS products development and their market, modeling and synthesis in developing innovative BIS architecture. The trends in BIS products development and their market are outlined, and based on them, a new model of modern BIS architecture is proposed. There is positive dynamics on the BIS market and in 2016 several shifts occurred among vendors, including the emergence of new ones. Users' preferences continue evolving and smart data discovery is sought after at an increasing rate, for example in processing native language queries. A rising number of vendors offer BIS as a service with data being stored in the cloud or on-premise.

13. **Ilieva**, G., Yankova, T., Klisarova-Belcheva, S. (2019) Business Intelligence. *Technosphere.* 1(43). p. 41–48. ISSN 1313-3861.

The development of technology has turned data and information into a source of competitive advantage for organizations. Modern business intelligence systems (BIS) perform multifunctional data analysis not only to provide a complete VIEW of the business, but also to make forecasts aiding better decision making. Some major trends in the development of BI in 2018 are outlined: artificial intelligence; multi-cloud computing; expanding natural language processing; enhanced real-time intelligence, open data, application of advanced analytics, predictive maintenance. Business intelligence tools from leading manufacturers are briefly presented: Tableau, Power BI, QlikView and QlikSense, SAP BusinessObjects BI (BOBI), TIBCO Spotfire. The paper also proposes an algorithm for multicriteria selection of business intelligence software, according to its functional capabilities.

14. **Ilieva**, G. (2019) Fuzzy Supervised Multi-Period Time Series Forecasting. *Cybernetics and Information Technologies*. 19(2). p. 74–85. Print ISSN: 1311-9702 Online ISSN: 1314-4081 https://doi.org/10.2478/cait-2019-0016

The goal of this paper is to propose a new method for fuzzy forecasting of time series with supervised learning and k-order fuzzy relationships. In the training phase based on k previous historical periods, a multidimensional matrix of fuzzy dependencies is constructed. During the test stage, the fitted fuzzy model is run for validating the observations and each output value is predicted by using a fuzzy input vector of k previous intervals. The proposed algorithm is verified by a benchmark dataset for fuzzy time series forecasting. The results obtained are similar or better than those of other fuzzy time series prediction methods. Comparative analysis shows the high potential of the new algorithm as an alternative to fuzzy prediction and reveals some opportunities for its further improvement.

15. Angelov, D., **Ilieva**, G., Yankova, T. (2020) Analysis of the competitiveness of the Bulgarian economy. In proceedings of the Jubilee international conference "*Economic and social [dis] integration*", 2019, Plovdiv University Publishing House "Paisii Hilendarski", p. 429–444. ISBN: 978-619-202-565-6, eISBN 978-619-202-566-3

The purpose of this paper is to assess the state and progress of the Bulgarian economy according to key indicators of competitiveness and innovation as compared to other EU member states. Thanks to its macroeconomic and financial market stability, Bulgaria has moved a few places ahead in competitiveness rankings in recent years, but it is falling behind in innovation index. This analysis shows that despite some positive signals, Bulgaria is among the European countries with the lowest values of the analyzed economic indicators. A summary of the obtained results has been made and some measures have been proposed to overcome the lagging behind.

16. **Ilieva**, G. (2020) Geospatial analysis and socio-economic aspects of the spread of breast cancer. In proceedings of the Jubilee international conference "*Economic and social [dis] integration*", 2019, Plovdiv University Publishing House "Paisii Hilendarski", p. 609–621. ISBN 978-619-202-565-6 eISBN 978-619-202-566-3

Breast cancer is one of the 21st century's socially significant diseases. This is the second most common cancer in the world, and the first – regarding women. The aim of the paper is to investigate the prevalence of breast cancer in Bulagria and to find out whether or not there is a dependence between the breast cancer morbidity and the geographical area. An outpatient assessment was carried out and clusters of administrative-territorial areas with similar morbidity were identified. Cluster analysis confirms the hypothesis that breast cancer differs across geographical areas and is likely to depend on both the social and the economic environmental factors (urbanization, poverty, pollution) and the individual factors (demographic features, prolonged stress, immobilization, a meal). The outlined dependencies can be used for the creation and the implementation of a concept of prophylactic and early-diagnosis screening programs.

17. Yankova, T. & **Ilieva**, G. (2019) Solving a fuzzy transportation problem based on exponential membership functions. *Annals of the Academy of Romanian Scientists: Series on Mathematics and its Applications*. 11(2). p. 245–265. ISSN 2066-6594, 2066-5997

In the traditional transportation problem, it is assumed that decision makers are confident about the exact values of transportation costs, supply and demand of the product. When solving a transportation problem with inaccurately determined transportation costs, supply and demand quantities, a fuzzy approach is used. In this paper, a transportation problem based on statistical data is considered. The frequency distributions on the transportation costs and the supply and demand quantities in real-life transportation problems are used as the base for determining the parameters of exponential membership functions. An approach for solving fuzzy transportation problem using exponential fuzzy numbers is proposed. A numerical example is solved to illustrate the described approach.

18. **Ilieva**, G. (2019) Decision analysis for big data platform selection. *Engineering Sciences*. LVI(2). p. 5–18. ISSN: 1312-5702 (Print), ISSN 2603-3542 (online) https://doi.org/10.7546/EngSci.LVI.19.02.01

The accumulation of enormous quantities of structured and unstructured data in the organizations is a prerequisite for the appearance of different IT solutions for data warehousing and fast processing of huge collections of information. The objective of this research is to compare frequently used cloud-based resources for large volumes of data focusing on their specific characteristics. This comparison will be a stepping stone in the creation of a fuzzy multi-criteria system for evaluating cloud platforms for deploying, operating and analysis of big data.

19. **Ilieva**, G. & Yankova, T. (2020) Early Multi-criteria Detection of Students at Risk of Failure. TEM Journal. 9(1). p. 344–350. ISSN 2217-8309 https://doi.org/10.18421/TEM91-47

In this paper, we present a new fuzzy methodology for early students' failure detection. High school background, subjects studied in the university and activities in learning management systems were determined to be the factors influencing students' performance. After selection of the impact factors of students' assessment, we convert linguistic evaluations into fuzzy numbers and employ multi-criteria methods for educational data processing. In two practical examples, the aggregate students' scores were calculated by using fuzzy multi-criteria algorithms. The obtained students' ranking helps instructors during the semester to detect students who will drop out the course and to plan additional learning activities for these students. In the future, we plan on analysing students' data from different university's courses and majors and mining several academic years in order to create a reliable assessment index for early prediction of students' failure.

20. **Ilieva**, G. (2020) Fuzzy Group Full Consistency Method for Weight Determination. *Cybernetics and Information Technologies*. 20(2). p. 50–58. Print ISSN: 1311-9702 Online ISSN: 1314-4081 https://doi.org/10.2478/cait-2020-0015

In this paper, the FUll COnsistency Method (FUCOM) is extended to work in a collective manner, to solve a fuzzy optimization problem and to obtain the fuzzy weights of criteria. The employment of a predefined order of criteria decreases the number of fuzzy comparisons needed in the evaluation phase. The defuzzified values of the optimal weight coefficients are calculated by Graded Mean Integration Representation formula. This feature also reduces time complexity without affecting the quality of the solution. Two practical examples are presented to verify the reliability and feasibility of the proposed fuzzy group FUCOM. The obtained results demonstrate that the new fuzzy group weight determination method can obtain appropriate criteria importance.

21. **Ilieva**, G., Yankova, T., Hadjieva, V., Doneva, R. and Totkov, G. (2020) Cloud Service Selection as a Fuzzy Multi-criteria Problem. *TEM Journal*. 9(2). p. 484–495. ISSN: 2217-8309 https://doi.org/10.18421/TEM92-09

Cloud adoption is an attractive technological innovation due to the capital cost reduction and fast quality improvements it provides. In this paper, we present a new fuzzy methodology for cloud service selection. Product features and functionalities, customer support, customer rating, and security options are just a few of the factors influencing cloud platforms evaluation. A practical example for ordering cloud storage systems is calculated by using fuzzy measurement of alternatives and ranking according to the compromise solution (MARCOS) method. After establishing the relevant indicators for cloud technologies' assessment and their relative weights, crisp values and linguistic terms are transformed into triangular fuzzy numbers and then multi-criteria analysis is employed. The obtained ranking helps managers make an informed and wellgrounded decision for cloud platform selection.

22. **Ilieva**, G. & Yankova, T. (2020) IoT in Distance Learning during the COVID-19 Pandemic. *TEM Journal*. 9(4). p. 1669–1674. ISSN: 2217-8309 https://doi.org/10.18421/TEM94-45

Despite the worldwide physical closing of educational institutions due to the pandemic of COVID-19 in the spring of 2020, the learning process was not interrupted. Learning management systems and digital tools for online collaboration ensured a safe distance and continuity of educational activities. However, the rapid transition to remote learning in electronic environment has created a number of challenges in higher education. In order to derive longterm benefits from the changes in the way of teaching and examining, the paper explores the possibilities of IoT technology for continuous monitoring and flexible management of the learning process. The proposed framework for IoT application in educational activities will facilitate the adaptation of studying process at universities to the new circumstances.

23. **Ilieva**, G., Yankova, T., Klisarova-Belcheva, S. and Ivanova, S. (2021) Effects of COVID-19 Pandemic on University Students' Learning. *Information*. 12, 163. 21 p. ISSN: 20782489 https://doi.org/10.3390/info12040163

The risk of COVID-19 in higher education has affected all its degrees and forms of training. To assess the impact of the pandemic on the learning of university students, a new reference framework for educational data processing was proposed. The framework unifies the steps of analysis of COVID-19 effects on the higher education institutions in different countries and periods of the pandemic. It comprises both classical statistical methods and modern intelligent methods: machine learning, multi-criteria decision making and big data with symmetric and asymmetric information. The new framework has been tested to analyse a dataset collected from a university students' survey, which was conducted during the second wave of COVID-19 at the end of 2020. The main tasks of this research are as follows: (1) evaluate the attitude and the readiness of students in regard to distance learning during the lockdown; (2) clarify the difficulties, the possible changes and the future expectations from distance learning in the next few months; (3) propose recommendations and measures for improving the higher education environment. After data analysis, the conclusions are drawn and recommendations are made for enhancement of the quality of distance learning of university students.

III. TEXTBOOK

24. **Ilieva**, G. (2016) *Management Intormation Systems*, Plovdiv University Publishing House "P. Hilendarski", 109 p. ISBN 978-619-202-144-3, ISBN 978-619-202-145-0 CD

The textbook reflects the lecture course on "Management Information Systems", usually enrolled in by junior (third-year) students majoring in "Business Administration" at the University of Plovdiv "Paisii Hilendarski". It aims to offer students specialized theoretical as well as practical professional knowledge about applications of information systems in management practice. Its content covers the theoretical foundations of modern management information systems – their peculiarities, functions, problems and challenges faced. Special attention is paid to the relationship between management, technology and organizational aspects in MIS deployment. The emphasis of the discipline is placed on the most popular information systems and business analysis software used by managers at all organizational levels and functional areas (manufacturing, marketing, finnce and accoubnting, human resource management). Students can employ the acquired knowledge and practical skills in their professional careers as managers in the modern information society.

Plovdiv, Bulgaria   Signature:

05.07.2021   assoc. prof. Galina Ilieva, PhD