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Fuzzy Tops is Ranking of Academic Programs' Competitiveness

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Abstract

Acknowledging the level of relevancy and competitiveness of academic programs is very important to education providers. This in return will benefit students enrolling in the programs. Measuring the level of relevancy and competitiveness of academic programs can be very subjective. In this paper, the application of a quantitative multi criteria decision making method known as Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is presented. The relevancy and competitiveness of eleven academic programs offered at the Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Shah Alam are ranked based on seven criteria using modified Fuzzy TOPSIS. The criteria used in ranking of the academic programs were gathered from a group of twelve decision makers which comprises of top management of the faculty and university understudied. Quantitative ranking process was done based on data provided by the education provider itself. The seven criteria used include percentage of Dean's Award recipients, percentage of graduates with CGPA > 3.5, percentage of graduate employability, program popularity, percentage of students' entrance CGPA > 3.0, optimum enrollment based on allocation of places offered and future job demand. The weights of the criteria are determined using Fuzzy Analytical Hierarchy Process (AHP) technique. Modified Fuzzy TOPSIS are then used to rank the academic programs by incorporating the weights of criteria found. Future job demand and percentage of graduate employability are found to be the top two most important criteria used in the ranking process. Bachelor of Science (Hons) Statistics, Bachelor of Information Technology (Hons) Intelligent System Engineering and Bachelor of Science (Hons) Actuarial Science are found to be the top three most competitive programs offered by the institution. Consistency ratio test done indicated that the responses of decision makers are highly consistent thus reliable as reflected in the consistency ratio being < 0.1.

Keywords: Academic Programs, Competitiveness, Ranking, TOPSIS

Introduction

We are now in the era of Industry 4.0 where competitiveness amongst Higher Education Providers (HEP) is at its peak. Thus, universities need to have a mechanism in identifying the competitiveness of their academic programs that would enable them to plan and strategize on how to stay relevant in the education industries at the same time HEP could help the nation producing human resources apt for the current and future market demand. On the other hand, choosing the right academic program to embark on after completing secondary school education is an important step for school leavers since it is related to future employability and job prospect. Many factors have to be considered thus leading to a subjective decision making. In this paper, a multi criteria decision making method is proposed to rank eleven academic programs offered at the Faculty of Computer and Mathematical Sciences, UiTM Shah Alam based on seven criteria. Input from a group of twelve decision makers comprises of the top management of the faculty and university were gathered through questionnaires and historical data collected from four respective departments of the university while data on future job demand were collected from the Bureau of Labor Statistics. Weights of criteria were found using fuzzy AHP criteria weight determination method while the ranking was done using Fuzzy Modified TOPSIS method.

Literature Review

Multi Criteria Decision Making (MCDM) has been applied by many organizations in solving their daily decision-making problems as it is highly suitable for solving problems involving conflicting constraints and / or criteria. Furthermore, when carried out in fuzzy environment, Fuzzy Multi Criteria Decision Making (FMCDM), it is capable of solving more complicated problems which involved elements of subjectivity and vagueness (Harliza, Daud & Hashimah, 2013). Performance evaluation involving human judgement is highly subjective since it commonly comprises of multi-criteria, multi alternatives and several decision makers simultaneously, thus best done using multi criteria decision making method in fuzzy environment (Zadeh, 1965; Bellman & Zadeh, 1970). Ranking of fuzzy numbers require similarity measure checked as to minimize the loss of information occurred in computational process. Similarity measurement in fuzzy environment is a very useful. Thus, new similarity measures have been introduced for fuzzy sets (Hashimah, Daud, Jamilah & Aniza, 2018). For a more reliable result used in the study presented in this paper. The objective of this paper is to highlight the use of a fuzzy multi criteria decision making method for the ranking of competitiveness of academic programs offered at a higher-level education institution.

Methods and Materials

The methods undertaken for the ranking of academic programs competitiveness using Fuzzy modified TOPSIS is summarized in the research framework given in Fig.1. There are two major parts namely finding the weights for the seven criteria based on decision makers input using Fuzzy AHP criteria weight determination method followed by ranking of academic programs using Fuzzy Modified TOPSIS. Fuzzy AHP method is chosen due to its comprehensiveness in pairwise comparisons made on all criteria used (Prascevic & Prascevic, 2016).

To cater for vagueness in multi criteria decision making process involving seven criteria and twelve decision makers, the ranking process was done in fuzzy environment as proposed by previous

researchers (Zadeh, 1965; Bellman & Zadeh, 1970; Hashimah & Mohamad, 2017; Hanif et al., 2013; Sulaiman & Mohamad, 2013). Descriptions of data obtained from respective departments and questionnaires distributed to decision makers had used fuzzy linguistic terms. All triangular fuzzy scales and triangular fuzzy reciprocal scales used are as shown in Table 1 are following fuzzy notations introduced by Bozbura et al., 2007.

Table 1: Linguistic Scale of Importance

Linguistic Term of Importance	Triangular Scale	Fuzzy Triangular Fuzzy Reciprocal Scale
Just Equal (JE)	(1, 1, 1)	(1, 1, 1)
Equally More Important (EMI)	(1/2, 1, 3/2)	(2/3, 1, 2)
Weakly More Important (WMI)	(1, 3/2, 2)	(1/2, 2/3, 1)
Strongly More Important (SMI)	(3/2, 2, 5/2)	(2/5, 1/2, 2/3)
Very Strongly More Important (VSMI)	(2, 5/2, 3)	(1/3, 2/5, 1/2)
Absolutely More Important (AMI)	(5/2, 3, 7/2)	(2/7, 1/3, 2/5)

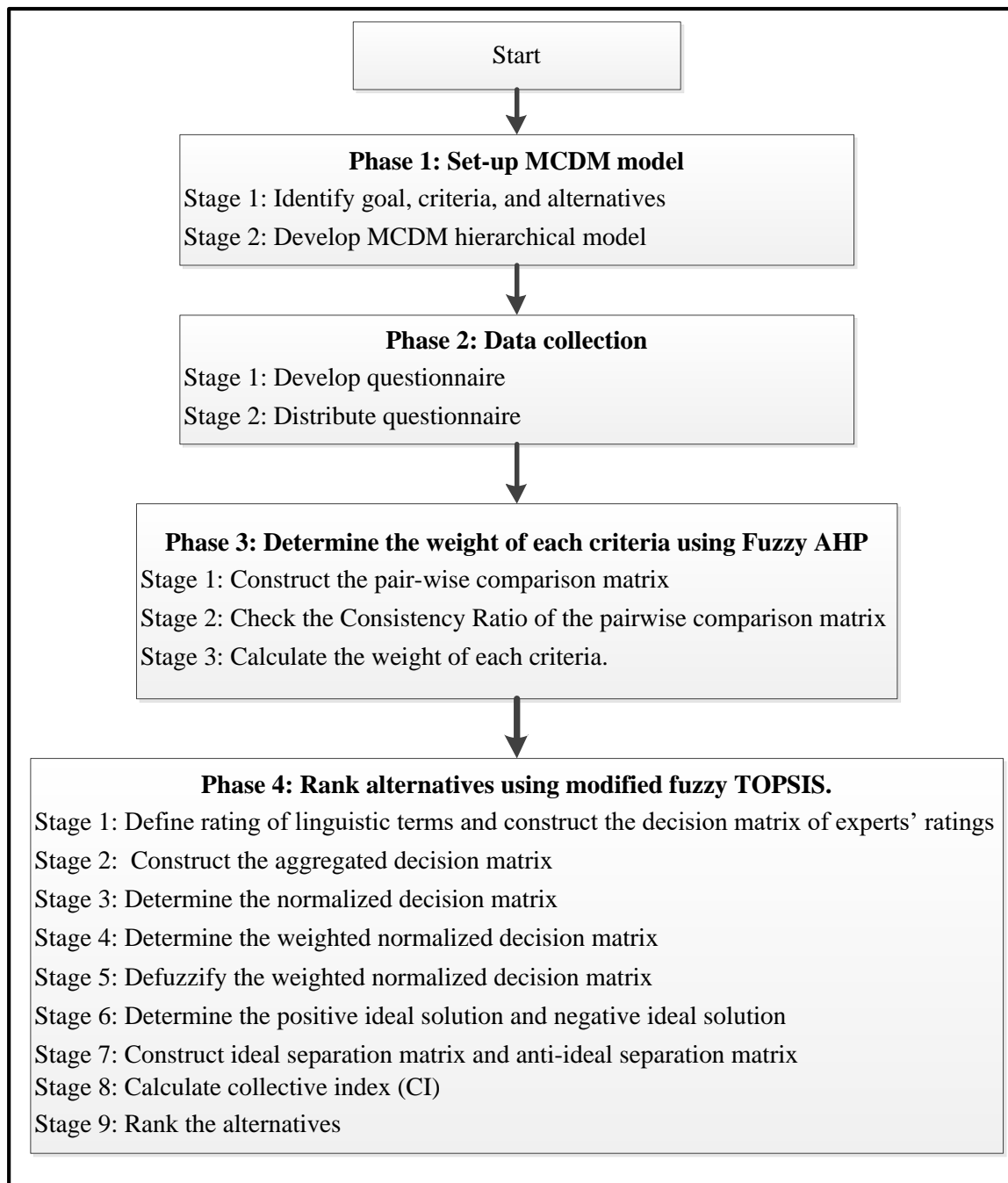


Fig. 1: Research Framework.

Fuzzy values were used to construct pairwise comparison matrices in which the pairwise comparison matrix given by A_k is the $n \times n$ matrix where n is the number of criteria for k^{th} decision maker. The ratings of qualitative criteria are also described in linguistic terms expressed in triangular fuzzy numbers as shown in Table 2.

Table 2: Linguistic terms for the ratings

Linguistic terms	Triangular fuzzy number
Very Good (VG)	(9,10,10)
Good (G)	(7,9,10)
Medium Good (MG)	(5,7,9)
Fair (F)	(3,5,7)
Medium Poor (MP)	(1,3,5)
Poor (P)	(0,1,3)
Very Poor (VP)	(0,0,1)

Decision makers had used the linguistic terms to evaluate the ratings of alternatives (academic programs) with respect to each of the seven criteria. Experts' evaluations are then converted into decision matrix of academic program competitiveness rating. Algorithms for weight determination and ranking process are as described by Prascevic & Prascevic (2016) and Vahdani, Mousavi, & Tavakkoli-Moghaddam (2011). Findings on the criteria weights and ranking are discussed in the following section.

Results and Discussion

There are two major parts of the work done, thus the findings are divided into two parts accordingly. The first finding shown in Table 3 is on the criteria weight determination using fuzzy AHP.

Table 3: Weight of criteria found using fuzzy AHP

Criteria	Weights
% Dean's Awards	0.1023
% Graduated CGPA > 3.5	0.1303
% Entrance CGPA > 3.0	0.1206
% Graduate Employability (GE)	0.1836
% Program Popularity	0.1455
% Optimum Enrolment Achieve	0.1394
% Future Job Demand	0.1782

Inputs from twelve decision makers regarding the importance of criteria (reflected by its comparative weights) are found using fuzzy AHP. The pairwise comparisons were aggregated and final criteria weights are reported in Table 3. The three most important criteria found to be used for ranking of academic programs are Graduate Employability (GE), Future Job Demand and Program Popularity based on UPU application records. While the two least important criteria are obtaining Dean's Award and Entrance CGPA > 3.0. This finding indicates that decision makers involved had associated the competitiveness of an academic program with the good prospect of its graduates being employed upon completing the program. In addition to that, an academic program is regarded as competitive when it has very promising future job demand for the graduates. This is understandable due to high percentage of graduate unemployment currently reported in this country for certain job areas (Kalaimagal and Norizan, 2012).

The criteria weights shown in Table 3 are based on responses from twelve decision makers. Consistency of all responses were checked using Consistency Ratio (CR) Index. The CR values are given in Table 4. The values of CR are all less than 0.1, thus the evaluations given by all decision makers are considered to be significantly consistent, hence acceptable to be used for the ranking of academic programs using Fuzzy Modified TOPSIS.

Table 4: Consistency Ratio for pairwise comparisons by twelve decision makers.

Decision maker	Consistency Ratio
1	0.0119
2	0.0413
3	0.0379
4	0.0318
5	0.0438
6	0.0446
7	0.0443
8	0.0444
9	0.0410
10	0.0468
11	0.0406
12	0.0319

Table 5 shows the findings on the ranking of eleven academic programs offered at the Faculty of Computer and Mathematical Sciences, UiTM Shah Alam found using Fuzzy Modified TOPSIS proposed by Vahdani, Mousavi, & Tavakkoli-Moghaddam (2011) by incorporating the weights found at the earlier stage.

Table 5: Ranking of Academic Programs at the Faculty of Computer and Mathematical Sciences, UiTM using Fuzzy Modified TOPSIS.

Name of Academic Program	Program Code	Collective Index (CI)	Ranking
CS240	Bachelor of Information Technology (Hons)	39294007.9996	11
CS241	Bachelor of Science (Hons) Statistics	3.8640	8
CS242	Bachelor of Science (Hons) Actuarial Science	4.0948	2
CS243	Bachelor of Information Technology (Hons) Intelligent System Engineering	4.0257	1
CS244	Bachelor of Information Technology (Hons) Business Computing	6.6695	10
CS245	Bachelor of Computer Science (Hons) Data Communication and Networking	5.0966	5
CS246	Bachelor of Information Technology (Hons) Information System Engineering	4.6514	4
CS249	Bachelor of Science (Hons) Mathematics	5.0664	6
CS230	Bachelor of Computer Science (Hons)	35481.6545	9
CS251	Bachelor of Computer Science (Hons) Netcentric Computing	4.4765	3
CS253	Bachelor of Computer Science (Hons) Multimedia Computing	49.6284	7

The three most competitive academic programs identified are CS243 (Bachelor of Information Technology (Hons) Intelligent System Engineering), CS242 (Bachelor of Science (Hons) Actuarial Science) and CS 251 (Bachelor of Computer Science (Hons) Netcentric Computing). The three least competitive programs are CS244 (Bachelor of Information Technology (Hons) Business Computing), CS240 (Bachelor of Information Technology (Hons) and CS230 (Bachelor of Computer Science (Hons)). It is interesting to note that Actuarial Science program is equally competitive to the computing programs in particular the Intelligent System Engineering and Netcentric Computing programs. This could be due to the fact that graduates in Actuarial Science, Intelligent System Engineering and Netcentric Computing are highly sought after by the industries in the present era of data analytics, digital technology and gamification.

It is also very interesting to note that Bachelor of Information Technology (Hons), Bachelor of Information Technology (Hons) Business Computing and Bachelor of Computer Science (Hons) are

placed at the bottom three of the ranking. The reason could be due to an excess number of graduates in IT leading to the future jobs availability for IT graduates in the future is shrinking rather steadily (Kalaimagal and Norizan, 2012).

As for the Bachelor of Computer Science, it could be due to the lack of interest among secondary school leavers to embark on a degree in computer science leading to a decrease in UPU applications among secondary school leavers to embark on at tertiary level (Suraya, Norsalawati & Nasir (2017). This issues had been identified by the Ministry of Education of Malaysia in which efforts to inculcate interest on computer programming has been introduced at secondary school level (Syahanim et al., 2013).

UiTM and FSKM is currently doing a lot of intervention efforts as to enhance their graduates' employability by introducing many futuristic features required by employers such as reviews of curriculum to embed data analytics, entrepreneurship, gamification, 2U2I and digital competencies to cater for IR 4.0 which is very much in line with the vision of the nation.

Conclusion

The findings of the study presented in this paper can help education providers and program owners to gauge their programs' relevancy and competitiveness. By knowing where, one stands, would enable education providers and program owners to plan and strategize on how to enhance the relevancy and competitiveness of their academic programs. This in return will benefit the students of respective programs now that their programs will be critically designed to suit current and future needs of the employers and to fulfil the demand of local and global human resource requirement.

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