Editorial

ADVANCES IN FUZZY TECHNIQUES AND APPLICATIONS: IN OCCASION OF LOTFI ZADEH 100 BIRTH ANNIVERSARY

Zeshui XU[1*], Enrique HERRERA-VIEDMA[2]

[1]*Business School, Sichuan University, Chengdu, 610064, Sichuan, China*
[2]*Andalusian Research Institute in Data Science and Computational Intelligence, University of Granada, E-18071 Granada, Spain*

We Associate Editors, Professor Zeshui Xu from the Sichuan University, China, together with Professor Enrique Herrera-Viedma from University of Granada, Spain, have organized and edited the eight papers of this special issue to address a new research trend on the advances in fuzzy techniques and applications in supply chain management and financial economics. Considering that, the fuzzy techniques involved in the eight papers are all based on the fuzzy theory proposed by Zadeh, and they all well integrate the original fuzzy theory into various decision-making method and further properly be applied into the most popular fields of supply chain management (SCM) and finance economics. It is suggested that the eight papers are appropriate for the special issue on fuzzy technique in occasion of Lotfi Zadeh 100 birth anniversary. Following are the messages that they would like to share with Journal "Technological and Economic Development of Economy" (TEDE) readers.

Fuzzy techniques, which introduce fuzzy theory into optimal modeling, method, computation, synthesis algorithms and approaches, provide effective and useful tools for solving decision-making (DM) problems. The studies on decision-making with the aid of fuzzy techniques in supply chain management (SCM) and financial economics has become promising in recent years. Decision-making methods with up-to-date fuzzy techniques has been recently published in TEDE (Nana Liu, Yue He, Zeshui Xu, Evaluate public-private-partnership's advancement using double hierarchy hesitant fuzzy linguistic PROMETHEE with subjective and objective information from stakeholder perspective, *Technological and Economic Development of Economy*, *25*(3), 1–35, 2019; Huchang Liao, Hongrun Zhang, Cheng Zhang, Xingli Wu, Abbas Mardani, Abdullah Al-Barakat, A q-rung orthopair fuzzy GLDS method for investment evaluation of be angel capital in China, *Technological and Economic Development of Economy*, *26*(1), 103–134, 2020; Zengxian Li, Guiwu Wei, Rui Wang, Jiang Wu, Cun Wei, Yu Wei, EDAS method for multiple attribute group decision making under q-rung

---

*Corresponding author. E-mail: xuzeshui@263.net

orthopair fuzzy environment, *26*(1), 86–102, 2020). However, it is still of great importance to explore the application of fuzzy techniques in the field of SCM and financial economics. In particular, the application of fuzzy techniques in green supplier selection, industrial procurement, financial optimization, inventory control and portfolio selection evolving topics are especially interesting.

The eight papers we selected according to the review criterion on technical contributions that highlight the evolving research concerning the fuzzy techniques and its applications in SCM and financial economics. Among them, the first four papers focus on the fuzzy techniques including TODIM, fuzzy COPRAS and FMIP and their applications in green supplier selection and industrial procurement. The fifth paper dedicates to investigating fuzzy modes integrating fuzzy EDAS, ABC analysis with fuzzy FUCOM for increasing business efficiency in inventory management. Supplier selection, procurement containing supplier and order allocation and inventory management are important parts of SCM.

In this regard, the following paper gives an overview of fuzzy techniques in supply chain management and proposes future directions regarding fuzzy techniques in SCM. The last two papers mainly investigate the financial optimization models including fusion MRDM model for improving the AI-enabled auditing techniques and interval type-2 fuzzy solution approach for solving PPSS problem in which split of projects and re-execution are allowable.

Specifically, the first paper, "A novel TODIM based on prospect theory to select green supplier with q-rung orthopair fuzzy Set" (authored by Xiaoli Tian, Meiling Niu, Weike Zhang, Lanhao Li, Enrique Herrera-Viedma), proposes a novel TODIM based on prospect theory with q-rung orthopair fuzzy set (q-ROFS) for choosing a proper green supplier, in which both the perceived transformed probability weighting function and the differences in risk attitudes are concerned. The authors carry out a new distance, which concerns the herd mentality, to measure the perceived difference of the q-ROFS. Besides, they establish a new systematic evaluation index system, named as PCEM (Product, Cooperation ability, Environment, Market). This system can be used for various green supplier problems, which shows excellent versatility. By applying the model into a case of pork supplier companies, the effectiveness of the novel TODIM is fully proved by comparing it with the extended TODIM and extended TOPSIS. Besides, the advantages of q-ROFS to IFS and PFS are also verified in the application of the case.

The second paper, "Automobile components procurement using a DEA-TOPSIS-FMIP approach with all-unit quantity discount and fuzzy factors" (authored by Jiajia Chen, Zeshui Xu, Xunjie Gou, Dongbin Huang, Jianchuan Zhang), devotes to proposing a two-stage approach consisting of a DEA-TOPSIS approach for screening suppliers, and subsequentially a fuzzy mixed integer programming (FMIP) model with multiple objectives for optimizing order allocations. The DEA-TOPSIS approach integrates suppliers' comparative performance and diversity performance into an overall index that improves the ranking of potential suppliers, while the FMIP model features a soft time-window in delivery punctuality and an all-unit quantity discount function in cost. This paper contributes to integrating multi-attribute decision analysis approach in the form of DEA cross evaluation with TOPSIS and FMIP model for supporting components procurement decisions. Finally, the authors apply the approach in an automobile procurement case of Chongqing SOKON Industry Group Stock

Corporation Ltd in China, and effectively supports decision makers in yielding procurement plans for various components offered by many potential suppliers.

Since the ambiguity of human judgment, a series of multi-attribute group decision-making methods with fuzzy theory appear. In this regard, the third paper, "An extended COPRAS model for multiple attribute group decision making based on single-valued neutrosophic 2-tuple linguistic environment" (authored by Guiwu Wei, Jiang Wu, Yanfeng Guo, Jie Wang, Cun Wei) develops the COPRAS model to solve the multiple attribute group decision making (MAGDM) under single-valued neutrosophic 2-tuple linguistic sets (SVN2TLSs). The authors introduce the relevant knowledge about SVN2TLSs in a nutshell, and then combine the traditional COPRAS model with SVN2TLNs, and structure as well as elucidate the computing steps of the SVN2TLN-COPRAS pattern. Furthermore, they propose a method for determining attribute weights in different situations relying on the maximizing deviation method with SVN2TLNs. Finally, the authors design a numerical example about assessing the safety of construction project and demonstrate the advantage of the new designed method.

This fourth paper, "COPRAS method for multiple attribute group decision making under picture fuzzy environment and their application to green supplier selection" (authored by Jianping Lu, Siqi Zhang, Jiang Wu, Yu Wei), focuses on exploring a novel picture fuzzy CO-PRAS to select the optimal supplier for enterprises. A method called CRITIC is utilized to calculate criteria's weights. Afterwards, the authors extend the conventional COPRAS method to the PFSs to calculate each alternative's utility degree. Finally, they carry out a numerical example of selecting applicable physician to show the effectiveness and practical implications of the proposed model. At last, the designed method is applied to a green supplier selection and the designed method's superiority is verified by comparative analysis.

Considering that appropriate implementation and organization of logistics activities greatly contributes to the creation of a better business environment in companies, it is necessary to lead proactive management with a focus on key resources, the fifth paper, "A novel fuzzy MCDM model for inventory management in order to increase business efficiency" (authored by Zeljko Stevic, Dragan Vukasovic, Dejan Gligovic, Svetlana Terzic, Perica Macura), creates two novel integrated models in fuzzy form. The first model includes the integration of the fuzzy FUCOM and the fuzzy EDAS method for sorting 78 products regarding the following four criteria: quantity, unit price, annual procurement costs and demand. The second model involves the integration of the fuzzy FUCOM method and ABC analysis for inventory sorting considering different significance of criteria. The advantages and verification of the developed integrated fuzzy models have been performed through comparison with former traditional approaches. It has been determined based on an extensive sensitivity analysis that the developed models have better performance compared to the existing ones.

Since the fuzzy techniques in supplier selection, industrial procurement and inventory management form the important parts of the application in supply chain management (SCM). The sixth paper, "An overview of fuzzy techniques in supply chain management: bibliometrics, methodologies, applications and future directions" (authored by Huchang Liao, Keyu Lu, Edmundas Kazimieras Zavadskas), analyzes the advances of fuzzy techniques in SCM and reviews 301 relevant papers from 1998 to 2020. By the analyses in terms of bibliometrics, methodologies and applications, publication trends, the authors find popular meth-

ods such as fuzzy MCDM methods, and hot applications such as supplier selection. Finally, they propose future directions regarding fuzzy techniques in SCM. This paper is helpful for scholars and practitioners in the field of fuzzy decision-making and SCM.

In addition, fuzzy techniques are widely used in the fields of finance economics. The seventh paper, "Identifying key factors for adopting artificial intelligence-enabled auditing techniques by joint utilization of fuzzy-rough set theory and MRDM technique" (authored by Kuang-Hua Hu, Fu-Hsiang Chen, Ming-Fu Hsu, Gwo-Hshiung Tzeng), proposes a fusion multiple rule-based decision making (MRDM) model that integrates rule-based technique (i.e., the fuzzy rough set theory (FRST) with ant colony optimization (ACO)) into MCDM techniques that can assist decision makers in selecting the best methods necessary to achieve the aspired goals of audit success. The authors also consider potential implications for articulating suitable strategies that can improve the adoption of AI-enabled auditing techniques and that target continuous improvement and sustainable development.

The last paper, "A new type-2 fuzzy optimization model for portfolio selection incorporating project interdependence and splitting with economic impacts" (authored by Samaneh Zolfaghari, Seyed Meysam Mousavi, Jurgita Antuchevičienė) presents a new optimization model and a new interval type-2 fuzzy solution approach for project portfolio selection and scheduling (PPSS) problem, in which split of projects and re-execution are allowable. The approach is realized as a multi-objective optimization that maximizes total benefits of projects concerning economic concepts by considering the interest rate and time value of money and minimizes the tardiness value and total number of interruptions of chosen projects. Besides, budget and resources limitation, newfound relations are proposed to consider dependency relationships via a synergy among projects to solve PPSS problem hiring interval type-2 fuzzy sets. Then, the authors provide and solve numerical instances by a new extended procedure based on fuzzy optimistic and pessimistic points of view considering several situations. Finally, their results are studied and the results show that it is more beneficial when projects are allowed to be split.

These eight papers show the new trends on fuzzy techniques and applications in supply chain management and financial economics. We would like to acknowledge all the contributors to this collection of insightful results and all reviewers who have collaborated in the review process too.