A study on application of fuzzy methods in entrepreneurship domain

Norhaidah Abu Haris 1,*, Fauziah Abdul Rahman 2

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

A R T I C L E   I N F O

Abstract

Entrepreneurial culture is receiving a greater amount of attention by academicians 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.

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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 entrepreneurial 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 uncertainties 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...
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)](image)

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).

![Fig. 2: The structure of FIS (Wang, 1999)](image)

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 |
| Objective         | 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 |
|                   | 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)](image)

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 Methods: |
|    |                        | • Experts experience and knowledge.                                          |
|    |                        | • Operators control actions learning                                         |
| 6  | Rules choices          | • Fuzzy model of the process or object under control usage                   |
| 7  | Defuzzification method choice | Learning technique application                                               |
| 8  | Fuzzy reasoning method choice | Choose the method according to criteria                                       |
| 9  | t norm and s norm calculation choice | Sugeno method-if computational efficiency and convenience analysis           |

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 | FuzzyLogic (Ferreira and Dionisio, 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 (Delkordi et al., 2012)       |
| 7  | Analyze 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., 2012)       |
| 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 (Ali 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 SeifiIlahi, 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 (Nisal, 2014)                   |
| 16 | Identify students entrepreneurial competencies quality | Neuro Fuzzy (Arafah, 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 (Angelas et al., 2015). The studies illustrate in Table 3 have 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   | 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 | 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. 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). The chosen alternative should have shortest distance from the positive ideal. |
| Fuzzy DELPHI | DELPHI                                         |                                                                          |
| Fuzzy TOPSIS | TOPSIS                                        |                                                                          |
6. Conclusion

Fuzzy methods can be versatile and flexible tool for data that are complex, vague and imprecise. Fuzzy addresses applications 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.

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