Ranking University's Academic Departments Based on Research Performance: A Comparative Study of MCDM Methods

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Abstract

In today's modern world, universities are competing to improve their competitiveness worldwide. It is usually indicated by ranking systems. Several ranking systems also vary depending on the evaluated aspects. In Indonesia, a university ranking system is often associated with the accreditation ensuring the quality of education. A rapid quality education improvement is appropriately implemented in public universities. However, this will bring more challenges for private universities as they are usually possessing limited resources. Accordingly, an effective decision-making system should be proposed, especially to assist private university achieving their goals. This study aims to evaluate academic departments in terms of research output in a university using the multi-criteria decision-making (MCDM) methods. To develop the model, a case study in an Indonesian private university with 16 undergraduate programs was demonstrated. The ANP method is selected to construct a hierarchical structure and to obtain the weights of the criteria. Then, a comparative study is conducted applying fuzzy TOPSIS, fuzzy SAW, and fuzzy EDAS to rank the departments. In this study, six criteria were identified, while the greatest weight was the citation criterion. Besides, these three methods also presented consistent ranks for the best and the worst performing departments. Practically, the results can later be adopted by the decision-makers (DMs) in the university to determine the priority-based strategies to accelerate improvements for the quality of education subject to limited resources.

Keywords
Education, university evaluation, MCDM, sensitivity analysis

1. Introduction

In today's globalized era, universities have a key influence in developing innovation, producing competent human resources, and contributing to economic development. These contributions strengthen their roles as a central education institution for multi-dimensional development including both economic and social (Meusburger et al. 2018). Due to the development, universities in emerging economies have also experienced a rapid growth. Unfortunately, it is often not in line with international competitiveness. For instance, in Indonesia several universities only contribute <10% of the total country's population in 2021 which describes that the national education goal has not been achieved (Yusuf 2022).

The increasing number of universities should be followed by efforts to improve the quality of both graduates and institutions. For academics, the education quality is usually associated with university rankings according to the scopes that can be either international or national. The term university ranking introduced globally since the 2000s has been popular in many parties (Brankovic et al. 2018). The systems, moreover, also attract more attention from many stakeholders who certainly have influences on competitiveness, existence, and development of higher education institutions, in developed and developing countries (Dembereldorj 2018, Johnes 2018). Musselin (2018) even stated that the competition to achieve the top rank of those systems has become a multi-level competition.

In Indonesia, the university ranking is closely related to accreditation. The term accreditation refers to an assessment process to determine the feasibility as well as the quality of programs and institutions. To achieve the Top 500 World Class Universities during the period 2020 and 2024, the Indonesian authority through the Ministry of Education, Culture, Research, and Technology has set academic indicators for selected universities, and applied the indicators to all universities nationwide (Kementerian Pendidikan dan Kebudayaan 2020). However, this attempt faces challenges once applied to private universities which have major percentage of 68% of the total universities in the country. It was recorded that from 2015 to 2021 around 130 private universities in Indonesia were closed due to several cases such as lack of students, internal conflicts, and lack of quality standards (Yusuf 2022). Limited resources are also another key challenge largely possessed by private universities. For this reason, it is very important to develop a good decision-making procedure to optimize the limited resources.

It is considered that a prioritization of academic departments with excellent performances can be executed to accelerate the quality improvement. To evaluate the departments' performance, multi-criteria decision-making (MCDM) techniques can be applied as the case involve multiple evaluation criteria as well as alternatives. The purpose of this study is to evaluate the performance of departments using the MCDM approaches. Several MCDM techniques were selected to apply the model including fuzzy technique for order preference by similarity to an ideal solution (F-TOPSIS), fuzzy simple additive weighting (F-SAW), and fuzzy evaluation based on distance from average solution (F-EDAS) to rank the alternatives. The results of these methods will be compared to make a reliable decision. In addition, a fuzzy environment will also be applied to obtain a more precise result. Before, the evaluation criteria are identified and weighted using the analytic network process (ANP) method. In this study, the scope is defined based on the research output. To apply the decision-making model, an Indonesian private university with 16 undergraduate programs is selected. This study may provide a practical application for strategic decision-making process that can be adopted by decision-makers (DMs) in other private universities to prioritize their academic departments with excellent performances. By making the decision, it is very possible to accelerate the accreditation in a university as an effort to improve the quality as well as capacity which will also indirectly increase the whole institution ranking.

2. Literature Review

MCDM has been widely used to solve complex decision-making problem involving multiple criteria and alternatives. The application of MCDM has also been demonstrated to various cases including education cases such as university performance evaluation and human resources performance evaluation. To evaluate university performance, several past studies combined fuzzy decision-making trial evaluation and laboratory (F-DEMATEL), best-worst method (BWM), fuzzy analytic hierarchy process (F-AHP) to determine the weight of decision criteria with TOPSIS, SAW, MOORA (multi-objective optimization by ratio), and COPRAS (complex proportional assessment). Further, several papers also conducted a comparative study comparing several MCDM techniques to obtain a more valid decision. In addition to the method selected, the criteria defined for evaluation also vary. For example, Ghomi et al. (2022) considered several criteria comprising education; research; commercialization; human capital; popularity; education facilities and infrastructure; and social, cultural, and welfare facilities. Nazari-Shirkouhi et al. (2020) defined four main evaluation criteria, namely financial, students, internal process, and learning and growth. These criteria were deployed into 42 sub-criteria. A complex decision-making system was also evaluated by Oladipupo et al. (2021) who included 33 criteria.

Apart from that case, several studies also developed an MCDM-based decision-making model to measure human resource performance. For instance, Tuan et al. (2020) evaluated lecturer's research productivity in a university in Vietnam using the Fuzzy AHP and TOPSIS method. The study considered some criteria including number of publications, quality of publications, number of books, supervising postgraduate students, and research grants secured as project leader. With the developed Dynamic FTOPSIS, Duc et al. (2019) also evaluated the lecturer's performance in a Vietnamese university considering six criteria, namely personality characteristics, students' evaluation, total number of publications, participation in professional society, classroom teaching experience, and fluency in a foreign language. In Indonesia, Watrianthos et al. (2021) proposed a combination of Geometric Analysis for Interactive Aid (GAIA) and Preference Ranking Organization Method for Enrichment Assessment (PROMETHEE) method to measure lecturer's performance based on five criteria, which were: international publications in reputable database, patent, national publications at SINTA 1-2, national grants, and national publications at SINTA 3-4.

With the same framework, this study will utilize a combination of several MCDM methods to evaluate program performance in a university. Firstly, the evaluation criteria are identified based on the performance of research output. These criteria are then weighted using the ANP method involving several experts at the institution. Then, a comparative study using three MCDM methods, namely F-TOPSIS, F-SAW, and F-EDAS, will be taken to rank the programs. To test the validity, a sensitivity analysis will be applied. Although the framework and methods selected in this study have been applied in pertinent past studies, the scope analyzed in this study is different. While past studies focused on evaluating the performance of an institution or resources, this paper ranks academic programs' performance which is an aggregation from lecturers' performance in each program. The evaluation model developed in this study can be adopted by DMs in other private universities within the context of developing countries to accelerate university competitiveness subject to limited resources.

3. Method

In this study, several MCDM methods are compared to evaluate the academic departments' performance in a private university situated in Indonesia. As clearly seen in figure 1 that there are three main steps to develop a decision-making model, namely determining criteria weight, ranking the alternatives using MCDM methods, and conducting sensitivity analysis. In the first step, the evaluation criteria are first identified based on the scope of evaluation, in this case it is assessed based on the research output criteria. Then, we construct a hierarchical model in the form of an ANP structure. To calculate the criteria weights, the method is selected as in generalized framework it can visualize the interdependent relationships between criteria and alternatives and calculate the weights using the super matrix algorithm Chang et al. (2013). Once the weights are obtained, the values are used as input values to rank the programs as indicated in the second step. (Figure 1)

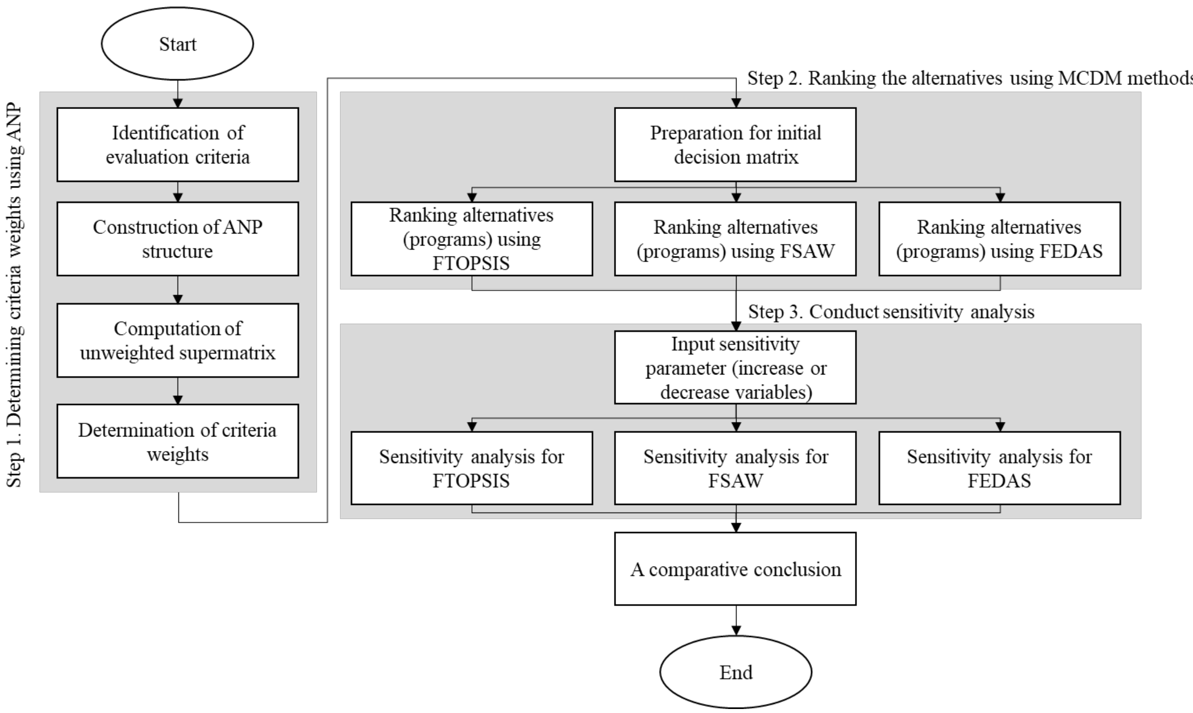

Figure 1. The conceptual framework

In the second stage, several MCDM will be utilized to rank the program performance, namely F-TOPSIS, F-SAW, and F-EDAS. To avoid the ambiguity associated by subjective judgment, a fuzzy logic is applied to these methods (Lin 2013). The TOPSIS method was firstly presented by Hwang and Yoon (1981) determine the alternatives' rank by computing the shortest distance from the positive-ideal solution and the farthest distance from the negative-ideal solution (Opricovic and Tzeng 2004). Similar to the principle of TOPSIS, the EDAS method is also a distance based MCDM method. However, this method considers the positive and negative distances from the average solution, while TOPSIS calculates the distance from the ideal solution (Gündoğdu et al. 2018). This principle makes the EDAS method become more effective when solving decision-making problems with conflicting criteria (Gündoğdu et al. 2018). Meanwhile, the SAW method is a simple MCDM method which evaluates the alternatives based on the weighted average (Afshari et al. 2010). It is considered that the three methods have their own principles as well as algorithms so that the sensitivity analysis is required to examine the stability of the result towards uncertainty.

4. Results and Discussion

Initially, the evaluation criteria are established. As mentioned earlier that the scope for evaluation is based on research output criteria since the criteria make a significant contribution to the whole university performance. Hence, six criteria were identified, namely citations (C_1), articles published in reputable international journals (C_2), articles published in nationally accredited journals (C_3), articles published in national journals (C_4), output from international proceedings

(C_5), and output from national proceedings (C_6). These six criteria were determined based on the weights in the national reaccreditation system as well as national university ranking adopted from several assessment systems. Subsequently, the DMs in the university were invited to provide a pairwise comparison scale of 1 – 9 according to the elements' relationships visualized in figure 2.

4.1. Determining criteria weights using the ANP method

Figure 2 illustrates the hierarchical structure of the relationships between criteria and sub-criteria. There are three relationships, which are: the W21 relation describing the criteria – goal interaction, W22 for criteria relationships, and the W32 relation indicating the sub-criteria – criteria interaction. This ANP structure is utilized as a basis for the DMs judgment to construct pairwise comparison matrices in which the values obtained are then inputted in the unweighted super matrix as presented in Table 1. With matrix multiplication on the spreadsheet, the final weights for the six criteria were C_1 (0.167), C_2 (0.062), C_3 (0.025), C_4 (0.010), C_5 (0.058), and C_6 (0.011), respectively. Then, we calculate the ranking of the programs using three MCDM methods.

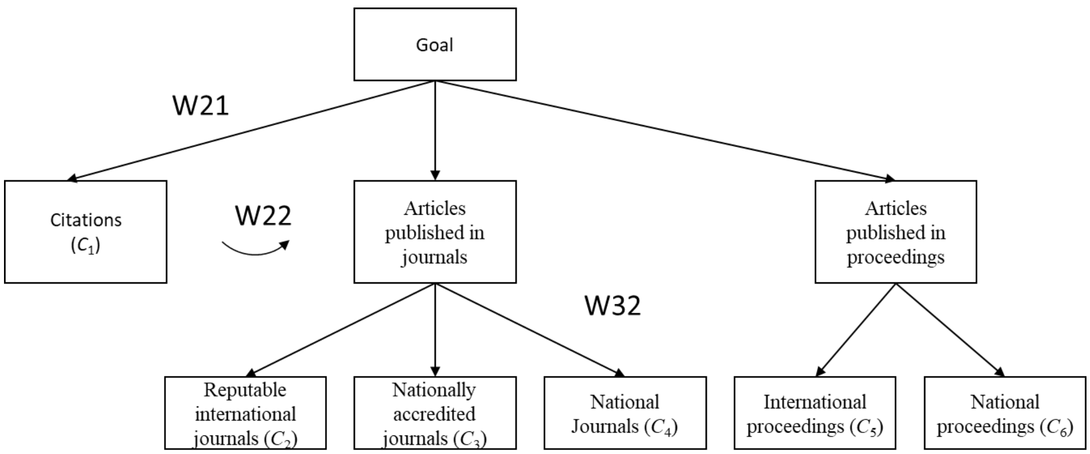

Figure 2. The ANP structure

Table 1. Unweighted super matrix

	Goal	Criteria			Sub-criteria					
		Citations	Articles published in journals	Articles published in proceedings	C_1	C_2	C_3	C_4	C_5	C_6
Goal										
Citations	0.493									
Articles published in journals	0.311									
Articles published in proceedings	0.196									
C_1		1.000								
C_2			0.632							
C_3			0.261							
C_4			0.107							
C_5				0.842						
C_6				0.158						

The criteria identified in this study are slightly different from the priority criteria determined in the Indonesian web-based research information system, called science and technology index. In that system, the citation criterion is further divided into Scopus document citation, WOS document citation, and Google Scholar document citation. The citation of Scopus and WOS, of course, has a significant difference compared to citation from Google Scholar's documents. However, the citation weight obtained is consistent with the system which indicates a significant contributing score.

In this study, the citation is considered as the most important criterion. This is consistent with Hensley (2011) and Liang et al. (2011) that citation was a key to finding the relevant and high-quality papers. With regards to the university ranking, Suryani et al, (2015) also stated that the citation criterion has become a key criterion for ranking universities as well as assessing researchers' performance.

4.2. Ranking the programs using MCDM methods

Table 2 provides information about the normalized decision matrix with a scale of 1 (very poor performance) to 10 (very excellence performance). Preliminary data as shown in Table 2 were previously collected which included the number or researchers in each department taken from the national higher education database, published article data taken from the national web-based research information, and the number of citations taken from google scholar.

Table 2. The normalized decision matrix

Departments	C_1	C_2	C_3	C_4	C_5	C_6
Dept. A	3	1	5	1	2	4
Dept. B	2	5	3	3	3	6
Dept. C	1	1	1	10	2	3
Dept. D	4	4	4	7	2	10
Dept. E	2	2	2	2	6	2
Dept. F	2	1	1	1	1	1
Dept. G	1	2	2	4	1	3
Dept. H	5	7	4	3	4	7
Dept. I	8	7	8	4	10	10
Dept. J	2	5	4	8	3	1
Dept. K	1	1	3	1	2	1
Dept. L	3	2	1	4	2	1
Dept. M	10	7	4	2	1	1
Dept. N	3	10	10	5	1	3
Dept. O	1	3	2	1	4	4
Dept. P	1	7	2	2	5	9
Weights	**0.167**	**0.061**	**0.025**	**0.010**	**0.058**	**0.011**

Table 3. The departments' final ranking from the three methods (F-TOPSIS, F-SAW, and F-EDAS)

Departments	F-TOPSIS		F-SAW		F-EDAS		Overall Rank	
	CC_i	Rank	A_i	Rank	AS_i	Rank	Geomean	Rank
Dept. A	0.193	7	0.255	10	0.3618	5	0.261	7
Dept. B	0.217	6	0.299	7	0.3613	6	0.286	6
Dept. C	0.036	15	0.149	14	0.0185	14	0.046	14
Dept. D	0.324	5	0.388	5	0.5164	4	0.402	4
Dept. E	0.170	10	0.273	9	0.3108	9	0.243	9
Dept. F	0.081	13	0.150	13	0.0777	13	0.098	13
Dept. G	0.045	14	0.145	15	0.0060	15	0.034	15
Dept. H	0.444	3	0.502	3	0.5821	3	0.506	3
Dept. I	0.793	1	0.812	1	0.9151	1	0.838	1
Dept. J	0.178	9	0.293	8	0.2768	10	0.243	8
Dept. K	0.023	16	0.129	16	0.0041	16	0.023	16
Dept. L	0.181	8	0.243	11	0.3183	8	0.241	10
Dept. M	0.773	2	0.686	2	0.6977	2	0.718	2
Dept. N	0.332	4	0.450	4	0.3413	7	0.371	5
Dept. O	0.085	12	0.208	12	0.1305	12	0.132	12
Dept. P	0.156	11	0.320	6	0.1586	11	0.199	11

Notes: CC_i refers to the closeness coefficient for TOPSIS, A_i refers to alternatives' weighted score for SAW, and AS_i refers to appraisal score for EDAS

Next, by using the three methods as well as the weights obtained from ANP, the departments were ranked. Table 3 shows the final rank for all departments using F-TOPSIS, F-SAW, and F-EDAS. Overall, although there may be a small difference, these three methods describe similar ranking results. For instance, the departments with good performance consistently rank at the top where Dept. I, Dept. M, and Dept. H place the 1st rank, the 2nd rank, and the 3rd rank, respectively. Meanwhile, these methods indicate the consistency for poor performance programs although the rankings are different in detail. For instance, Dept. C and Dept. G have different order, yet these programs are consistently placed in the lower ranking area. Interestingly, a few programs have very different ranks as occurred in Dept. A, Dept. L, and Dept. P. Both F-TOPSIS and F-EDAS present the same rank for the Dept. L and the Dept. P, while they show different ranks for the Dept. A. This situation also occurs for F-TOPSIS and F-SAW as well as F-SAW and F-EDAS. To aggregate the results, each performance obtained from the three methods is then calculated using the geomean and hence the completed rank from the first to the last is Dept. I, Dept. M, Dept. H, Dept. D, Dept. N, Dept. B, Dept. A, Dept. J, Dept. E, Dept. L, Dept. P, Dept. O, Dept. F, Dept. C, Dept. G, Dept. K.

4.3. Conducting the sensitivity analysis

To test the validity of the decision-making result, a sensitivity analysis was carried out. A sensitivity analysis is required to examine the stability of the ranking when some key variables are changed (Valipour et al. 2018). In this case, a sensitivity analysis will present some changes in departments' rank whether the idea given by the DMs also changes. Hence it describes the capacity of the decision-making model to address uncertainty. In this study, the analysis was carried out by changing the criteria weights (decrease or increase). There were nine sensitivity scenarios with a range of 10% - 90% changes. With Solver Add-in, it could be revealed which criteria should be increased or decreased. Table 4 shows the nine sensitivity scenarios indicating the changing in criteria weights.

Table 4. Various criteria weights for the sensitivity analysis

Uncertainty values	C_1	C_2	C_3	C_4	C_5	C_6
0.1	0.1500	0.0674	0.0278	0.0115	0.0635	0.0119
0.2	0.1333	0.0735	0.0303	0.0125	0.0693	0.0130
0.3	0.1166	0.0797	0.0328	0.0135	0.0751	0.0141
0.4	0.2333	0.0368	0.0152	0.0063	0.0347	0.0065
0.5	0.2500	0.0306	0.0126	0.0052	0.0289	0.0054
0.6	0.2666	0.0245	0.0101	0.0042	0.0231	0.0043
0.7	0.2833	0.0184	0.0076	0.0031	0.0173	0.0033
0.8	0.2999	0.0123	0.0051	0.0021	0.0116	0.0022
0.9	0.3166	0.0061	0.0025	0.0010	0.0058	0.0011

Then, the changing weights as provided in Table 4 were calculated by F-TOPSIS, F-SAW, and F-EDAS. The sensitivity results from these three methods are illustrated in Figure 3, Figure, 4, and Figure 5.

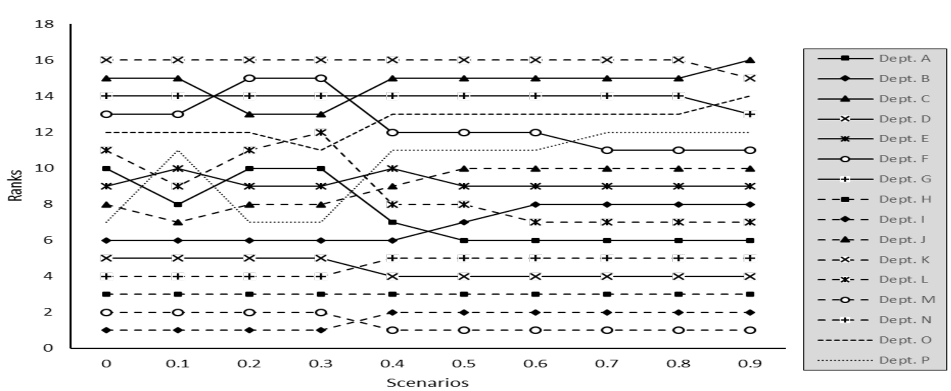

Figure 3. The sensitivity result of F-TOPSIS

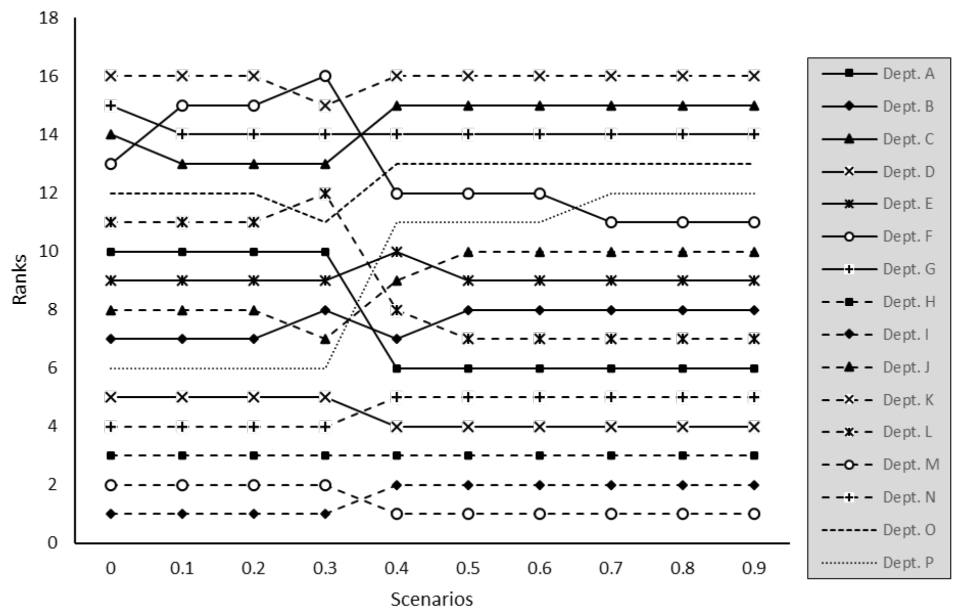

Figure 4. The sensitivity result of F-SAW

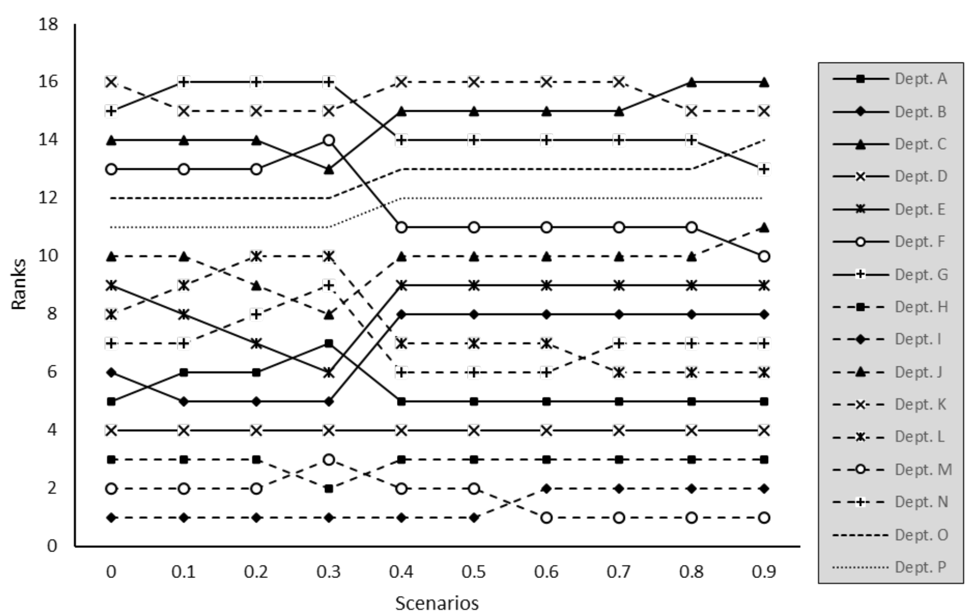

Figure 5. The sensitivity result of F-EDAS

As can be seen in those figures, the F-SAW method shows stable ranks given nine scenarios. Once there are >50% changes, the ranking obtained using the F-SAW is still consistent. This reveals that the changes in ideas or expert judgments will not affect the result significantly. Meanwhile, the other methods present very susceptible to change once there is uncertainty below 50% condition. Further, the sensitivity results indicate a very radical change for the departments placed in the middle ranks between the 6th and the 10th ranks. Although the three methods indicate different capacity when responding uncertainty, the top three rankings are absolutely occupied by the Dept. I, the Dept. M, and the Dept. H. This describes that even if there will be some changes in ideas or judgments from the DMs regarding the importance level of criteria, these three departments have obviously been agreed to be the best programs. In other words, these departments have a great opportunity to be further improved such as an acceleration initiative to apply international accreditation where the limited resources possessed by the university can be prioritized to the initiative. By considering the result, the decision-making process will be more efficient, and the quality education improvement will also be more effective.

5. Conclusion

This study has developed a decision-making model to evaluate a university performance at the department level. In addition, this research has compared several MCDM methods which are relevant and practically applicable to solve this case. In this study, the ANP method was selected to weight the identified criteria since it is able to consider the interdependent relationships between criteria and sub-criteria. The obtained weights indicated that the citation criterion was the most influencing criterion among the others. Subsequently, the three methods selected to rank the departments – F-TOPSIS, F-SAW, and F-EDAS – have determined the departments' ranking aggregated with geomean values. As each method has its respective principle, a sensitivity analysis was carried out to test the stability of the decision-making result. Based on the sensitivity results, the F-SAW method shows a stable rank when uncertainty occurs. Also, all methods indicate consistent ranking especially for both departments at the top and lower positions. This study focuses on research output criteria to evaluate the performance. However, it is encouraged to include other aspects such as teaching and learning aspects and university's impacts to obtain the thorough performance.

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Biography

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Edi Susanto and **Fatah Nur Hasyim** are undergraduate students at the Department of Industrial Engineering Universitas Sarjanawiyata Tamansiswa. They are currently assigned to carry out their final-year projects in the field of multi-criteria decision-making.