

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Multi Criteria Decision Making (MCDM) problems are important in social science, medical science, management science, systems engineering and operation research. A MCDM method is a procedure that specifies how criteria information is to be processed in order of arriving at a choice.

The Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method, which is initially proposed by Hwang et al (1981), is one of the well-known multiple criteria decision making (MCDM) methods. The TOPSIS method introduces the shortest distance from the positive ideal solution (PIS) and the farthest distance from the negative ideal solution (NIS) to determine the best alternative. TOPSIS method has become a popular multiple criteria decision technique due to its theoretical rigorousness a sound logic that represents the human rationale in selection and it is one of the most appropriate methods in solving traversal rank.

As indicators are fuzzy in many decision making problems, scientists have tried to expand TOPSIS decision making model to fuzzy TOPSIS to solve such problems.

Recently, some researchers have focused on developing Fuzzy TOPSIS methods to deal with imprecise information.

Chu et al (2009) designed a fuzzy TOPSIS model based on interval arithmetic of fuzzy numbers.

In 2009 Ting-Yu Chen and Yi-Wen Li extended TOPSIS method for solving multi criteria decision analysis problems with intuitionistic fuzzy data that are expressed in terms of Intuitionistic Fuzzy Sets.

In 2010 Fuzzy Flexible TOPSIS was proposed with the objective of improving the Fuzzy TOPSIS ability to deal with uncertainty through the

combination of the mathematical process involved in the original Fuzzy TOPSIS with the expert empirical knowledge.

The following are some of the articles published on Fuzzy TOPSIS methods in decision making problems.

- 1) "Extensions of the TOPSIS for group decision-making under fuzzy environment", Chen, C.T., 2000 [11].
- 2) "Inter-company comparison using modified TOPSIS with objective weights", Deng, H., Yeh, C.H. and Willis, R.J., 2000 [18].
- 3) "Selecting plant location via a fuzzy TOPSIS approach", Chu, T.C., 2002 [15].
- 4) "Facility location selection using fuzzy TOPSIS under group decisions", Chu, T.C., 2002 [14].
- 5) "Extensions of TOPSIS for multi-objective large-scale nonlinear programming problems", Abo-Sinha, M.A. and Amer, A.H., 2005 [1].
- 6) "Multi-Criteria Group Decision Making a Modified Fuzzy TOPSIS Procedure", Soroush Saghafian and Reza Hejazi, S., 2005 [58].
- 7) "An Extension of TOPSIS for Group Decision Making", Hsu-Shih, Shih., Huan-Jyh, Shyur. and Stanley, Lee.E., 2006 [26].
- 8) "An algorithmic method to extend TOPSIS method for decisionmaking problems with interval data", Jahanshaloo, G.R, Hosseinzadeh F. Lotfi, M. Izadikhah, 2006 [31].
- 9) "Extension of the TOPSIS method for decision-making problems with fuzzy data", Jahanshaloo, G.R, Hosseinzadeh F. Lotfi, Izadikhah, M., 2006 [32].
- 10) "Fuzzy TOPSIS method based on alpha level sets with an application to bridge risk assessment", Ying-Ming Wang and Taha M.S. Elhag, 2006 [67].

- 11) "Generalizing TOPSIS for fuzzy multiple-criteria group decision-making", Wang, Y.J., Lee, H.S., 2007 [65].
- 12) "The interval-valued fuzzy TOPSIS method and experimental analysis", Ting-Yu Chen and Chueh-Yung Tsao., 2008 [60].
- 13) "Performance evaluation of Turkish cement firms with fuzzy analytic hierarchy process and TOPSIS methods", Ertugrul, I. and Karakasoglu, N., 2007 [22].
- 14) "Fuzzy hierarchical TOPSIS for supplier selection", Wang, J.W, Cheng, C.H. and Cheng, H.K., 2009 [63].
- 15) "Fuzzy Systems for Multicriteria Decision Making", Fabio J. J., Santos and Heloisa A. Camargo, 2010 [23]
- 16) "Service Selection Based on Fuzzy TOPSIS Method", Chi-Chun Lo, Ding-Yuan Chen, Chen-Fang Tsai and Kuo-Ming Chao, 2010 [12].
- 17) "An Integrated Fuzzy TOPSIS Method for Ranking Alternatives and its Application", Ji- Feng Ding, 2011 [33].
- 18) "Fuzzy TOPSIS Method in the selection of Investment Boards by Incorporating Operational Risks", Elissa Nadia Madi and Abu Osman Md Tap, 2011 [21].
- 19) "Introducing a new method to expand TOPSIS decision making model to fuzzy TOPSIS with trapezoidal fuzzy data", Mohammadi, Ali., Mohammadi, Abolfazl., Mohammadi, Madineh. and Aryaeefar, Hossain., 2011 [4].

In this review of literature a brief survey of some of the articles published on Fuzzy TOPSIS Methods and their applications are given.

1) Extentions of the TOPSIS for Group Decision-Making under Fuzzy Environment

Chen, T.C., (2000) [11]

In this paper, the rating of each alternative and the weight of each criterion are described by linguistic terms which can be expressed in triangular fuzzy numbers. Then, a vertex method is proposed to calculate the distance between two triangular fuzzy numbers. According to the concept of the TOPSIS, a closeness coefficient is defined to determine the ranking order of all alternatives by calculating the distances to both the fuzzy positive-ideal solution (FPIS) and fuzzy negative-ideal solution (FNIS) simultaneously. Finally, an example is shown to highlight the procedure of the proposed method at the end of this paper.

2) Using a Combined Intuitionistic Fuzzy Set-TOPSIS Method for Evaluating Project and Portfolio Management Information Systems

Vassilis C. Gerogiannis, Panos Fitsilis, and Achilles D. Kameas (2001) [62]

Contemporary Project and Portfolio Management Information Systems (PPMIS) have embarked from single-user, single-project management systems to web-based, collaborative, multi-project, multi-functional information systems which offer organization-wide management support. The variety of offered functionalities along with the variation among each organization needs and the plethora of PPMIS available in the market, make the selection of a proper PPMIS a difficult, multi-criteria decision problem. The problem complexity is further augmented since the multi stakeholders involved cannot often rate precisely their preferences and the performance of candidate PPMIS on them. To meet these challenges, this paper presents a PPMIS selection/evaluation approach that combines

TOPSIS with intuitionistic fuzzy group decision making. The approach considers the vagueness of evaluators' assessments when comparing PPMIS and the uncertainty of users to judge their needs.

3) Selecting Plant Location via a Fuzzy TOPSIS Approach

Chu, T. C (2002) [15]

In this paper a Fuzzy TOPSIS approach for selecting plant location is proposed, where the ratings of various alternative locations under various criteria and the weights of various criteria are assessed in linguistic terms represented by fuzzy numbers. In the proposed method, the ratings and weights assigned by decision makers are averaged and normalized into a comparable scale. The membership function of each normalized weighted rating can be developed by interval arithmetic of fuzzy numbers. To avoid complicated aggregation of fuzzy numbers, these normalized weighted ratings are defuzzified into crisp values. A closeness coefficient is defined to determine the ranking order of alternative locations by calculating the distances to both the ideal and negative-ideal solutions. Using the suggested method, the decision makers' fuzzy assessments with different rating viewpoints and the trade-off among different criteria are considered in the aggregation procedure to assure more convincing decision making. A numerical example demonstrates the feasibility of the proposed method.

4) A Fuzzy TOPSIS Method for Robot Selection

Chu, T.C. and Lin, Y.C (2003) [16]

A fuzzy TOPSIS method for robot selection is proposed, where the ratings of various alternatives versus various subjective criteria and the weights of all criteria are assessed in linguistic terms represented by fuzzy numbers. The values of objective criteria are converted into dimensionless indices to ensure compatibility between the values of objective criteria and the linguistic ratings of subjective criteria. The membership function of each weighted rating is developed by interval arithmetic of fuzzy numbers. To

avoid complicated aggregation of fuzzy numbers, these weighted ratings are defuzzified into crisp values by the ranking method of mean of removals. A closeness coefficient is defined to determine the ranking order of alternatives by calculating the distances to both the ideal and negative-ideal solutions. A numerical example demonstrates the computational process of the proposed method.

5) TOPSIS and Fuzzy Multi-Objective Model Integration for Supplier Selection Problem

Jadidi,O., Hong, T.S., Firouzi, F., Yusuff, R.M. and Zulkifli, N (2008) [30]

In this paper model is established for supplier selection problem and later the proposed single objective model is used to calculate the optimum order quantities among the selected suppliers. The problem includes the three objective functions: minimizing the total cost, the net rejected items and the inverse total value of purchasing (TVP), while satisfying capacity and demand requirement constraints. A numerical example is given to illustrate how the model is applied.

6) An Application of Fuzzy TOPSIS method in an SWOT analysis

Adel Hatami-Marbini and Saber Saati (2009) [2]

In this paper, linguistic variable represented with fuzzy numbers are used to assess the ratings and weights. Then, a Multi-Criteria Decision Making model based on fuzzy sets theory is proposed to handle the strategy selection problem with imprecise data. According to the concept of the TOPSIS in multiple-criteria group decision making (MCGDM) problem, an index of closeness coefficient (CC) is defined to determine the ranking order of all strategies by calculating the distance to the both fuzzy ideal solution and fuzzy anti-ideal solution based on approach of ordering of the fuzzy numbers simultaneously. Finally, an example is given to highlight the procedure of the proposed method.

7) Fuzzy AHP-TOPSIS Two Stage Methodology for ERP Software Selection: An Application in Passenger Transport Sector
Nurgul Demirtas, Ozge Nalan Alp, Umut Rifat Tuzkaya and Hayri Baracli (2011) [51]

In this paper, the most effective ERP (Enterprise Resource Planning) software is selected for a firm that services at urban passenger transport sector using two-stage fuzzy decision making technique. In the first stage, after the lack of the software application is determined, the decision of developing the new software by software development department in firm or buying a package program is given. In the second stage, if developing of the new software in firm is selected, the programming language is determined to develop the most effective ERP software application platform using fuzzy decision making technique. On the contrary, if buying a package program is chosen, the most effective package program is selected by using fuzzy decision making techniques.

8) A Fuzzy Topsis Multiple-Attribute Decision Making for Scholarship Selection
Shofwatul 'Uyun and Imam Riadi (2011)[57]

As the education fees are becoming more expensive, more students apply for scholarships. Consequently, hundreds and even thousands of applications need to be handled by the sponsor. To solve the problems, some alternatives based on several attributes (criteria) need to be selected. In order to make a decision on such fuzzy problems, Fuzzy Multiple Attribute Decision Making (FMADM) is applied. In this paper, Unified Modeling Language (UML) in FMADM with TOPSIS and Weighted Product (WP) methods is applied to select the candidates for academic and non-academic scholarships at Universitas Islam Negeri Sunan Kalijaga. Data used were a crisp and fuzzy data. The results show that TOPSIS and Weighted Product FMADM methods can be used to select the most suitable candidates to

receive the scholarships since the preference values applied in this method can show applicants with the highest eligibility.

9) Introducing a New method to Expand TOPSIS Decision Making Model to Fuzzy TOPSIS

Ali Mohammadi, Abolfazl Mohammadi and Hossain Aryaeefar (2011)[3]

In this paper, a new method is presented for fuzzy TOPSIS with triangular fuzzy data. So, it has better and more accurate outputs. At last, a fuzzy multiple attributes decision making problem to demonstrate the proposed method is solved.

10) A Facility Location Selection Problem by Fuzzy TOPSIS

Pelin Alcan and Huseyin Basligil (2011) [55]

In this paper Fuzzy TOPSIS model under group decisions is used for solving the facility location selection problem in Turkey.

11) The DEA and Intuitionistic Fuzzy TOPSIS Approach to Departments' Performances: A Pilot Study

Babak Daneshvar Rouyendegh (2011) [8]

This paper processes a unification of Fuzzy TOPSIS and Data Envelopment Analysis (DEA) to select the units with most efficiency. This research is a two-stage model designed to fully rank the organizational alternatives, where each alternative has multiple inputs and outputs. First, the alternative evaluation problem is formulated by Data Envelopment Analysis (DEA) and separately formulates each pair of units. In the second stage, the opinion of experts to be applied into a model of group Decision-Making (DM) called the Intuitionistic Fuzzy TOPSIS (IFT) method. The results of both methods are then multiplied to obtain the results. DEA and Intuitionistic Fuzzy TOPSIS ranking do not replace the DEA classification model; rather, it furthers the analysis by providing full ranking in the DEA context for all

units by aggregate individual opinions of decision makers for rating the importance of criteria and alternatives.

12) Application of Fuzzy TOPSIS Technique for Strategic Management Decision

Mostafa Emami, Kamran Nazari and Haniyeh Fardmanesh (2012) [49]

This paper discusses the use of MCDA (Multi-Criteria Decision Analysis) for supporting strategic management. By considering the technical issues associated with the content of strategic decisions, and also the social aspects that characterize the processes within which they are created. This paper presents a fuzzy TOPSIS technique for strategy selection problem.

13) A Fuzzy TOPSIS Method Based on Left and Right Scores

Mir. B. Aryanezhad, Tarokh, M.J., Mokhtarian, M.N., and Zaheri, F., (2011)[44]

Multiple criteria decision making (MCDM) problem is one of the famous different kinds of decision making problems. In more cases in real situations, determining the exact values for MCDM problems is difficult or impossible. So, the values of alternatives with respect to the criteria and the values of criteria weights, are considered as fuzzy values (fuzzy numbers). In such conditions, the conventional crisp approaches for solving MCDM problems tend to be less effective for dealing with the imprecise or vagueness nature of the linguistic assessments. In this situation, the fuzzy MCDM methods are applied for solving MCDM problems. In this paper, a Fuzzy TOPSIS (for Order Preference by Similarity to Ideal Solution) method based on left and right scores for fuzzy MCDM problems is proposed. To show the applicability of the proposed method, two numerical examples are presented. As a result, proposed method is precise, easy use and practical for solving MCDM problem with fuzzy data. Moreover, the proposed method considers the decision makers (DMs) preference in the decision making

process. It seems that the proposed fuzzy TOPSIS method is flexible and easy to use and has a low computational volume.

14) Application of Fuzzy TOPSIS Method for the Selection of Warehouse Location: A Case Study

Maysam Ashrafzadeh, Farimah Mokhatab Rafiei, Naser Mollaverdi Isfahani and Zahra Zare (2012) [40]

Warehouse location selection is a multi-criteria decision problem including both quantitative and qualitative criteria and has a strategic importance for many companies. The conventional approaches to warehouse location selection problem tend to be less effective in dealing with the imprecise or vague nature of the linguistic assessment. Under many situations, the values of the qualitative criteria are often imprecisely defined for the decision-makers. To overcome this difficulty, fuzzy multi-criteria decision-making methods are proposed. In this paper, a multi-criteria decision making approach for selecting warehouse location under partial or incomplete information (uncertainty) is presented. The proposed approach comprises of two steps. In step 1, the criteria for warehouse location selection is identified. In step 2, experts provide linguistic ratings to the potential alternatives against the selected criteria. Fuzzy TOPSIS is used to generate aggregate scores selection of best alternative. This paper shows a successful application of fuzzy TOPSIS to a real warehouse location selection problem of a big company in Iran.

15) An Evaluation Model of E-Service Quality by Applying Hierarchical Fuzzy TOPSIS Method

Chih-Cheng Lee, Chi Chiang and Chen-Tung Chen (2012) [13]

In this paper a hierarchical Multi-Criteria Decision Making evaluation model based on the Fuzzy Analytic Hierarchy Process (FAHP) and the Fuzzy Technique for Order Preference by Similarity to Ideal Solution (FTOPSIS) methods. In this paper, the weights of criteria and ratings of

alternatives are assessed by linguistic (natural language) variables expressed in triangular fuzzy numbers are proposed. Finally, four representative travel websites in Taiwan are provided to illustrate the practicability and usefulness of the proposed model. Moreover, the results of this study will help travel website managers understand their ranking positions relative to their competitors, thus can motivate travel website managers to provide appropriate levels of service quality in response to the e-customers' needs.

16) Evaluation of Green Supply Chain Management Strategies Using Fuzzy AHP and TOPSIS

Muralidar, P., Dr. Ravindran, K., Dr. Srihari, V. (2012) [50]

This paper presents a new decision making approach for group multi-criteria evaluation for green supply chain management strategies, which clubs green procurement, manufacturing , green service to customer and environmental management process with order allocation for dynamic supply chains to cope market variations. More specifically, the developed approach imitates the knowledge acquisition and manipulation in a manner similar to the decision makers who have gathered considerable knowledge and expertise in procurement domain. Using fuzzy TOPSIS method, the criteria application is quantitatively evaluated for order allocation among the selected strategies. As a result, the approach generates decision-making knowledge, and thereafter, the developed combination of rules for order allocation can easily be interpreted, adopted and at the same time if necessary, modified by decision makers. To demonstrate the applicability of the proposed approach, an illustrative example is presented and the results analyzed.

17) A Simplified Description of Fuzzy TOPSIS

Balwinder Sodhi and Prabhakar, T.V. (2012) [9]

A simplified description of Fuzzy TOPSIS (Technique for Order Preference by Similarity to Ideal Situation) is presented in this paper. The

TOPSIS description from existing Fuzzy theory literature is adapted and the bare minimum concepts required for understanding and applying TOPSIS is distilled. And also an example has been worked out to illustrate the application of TOPSIS for a multi-criteria group decision making scenario.

**18) Developing Fuzzy TOPSIS Method based on Interval valued Fuzzy Sets
Yahia Zare Mehrjerdi (2012) [66]**

Ranking competing alternatives in terms of their overall performance with respect to some criteria in fuzzy environment is possible by the use of fuzzy TOPSIS methodology using interval-valued fuzzy-sets concepts. This author presents an effective fuzzy multi-criteria method based upon the fuzzy model and the concepts of positive ideal and negative ideal solution points for prioritizing alternatives using inputs from a team of decision makers in this paper. The fuzzy sets concepts are used to evaluate the performance of alternatives and the importance of criteria. Fuzzy TOPSIS based on the interval-valued fuzzy-sets is fully described and a case study on RFID comprised of four main criteria and five alternatives is constructed and solved by the proposed extended TOPSIS method. The TOPSIS methodology used in this article is able to grasp the ambiguity exists in the utilized information and the fuzziness appears in the human judgments and preferences. TOPSIS technique can easily produce satisfactory results, and hence stimulates creativity and the invention for developing new methods and alternative approaches. This article is a very useful source of information for Fuzzy TOPSIS based on the interval-valued fuzzy sets and extends the area of application of RFID (Radio Frequency Identification) technology in general. Due to the fact that a better management of a system is related to the full understanding of the technologies implemented and the system under consideration, sufficient background on the methodologies are provided and a case study is developed and solved by the proposed method.

19) A New Fuzzy Positive and Negative Ideal Solution for Fuzzy TOPSIS

Mehdi Amiri-Aref, Nikbakhsh Javadian and Mohammad Kazemi (2012) [41]

This paper presents a fuzzy multiple criteria decision making (FMCDM) problem with the Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) based on the new concept of positive and negative ideal solution. Whereas decision making is a process which accuracy of data play major role to select the best alternative, considering decision making problems in fuzzy environments motivate the authors to search in this field. Triangular fuzzy numbers (TFN) among decision making process are used to evaluate the weighted different alternatives versus various criteria and a fuzzy group weight is made by different experts. In this paper, additionally, a new fuzzy distance formula is applied to compute distance between each alternative and positive as well as negative ideal solution. There is a flexibility to consider general fuzzy numbers (such as triangular, trapezoidal, interval), though. Then, new fuzzy TOPSIS to determine the ranking order of the alternatives is also presented. Finally, a numerical example from the literature is solved to demonstrate applicability of the proposed model. The comparison of illustrated algorithm with the three methods in the literature on various examples proved the efficiency of the proposed decisions.

20) Integrated Multi-criteria Flood vulnerability approach using Fuzzy TOPSIS and Delphi Technique

Lee, G., Jun, K.S., and Chung, E.S., (2013) [36]

This paper develops a new procedure that combines multi-criteria spatial vulnerability analysis with the traditional linear probabilistic risk approach. This approach is named integrated fuzzy flood vulnerability assessment because it combines the watershed-based vulnerability framework with stream-based risk analysis. The Delphi technique and

pressure-state-impact-response framework are introduced to objectively select evaluation criteria, and the fuzzy TOPSIS technique is proposed to address the uncertainty of weights to all criteria and crisp input data of all spatial units. This framework is applied to the south Han River basin in South Korea. As a result, the flood vulnerability ranking was derived and vulnerability characteristics of all spatial units were compared. This framework can be used to conduct a prefeasibility study for flood mitigation projects when various stakeholders should be included.