Contents lists available at Science-Gate

International Journal of Advanced and Applied Sciences

Journal homepage: http://www.science-gate.com/IJAAS.html

A study on application of fuzzy methods in entrepreneurship domain

Norhaidah Abu Haris [1,*], Fauziah Abdul Rahman [2]

[1]Malaysian Institute of Information Technology, Universiti Kuala Lumpur, 50300 Kuala Lumpur, Malaysia
[2]Malaysian Institute of Industrial Technology, Universiti Kuala Lumpur, 81750 Masai, Johor, Malaysia

ARTICLE INFO

Article history:
Received 1 December 2016
Received in revised form
2 September 2017
Accepted 16 October 2017

Keywords:
Entrepreneurship
Fuzzy methods
Prediction

ABSTRACT

Entrepreneurial culture is receiving a greater amount of attention by academician and practitioners. Various fields of studies on entrepreneurship domain have been analyzed using fuzzy methods for prediction. The fuzzy method's application is believed could be utilized to obtain meaningful knowledge on the various areas of entrepreneurship domain of studies.

1. Introduction

Research in entrepreneurship is perceived importance for developing countries like Malaysia to boost economic progress and social adjustment. Attitudes towards opportunity for entrepreneurial activity have effects on their intention to create a new venture. The entrepreneurial intention is considered as a state of an individual mind directing and guiding them towards the development and implementation of new business concepts (Bird, 1988). The fuzzy methods approach can be used to evaluate the entrepreneurship tendencies in any organization (Hornaday, 1992) thru:

- Assisting organizations improve their culture by explaining the elements of entrepreneurship by encouraging entrepreneurial activities when appropriate.
- Advising on entrepreneurial activities where political structure should provide a climate in which economic innovation, organization creation and profit seeking on the market can take place.

This paper attempted to explore on Fuzzy methods applied in entrepreneurship domains. Fuzzy methods are designed to handle imprecise and complex problems. The cognitive framework of Fuzzy methods could be exploited by formalizing the way a human being interprets on the problems and situations. The integration of Fuzzy methods could be a reliable methodology for managers, practitioners and analysts for decision making (Malagoli et al., 2007).

2. Fuzzy theory

The Fuzzy method was introduced by Zadeh (1965). Fuzzy methods are a computational methods based on human thinking. The significant concept in Fuzzy methods is the application of linguistic variables in which the variables values in the form of words or sentences in Natural Language (Zadeh, 1975). A wide particular application have found that Fuzzy Controllers and Fuzzy Reasoning approach are efficient in designing certain complex industrial and management systems, which cannot be modeled precisely under various assumptions and approximations (Tzafestas et al., 1994). Fuzzy methods can be roughly classified into five major areas (Wang, 1999):

a. Fuzzy Mathematics-classical mathematical concepts are extended by replacing classical sets with fuzzy sets.
b. Fuzzy logic and Artificial Intelligence-approximations to classical logic are introduced and expert systems are developed based on fuzzy information and approximate reasoning.
c. Fuzzy systems-fuzzy control and fuzzy approaches in signal processing and communications.
d. Uncertainty and information-different kinds of un-certainties are analyzed.
e. Fuzzy decision making-considers optimization problems with soft constraints. Fig. 1 illustrates in detail the area of Fuzzy Methods.

Fuzzy methods also provide a simple way to arrive at a definite conclusion based upon vague, ambiguous, imprecise, noisy or missing input information. The prediction using Fuzzy methods

* Corresponding Author.
Email Address: norhaidah@unikl.edu.my (N. A. Haris)
https://doi.org/10.21833/ijaas.2017.012.036
2313-626X/© 2017 The Authors. Published by IASE.

could be organized in the following stages. The stages (Kaur and Aggrarwal, 2013) are:

- Define the objectives-identify the parameter to control, identify the action to control the system, identify the possible response, and identify the probability of system failure modes.
- Identify input and output-identify the input and output relationship. Choose a minimum variable for input to fuzzy engine.
- Create rule-using the rule based structure of FL, break the problem down that escalated into a set of rules.
- Fuzzy membership function-create fuzzy membership functions that define the input or output used in the rules.
- Fuzzy Functions-create necessary fuzzy functions.
- Results Evaluation-test the system, evaluates the results, tune the rules and membership functions, and retest until satisfactory results are obtained.

3. Fuzzy inference system

Fuzzy inference system is an application of Fuzzy Logic and Fuzzy Set Theory (Zadeh, 1965), which can be helpful to achieve classification tasks, offline process, simulation and diagnosis, online decision support tools and process control. FIS was adopted in several studies as a prediction model. This method was useful when the data sample includes linguistic variables or the data was from non-numerical sources such as questionnaires (Kusan et al., 2010).

The structure of FIS as shown in Fig. 2 consists of:

- Knowledge Base-consists of database and rule base. Rule base containing a number Fuzzy IF-THEN rules. A database defines Fuzzy Membership function of the fuzzy sets used in the fuzzy rules.
- Process under control-perform the inference operation of the rules.
- Fuzzification interface-transform inference results into crisp output.
- Defuzzification interface-transform inference fuzzy results into crisp output.

3.1. Fuzzy membership function

Fuzzy Membership functions can be determined with two approaches. The first approach is to use the knowledge of human experts and the second approach is to use data collected from various sensors. There are several membership functions such as triangular, normal distribution, trapezoidal, quadratic, Gaussian (exponential) and special function (cos-function) (Reznik 1997; Wang 1999; Zhang and Liu, 2006). The shape of membership functions usually dependent on the system being studied or the application problems (Reznik, 1997). Fuzzy membership approaches are listed in detail in Table 1.

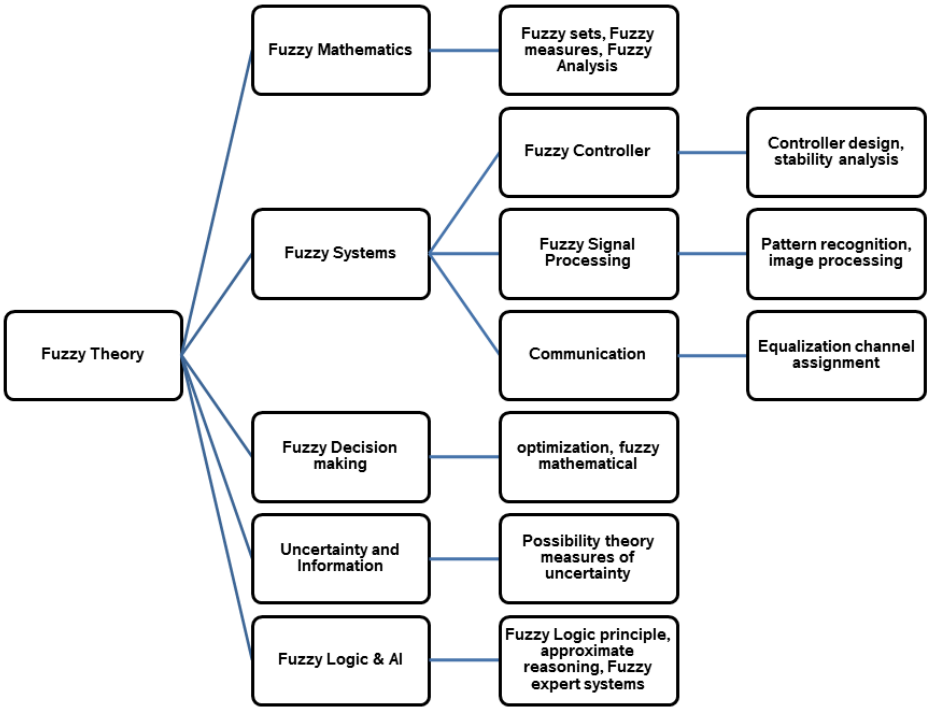

Fig. 1: Research area in fuzzy methods (Wang, 1999)

3.2. Fuzzy control and choice of parameters

Fuzzy Controller has three types which are Simple Fuzzy Controllers, Complex and/or multilevel fuzzy controllers and Adaptive and/or self-organizing fuzzy controller (Reznik, 1997). Fuzzy controllers can be easily modified and be employed with multiple inputs and outputs. The choice of fuzzy controllers is dependent on the choice of parameters. Therefore, to choose a parameter for

certain conditions or problems, certain procedure needs to be followed. Table 2 presented the flow that must be pursued in order to produce a prediction using Fuzzy methods.

4. Application of fuzzy methods in entrepreneurship domain

There has been a significant increase in entrepreneurship domain studies using fuzzy methods. This has in turn increased academicians and practitioner's interest in various facets of entrepreneurial activities. In order to promote entrepreneurship, identifying and overcome the obstacles in every possible area of entrepreneurship domain are very important (Alroaia et al., 2012a). Fuzzy methods have been identified beneficial to produce a certain prediction.

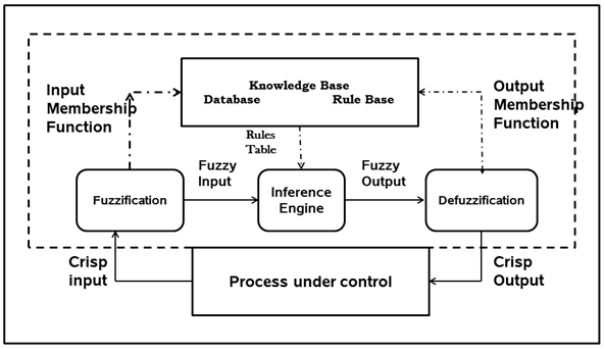

Fig. 2: The structure of FIS (Wang, 1999)

Table 1: The FIS approach structure (Liu et al., 2016)

Approach	Method	Description
Subjective	Expert knowledge and intuition	Expert generates information based on knowledge and problem area. Descriptive fuzzy set with the linguistic term
	Opinion poll results processing	Expert generates information based on knowledge and problem area. Descriptive fuzzy set with the linguistic term.
	Ranking	Expert ability to compare and rank different objects. Determine the membership degree through pairwise comparison.
	Logic inference	Deductions from available knowledge (nature's laws or expert knowledge). Membership degree is deduced from some information available and related to the object considered.
	Inductive reasoning	Derived membership degrees from particular sets. Membership degrees are derived by generalizing some available data.
	Fuzzy statistics	Statistical processing of the data available. Membership degrees are derived from the methods of mathematical statistics.
Objective	Control engineering	Assigned membership functions from recommendations of control theory. Membership functions are assigned according to some rules derived from control theory method
	Neural networks	Modelling membership functions or their parameters with neural network. Neural Network becomes a part of a neural fuzzy system modelling
	Genetic algorithm	Choosing the parameters of the membership functions with genetic/evolutionary algorithm. Parameters of the membership functions initially chosen are charged by applying a special optimization technique.

The fuzzy methods in most of the studies of human behavior were used through a questionnaire. However, uncertainty in the related data leads to the notion of imprecision (Kushwaha and Kumar, 2009). These studies in entrepreneurship domain believe that fuzzy methods have the advantage to reduce uncertainty and clarity in results.

Table 3 illustrates several studies that have applied fuzzy methods to extract and analyze particular information of interest in entrepreneurship domain.

Table 2: The flow structure to produce fuzzy prediction (Wang, 1999)

No	Control Flow Structure	Description
1	Structure choice	Apply hierarchical structure when in doubt on the stability of a fuzzy control system
2	Inputs choice	Choose inputs that are dependent on the control rules and dependent on the output of these inputs
3	Scaling factors choice	Scaling factors must satisfy the performance parameters
4	Number of class choices	The number of membership functions dependent on function density in the input region.
5	Membership functions choices	The approach could be determined by the expert or control engineering
6	Rules choices	Methods: • Experts experience and knowledge. • Operators control actions learning • Fuzzy model of the process or object under control usage • Learning technique application
7	Defuzzification method choice	Choose the method according to criteria
8	Fuzzy reasoning method choice	Mamdani method-if the rules formulated by human experts. Sugeno method-if computational efficiency and convenience analysis
9	t norm and s norm calculation choice	t norm-min or product operators s norm-max or algebraic sum

5. The implementation of fuzzy methods in entrepreneurship domain studies

The data collected in most of these studies were through questionnaires or surveys. Questionnaires are usually designed to assess many domains on issues related to psychology such as perceptions, opinions, emotional states, etc. The questionnaires responses usually distributed using Likert scales (Suárez et al., 2013; Castillo et al., 2014). Therefore,

in order to exploit individual differences in responding questionnaires, an expressive scale should be exploited. The questionnaires using Likert scales usually require respondents to choose one within a list of prefixed labels.

Table 3: Studies using fuzzy methods in entrepreneurship domain

No	Areas of Studies	Methods
1	Analyze the economic, psychological model of factors that influence individual's intentions to become entrepreneurs in Tunisia	Fuzzy Sets (Khefacha and Belkacem, 2015)
2	Analyze specific conditions of social entrepreneurs' confidence in managing their business	Fuzzy Sets (Munoz and Kibler, 2016)
3	Analyze various characteristics to distinguish which entrepreneurs will sustain in their business	Fuzzy Sets (Munoz, 2012)
4	Analyze the necessary and sufficient conditions for higher entrepreneurs rates	Fuzzy Logic (Ferreira and Dionısio, 2016)
5	Identify business opportunity based on the factors related to entrepreneurial activities	Fuzzy AHP (Sheela and Murthy, 2015)
6	Analyzing students' entrepreneurial intention based on emotional intelligence and personality traits	Fuzzy DEMATEL (Dehkordi et al., 2012)
7	Analyze on the obstacles to develop entrepreneurship in the industries. Identify the critical external and internal obstacles that will hinder the development	Fuzzy DEMATEL (Alroaia et al., 2012a)
8	Analyze the engineering lecturers' knowledge on entrepreneurship elements or contents in teaching entrepreneurship modules	Fuzzy DELPHI (Mohd et al., 2015)
9	Determine the problems criteria related to entrepreneurship in corporate organizations	Fuzzy DEMATEL (Aliei and Rafiean, 2014)
10	Evaluation of entrepreneurial universities based on a set of criteria	Fuzzy AHP And Fuzzy TOPSIS (Mavi, 2014)
11	Analyze the relationship between organizational entrepreneurship and social capital to encourage people changing the organization from no entrepreneurship to entrepreneurship	Fuzzy Logic (Yaghoubi et al., 2011)
12	Measure the entrepreneurial orientation to determine the degree of entrepreneurial behaviors of the firms	Fuzzy AHP (Rezaei et al., 2013)
13	Evaluate the strength and gaps of the technological entrepreneurship capabilities of high tech firms	Fuzzy Logic (Hejazi and Seifollahi, 2016)
14	Evaluate the priority factors in the establishment of an entrepreneurial university	Fuzzy AHP (Nikfarjam et al., 2013)
15	Identify the ranking on best online business course programs conducted by a few universities	Fuzzy VIKOR (Nisel, 2014)
16	Identify students entrepreneurial competencies quality	Neuro Fuzzy (Arafeh, 2016)
17	Identify the influence of social capital, entrepreneurial alertness and entrepreneurship environment on business performance	Fuzzy set Qualitative Comparative Analysis (Liu et al., 2016)
18	Identify the rank and the effective factors on the success of entrepreneurs which will give impact on the development in the industrial section	Fuzzy DEMATEL (Alroaia et al., 2012b)

However, the questionnaires based on fuzzy have a format that combines visual analogue and fuzzy linguistic scale when analyzing responses. The novelties of analyzing data using fuzzy methods that each data are treated entirely therefore relevant information will not lost (Angeles et al., 2015).The studies illustrate in Table 3 have chosen certain fuzzy methods that are possible to solve the encountered problems. The strength of these fuzzy methods was chosen because these researchers believed the studies could be solved efficiently. The strength of these fuzzy methods was further described in Table 4.

Table 4: Fuzzy methods strength in solving problems

Methods	Definition	Strength
Fuzzy AHP (Saaty, 1987)	AHP-Analytical Hierarchy Process	A systematic method to solve complex and multi-level decision making problems. This method is applicable in situations where decision makers and experts are available. This method able to solve hierarchical fuzzy decision making problems.
Fuzzy DEMATEL (Gabus and Fontela, 1973; Gabus and Fontela, 1972)	DEMATEL-Decision Making Trial and Evaluation Laboratory	A structural model that gathers group knowledge and visualize the causal relationship of criteria by using graphical diagram. This is a decision making method in the case that several criteria have complex relationships. This method allows extraction on interdependencies and strength among the criteria.
Fuzzy DELPHI (Kaufmann and Gupta, 1988)	DELPHI	The method is used for structuring a group communication process to facilitate group problem solving and to structure models (Linstone et al., 1975). The method can also be used as a judgment, decision-aiding or forecasting tool (Rowe and Wright 1999), and can be applied to program planning and administration (Delbecq et al., 1975). The Delphi method can be used when there is incomplete knowledge about a problem or phenomena (Adler and Ziglio, 1996; Delbecq et al., 1975). The method can be applied to problems with subjective judgments of individuals on a collective basis (Adler and Ziglio, 1996) and focus collective human intelligence on the problem at hand (Linstone et al., 1975) and can also be used to investigate what does not yet exist (Czinkota and Ronkainen, 1997; Skulmoski and Hartman, 2002)
Fuzzy TOPSIS	TOPSIS	The chosen alternative should have shortest distance from the positive ideal

(Hwang and Yoon, 1981)		solution and the farthest distance from the negative ideal solution.
Fuzzy VIKOR (Opricovic, 1998; Opricovic and Tzeng, 2007; Opricovic and Tzeng, 2004; Tzeng et al., 2002)	VIKOR-Vlse Kriterijumska Optimizacija I Kompromisno Resenje pronounce in Serbian which means Multi criteria Optimization and compromise solution	This method able to solve MCDM problem with conflicting or non-commensurable criteria (Opricovic and Tzeng, 2004). A set of alternatives is ranked and selected under conflicting criteria then each alternative is evaluated according to each criterion function. The compromise rank is selected by comparing the measure of closeness to the compromise alternative (Opricovic and Tzeng, 2004; Opricovic and Tzeng, 2002). The compromise solution will be basis for negotiations which involve decision makers' preference criteria weight (Opricovic, 2009).
Neuro Fuzzy (Jang, 1993)	Artificial Neuro fuzzy Inference Systems (ANFIS)	This method is used to achieve the reasoning and learning capabilities of Fuzzy Logic and Neural Network.
Fuzzy Set QCA (Ragin, 2000; Rihoux and Ragin, 2008)	Fuzzy set Quality Comparative Analysis (fsQCA)	Enables to draw conclusion about logical relationships without having to reduce the data to crisp binary sets.

6. Conclusion

Fuzzy methods can be versatile and flexible tool for data that are complex, vague and imprecise. Fuzzy addresses application that resembles human in decision making. Fuzzy methods have the ability to generate precise solutions for certain or approximate information and the data generates through fuzzy methods has the advantage of reducing uncertainty.

References

Adler M and Ziglio E (1996). Gazing into the oracle: The Delphi method and its application to social policy and public health. Jessica Kingsley Publishers, London, UK.

Aliei M and Rafiean H (2014). Generating Corporate entrepreneurship based on fuzzy DEMATEL in Iranian institutes. Journal of Engineering Technology, 2: 110-125.

Alroaia YV, Hemati M, and Javadinia M (2012a). A new approach to develop entrepreneurship of the industry using fuzzy DEMATEL. Management Science Letters, 2(4): 1279-1288.

Alroaia YV, Javidnia M, Shahmirzadi MK, and Nabavi SR (2012b). A survey of the effective factors on the entrepreneurial success and its impact on the development of industrial section by use of fuzzy DEMATEL. Caspian Journal of Applied Sciences Research, 1(10): 83-93.

Angeles GM, Lubiano MA, De Sáa SD, and Sinova B (2015). Analyzing data from a fuzzy rating scale-based questionnaire: A case study. Psicothema, 27(2): 182-191.

Arafeh L (2016). An entrepreneurial key competencies' model. Journal of Innovation and Entrepreneurship, 5: 1-26.

Bird B (1988). Implementing entrepreneurial ideas: The case for intention. Academy of Management Review, 13(3): 442-453.

Castillo I, Tomás I, Ntoumanis N, Bartholomew K, Duda JL, and Balaguer I (2014). Psychometricproperties of the Spanish version of the controlling coach behaviors scale in the sport context. Psicothema, 26(3): 409-414.

Czinkota MR and Ronkainen IA (1997). International business and trade in the next decade: Report from a Delphi study. Journal of International Business Studies, 28(4): 827-844.

Dehkordi AM, Sasani A, Fathi MR, and Khanmohammadi E (2012). Investigating the effect of emotional intelligence and personality traits on entrepreneurial intention using the fuzzy DEMATEL method. International Journal of Business and Social Science, 3(13): 286-296.

Delbecq AL, Ven DVAH, and Gustafson DH (1975). Group techniques for program planning: A guide to nominal group and Delphi processes. Scott Foresman, Glenview, USA.

Ferreira P and Dionısio A (2016). Entrepreneurship rates: The fuzzy-set approach. Eastern European Business and Economics Journal, 2(2): 111-128.

Gabus A and Fontela E (1972). World problems, an invitation to further thought within the framework of DEMATEL. Battelle Geneva Research Center, Geneva, Switzerland.

Gabus A and Fontela E (1973). Perceptions of the world problematique: Communication procedure, communicating with those bearing collective responsibility. Battelle Geneva Research Centre, Geneva, Switzerland.

Hejazi S and Seifollahi M (2016). A fuzzy-based model to assess technological entrepreneurship capabilities: Cases of high-tech firms. Asian Journal of Research in Business Economics and Management, 6(8): 1-24.

Hornaday RW (1992). Thinking about entrepreneurship: A fuzzy set approach. Journal of Small Business Management, 30(4): 12-24.

Hwang CL and Yoon K (1981). Multiple atrribute decision making methods and application a state-of-the-art-survey. Springer Heidelberg, Berlin, Germany.

Jang JS (1993). ANFIS: Adaptive-network-based fuzzy inference system. IEEE Transactions on Systems, Man, and Cybernetics, 23(3): 665-685.

Kaufmann A and Gupta MM (1988). Fuzzy mathematical models in engineering and management science. Elsevier Science Inc, Atlanta, USA.

Kaur B and Aggrarwal H (2013). An optimization of a planning information system using fuzzy inference system and adaptive neuro-fuzzy inference system. WSEAS Transactions on Information Science and Applications, 10(8): 249-260.

Khefacha I and Belkacem L (2015). Modeling entrepreneurial decision-making process using concepts from fuzzy set theory. Journal of Global Entrepreneurship Research, 5(1): 13-34.

Kusan H, Aytekin O, and Özdemir l (2010). The use of fuzzy logic in predicting house selling price. Expert Systems with Applications, 37(3): 1808-1813.

Kushwaha GS and Kumar S (2009). Role of the fuzzy system in psychological research. Europe's Journal of Psychology, 5(2): 123-134.

Linstone HA, Turoff M, and others (1975). The Delphi method: Techniques and applications. Addison-Wesley, Boston, USA.

Liu HW, Lin YL, Xu F, and Wang H (2016). Environmental conditions, entrepreneur alertness and social capital on performance. International Business Research, 9(8): 1-13.

Malagoli S, Magni CA, and Mastroleo G (2007). The use of fuzzy logic and expert systems for rating and pricing firms: A new perspective on valuation. Managerial Finance, 33(11): 836-852.

Mavi RK (2014). Indicators of entrepreneurial university: Fuzzy AHP and fuzzy TOPSIS approach. Journal of the Knowledge Economy, 5(2): 370-387.

Mohd RMJ, Saedah S, Farazila Y, Nurulrabihah MN, Zaharah H, and Ahmad Arifin S (2015). Aplikasi teknik Fuzzy Delphi terhadap keperluan elemen keusahawanan bagi pensyarah kejuruteraan Politeknik Malaysia. International Journal of Business and Technopreneurship, 5(1): 135-150.

Munoz P (2012). A fuzzy set approach to empirical typologies in sustainability entrepreneurship (interactive paper). Frontiers of Entrepreneurship Research, 32(5). Available online at: http://digitalknowledge.babson.edu/fer/vol32/iss5/25

Munoz P and Kibler E (2016). Institutional complexity and social entrepreneurship: A fuzzy-set approach. Journal of Business Research, 69(4): 1314-1318.

Nikfarjam A, Kiani MR, and Fazli S (2013). Prioritizing entrepreneurial university factors by fuzzy analytic hierarchy process. International Journal of Economy, Management and Social Sciences, 2(10): 876-884.

Nisel S (2014). An extended VIKOR method for ranking online graduate business programs. International Journal of Information and Education Technology, 4(1): 103-107.

Opricovic S (1998). Multicriteria optimization of civil engineering systems. Faculty of Civil Engineering, Belgrade, 2(1): 5-21.

Opricovic S (2009). Compromise in cooperative game and the VIKOR method. Yugoslav Journal of Operations Research, 19(2): 225-238.

Opricovic S and Tzeng GH (2002). Multicriteria planning of post-earthquake sustainable reconstruction. Computer-Aided Civil and Infrastructure Engineering, 17(3): 211-220.

Opricovic S and Tzeng GH (2004). Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS. European Journal of Operational Research, 156(2): 445-455.

Opricovic S and Tzeng GH (2007). Extended VIKOR method in comparison with outranking methods. European Journal of Operational Research, 178(2): 514-529.

Ragin CC (2000). Fuzzy-set social science. University of Chicago Press, Chicago, USA.

Rezaei J, Ortt R, and Scholten V (2013). An improved fuzzy preference programming to evaluate entrepreneurship orientation. Applied Soft Computing, 13(5): 2749-2758.

Reznik L (1997). Fuzzy controllers handbook: How to design them, how they work. Butterworth-Heinemann, Oxford, UK.

Rihoux B and Ragin CC (2008). Configurational comparative methods: Qualitative comparative analysis (QCA) and related techniques. Sage Publications, Thousand Oaks, Califirnia, USA.

Rowe G and Wright G (1999). The Delphi technique as a forecasting tool: Issues and analysis. International Journal of Forecasting, 15(4): 353-375.

Saaty RW (1987). The analytic hierarchy process-What it is and how it is used. Mathematical Modelling, 9(3-5): 161-176.

Sheela P and Murthy M (2015). The use of fuzzy analytical hierarchy process (FAHP) model for the primary screening of business opportunity in the process of entrepreneurial activity. International Journal of Marketing, Financial Services and Management Research, 4(5): 1-14.

Skulmoski G and Hartman F (2002). The Delphi method: Researching what does not exist (yet). In the IRNOP V Conference on International Research Network on Organization by Projects, Renesse, Netherlands.

Suárez EP, Muñiz J, Campillo AÁ, Fonseca PE, and García CE (2013). Assessing organizational climate: Psychometric properties of the CLIOR scale. Psicothema, 25(1): 137-144.

Tzafestas S, Venetsanopoulos A, and Terzakis S (1994). Fuzzy sets and fuzzy reasoning: An introduction. In: Tzafestas SG and Venetsanopoulos AN (Eds.), Fuzzy reasoning in information, decision and control systems: 3-29. Springer Science and Business Media, Berlin, Germany.

Tzeng, GH, Teng MH, Chen JJ, and Opricovic S (2002). Multicriteria selection for a restaurant location in Taipei. International Journal of Hospitality Management, 21(2): 171-187.

Wang LX (1999). A course in fuzzy systems. Prentice Hall, Upper Saddle River, USA.

Yaghoubi NM, Moloudi J, and Banihashemi SA (2011). Entrepreneurship in organization and social capital: Fuzzy logic approach. China-USA Business Review, 10(12): 79-86.

Zadeh LA (1965). Fuzzy sets. Information and Control, 8(3): 338-353.

Zadeh LA (1975). The concept of a linguistic variable and its application to approximate reasoning-I. Information Sciences, 8(3): 199-249.

Zhang H and Liu D (2006). Fuzzy modeling and fuzzy control. Springer Science and Business Media, Berlin, Germany.