New AHP Improvement using COMET Method Characteristic to Eliminate Rank Reversal Phenomenon

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***Abstract*—Rank Reversal in Multi-Criteria Decision Making (MCDM) is a phenomenon that occurs when an alternative is added or deleted because of a change in the order in which the result is ranked. The evaluation of the weight of criteria, which are established based on whether a decision maker considers them important, impacts the alternative ranking result in MCDM. Changes in decision result ranking called rank reversal cannot be acceptable. Many researchers have done lots of research and created new methods for eliminating rank reversal, but until now there is still research that denies these new methods are free from rank reversal. The Analytical Hierarchy Process Method (AHP), the oldest Decision support Method has an advantage in the decision according to the Decision Maker's (DM's) preference. Still, it is vulnerable to the rank reversal phenomenon. While Characteristic Object Method (COMET) is a method claimed to be free of rank reversal phenomenon. This paper will discuss how the integration of COMET to AHP especially in the phase of generating characteristic value and characteristic objects is added to the AHP phase, which will have an impact on digital marketing strategy decision-making for private Universities in Indonesia, especially the city of Palembang. The combination of COMET and AHP in this paper is tested with several testing tools; they are case study testing, accuracy testing, and sensitivity analysis testing. The result of the combination of COMET and AHP will be named C-AHP, which is a consideration of DM's preference for the criteria weight, and the generation of alternative comparison based on criteria, or any other attributes makes AHP free from rank reversal.**

***Keywords*—Method; combination; C-AHP; rank reversal; elimination**

I. INTRODUCTION

Multi-Criteria Decision Making (MCDM) Alternative ranking is affected by the weight given by the DMs (Decision Makers) to the criteria. The main methods of MCDM such as TOPSIS (Technique for Order Preference by Similarity to Ideal Solution), ELECTRE (Elimination Et Choix Tradusiant la REalite), PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation), AHP (Analytical Hierarchy Process), and their combination, have been criticized in accordance with the occurrence of a problem called Rank Reversal Phenomenon (RRP) [1]. Rank reversal is a phenomenon where the alternative's order of preference is altered when a new alternative is added, or an existing alternative is deleted from a decision problem. A rank reversal occurs when a new alternative has been added or an old alternative eliminated from decisions, and the order of preference for other options is changed. In 1980 Belton and Gear first observed a change in ranking in the AHP [2]. One of the most important criteria for selecting the MCDM method is the phenomenon of rank reversal. There has been no answer to the question of a shift in rank as far as MCDM is concerned. Therefore, to obtain genuine results, a DMM (Decision-Making Method) using MCD (Multi-Criteria Decision) methods must know the problems that arise because of rank reversal. The rank reversal issue has not been solved yet in the MCDM context. Consequently, to obtain a valid result, DMs using MCDM methods should be familiar with rank reversal phenomenon challenges. Although a lot of researchers declare that RRP is a natural feature of the decision-making process, RRP is undesirable and unwanted because it indicates unreliability in the MCDM approach, in the research about sustainable material selection, the research result showed that there was no way to confirm whether the number of options and criteria had any effect on rank reversal [3].

There have been many studies regarding RRP, which tried to eliminate rank reversal using various methods for the past 10 years. In 2014, a framework for the experiments to determine the cause of rank reversal in an MCDM Method was done, the result is a modification of a method with a robust combination in it [4]. In addition to the RRP research carried out in 2017 with a reciprocal fuzzy preference relationship based on additive consistency for addressing RRP, there were also new methods that use proximity-indexed values and have demonstrated their accuracy compared to existing MCDM methods [1] [2]. An RRP investigation into potential causes of rank reversal was carried out in 2018, which indicates that preference followed by ranking score aggregation is the primary cause of RRP because of a lack of information in other research papers. A method for aggregation of scores has been proposed in some research to describe and illustrate the phenomenon of rank reversal using numerical examples. Compared to other tested methods, the results are better. According to the literature on decision-making, several methods suffer from this phenomenon, and one of them is AHP [5]. From 2020 era until 2023 the RRP research focused on the new method and/or the enhancement of the old method in MCDM with the additional Fuzzy to eliminate RRP such as AHP and TOPSIS method [6][7][8].

AHP as the method that applied for the last 25 years in many MCDM decision-making, has been used in lots of decisions in various fields. The pairwise comparison is the basic way of breaking down the problem into a hierarchy of subproblems making AHP a method with its advantages [9][10]. The numeric value assigned to each variable in AHP helps decision-makers defend a cohesive paradigm by deriving the relative weight of each component of the hierarchy, criteria, and alternatives [11]. For the management of qualitative and quantitative multicriteria elements in decisions, as a powerful and efficient tool, For the following criteria and benchmarks, AHP is capable of applying sensitivity analysis. Because of combined comparisons, judgment and calculation are easy in AHP. Moreover, AHP provides proof of compatibility and incompatibility decisions which is the compensation for the multicriteria decision making. With the combination of mathematics and expert judgment, AHP helps decision makers to make better choices both about tangible criteria and intangible criteria [12][13][14]. Besides its advantages, AHP also has disadvantages; RRP is neither a fatal flaw of the AHP nor a desirable property of it. It is a symptom of inherent problems with the AHP [15]. [16] When a decision problem is broken down into smaller problems, ranking irregularities occur in AHP each comprising two alternative solutions and a set of identical criteria as the first problem, which is called the Rank Reversal Phenomenon (RRP) in AHP.

Continuing the first version of the AHP method affected by RRP which was founded by Saaty & Vargas in 1984, Belton and Gear in 1983-1985, and Schoner & Wedley in 1989 who brought out a new version of AHP called the 'ReferenceAHP', to avoid RRP. This means that the weighting of the criteria is changed on each occasion when a different criterion is introduced or deleted. The underlying mathematical justification for this phenomenon is rank reversal local preferences are normalized, in the relative measurement mode, with a reduced level of hierarchy so that they add up to 1. As new alternatives are inserted or removed, Changes in local preferences will be influenced by other alternatives the result may therefore be a change in the end ranking of alternatives. Belton & Gear agrees with this statement as well [17]. In 2012, scholarly papers from an assessment of 61 scholarly papers on AHP methodologies and ranking reversals were carried out in 18 journals [18]. [19]A few studies conclude that the findings do not cover all the areas, the establishment of a new hybrid method for implementing and evaluating the results of studies will be proposed in future work, together with its proposal to evaluate every completed study. By using different methods that will be used in future work, a hybrid method will be integrated and used.

By using different methods that will be used in future work, a hybrid method will be integrated and used. Unlike conventional methods, COMET (Characteristic Object Method) uses a different approach, during initial investigations the phenomena of rank reversal have not been observed. To determine the measurement standard with a fuzzy reference model, a constant set of specially selected characteristic objects distinguishes the COMET model which is independent of the alternatives. The ability of COMET to detect multiple criteria models for the decision-makers, including a nonlinear multicriteria model, is its greatest advantage. [20] The COMET method was primarily designed to deal with actual value data in the first place. In several cases, it has proved difficult to define precisely the exact attributes of decision criteria. Therefore, in complicated decisions with data uncertainties, the use of intervals or fuzzy numbers should be substituted for numerical values.

In this research, as the solution to the AHP in the RRP problem, the advantage of COMET in analyzing characteristics through the categorization of characteristics objects with characteristic value and the classification of criteria and the consistent criteria will be added to AHP and combined with the pairwise comparison in AHP. The purpose of this research is to avoid and eliminate RRP in AHP and the impact on the case of digital marketing strategy decisions in private higher education in Palembang City, Indonesia.

II. Literature Review

A. The Correlation COMET and AHP

COMET and AHP have similarities in the pairwise comparison step. The unstable solution obtained in AHP is caused by the only discrete value of priority for all alternatives from the space of problem which COMET can provide the solution for it [21]. AHP is the best way to prioritize as it delivers highly accurate results for decisions that need to be made. Conventional AHP has scalability problems that can be solved with the modification of the AHP method structure [22]. AHP is also the method to have a coherent result, where to calculate the weights of the criteria, first, we need to establish the criteria' weight by comparing them in pairs [23]. With this strength of AHP combined with the advantage of COMET, AHP can be more powerful in avoiding and eliminating the RRP.

B. COMET and AHP Combination

To create a free RRP, the COMET method needs to be done step by step, the following Fig. 1 is the step of the COMET method [24][25].

Meanwhile, two main steps are carried out in the AHP method, Setting up the problem's hierarchy structure is an initial step, The next step is to give each grade of the hierarchy a nominal value, then set up a pairwise comparison matrix [12][26] The AHP hierarchy structure, and the form of the structure is as presented in Fig. 2.

From the COMET framework steps, and AHP, can be stated that COMET has the biggest contribution in the criteria modification which the adding of a characteristic value and characteristic object to the Criteria is the main key to eliminate the rank reversal. Before adding the numerical example, let's look at the combination of COMET and AHP named the C-AHP method which is depicted in the following Fig. 3.

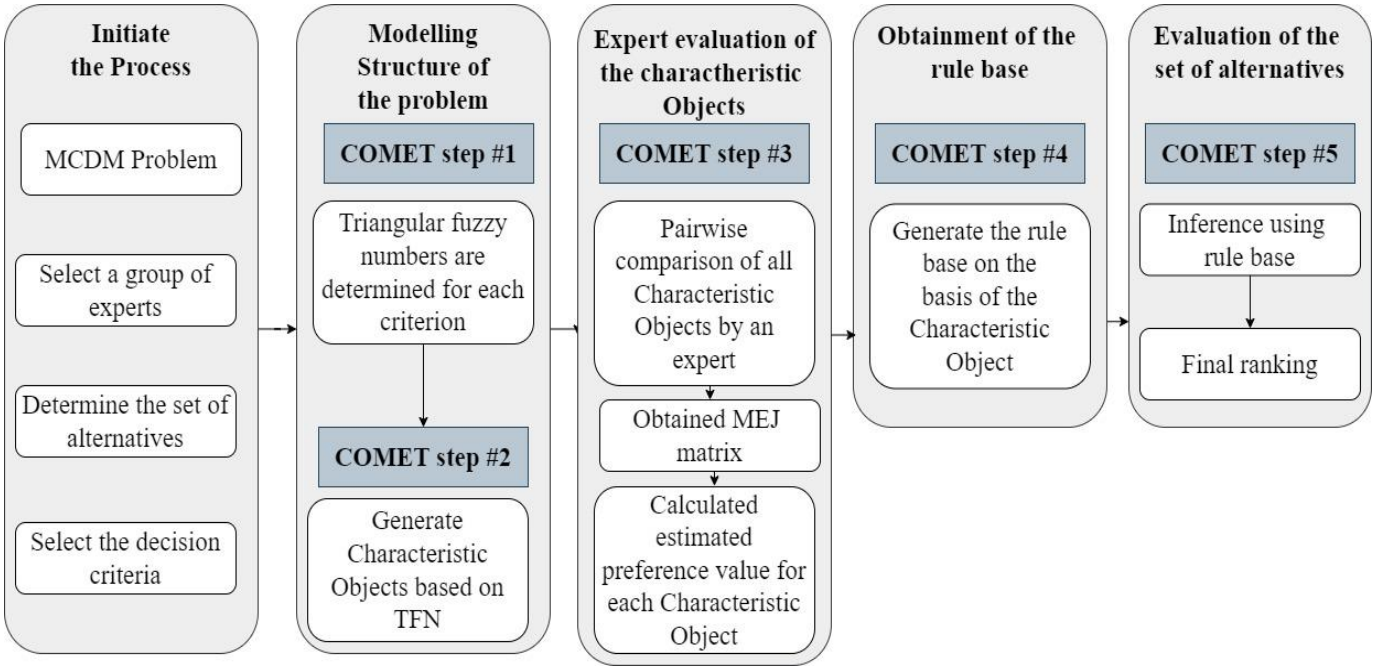

Fig. 1. COMET method model.

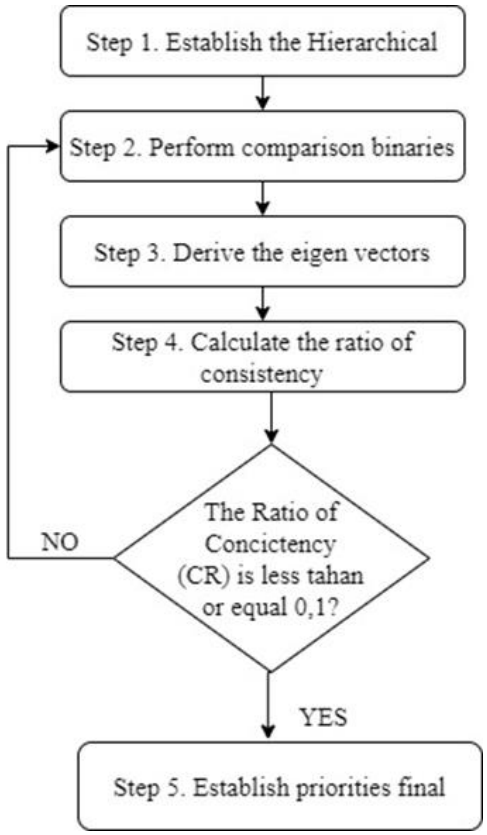

Fig. 2. The AHP method model.

C. Characteristic Object and Value

The characteristic object method (COMET) is based on the idea that a characteristic object is obtained as a combination of values characteristic to individual criteria, points that are regularly distributed in the problem state. By combining fuzzy theory set elements to define a decision model in the area of a problem, which is mainly designed for dealing with real-valued data [23][27]. In COMET, it is the first step to determine how many variants are associated with certain linguistic values that describe criteria, then, a characteristic variable is generated from values of vertices with particular fuzzy numbers [28]. Before the pairwise comparison is conducted, based on the distance from the nearest characteristic objects and their values, preference is given to each alternative [29][30]. For all these criteria, the domains and fuzzy numbers are determined. As a combination of the crisp values of all the fuzzy numbers, the characteristic objects are obtained.

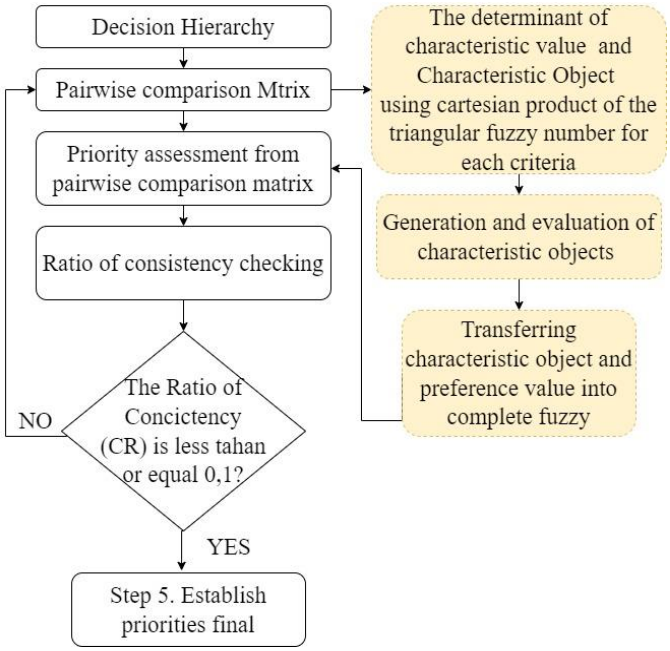

Fig. 3. The C-AHP method framework combination.

III. RESEARCH METHODOLOGY

The methodology of this research as shown in Fig. 4, started with the COMET method component analysis that gives the biggest part to reduce or remove rank reversal in decision-making. Formulation of COMET and AHP focusing on the characteristic value and characteristic object exist in the COMET method, and how its triangular fuzzy number affects the weight of the criteria in AHP. The combination of COMET and AHP is then generated into one framework combination form of those two methods which is later called C-AHP. The new framework, C-AHP, will be implemented in the numeric case, it is digital marketing for private higher education.

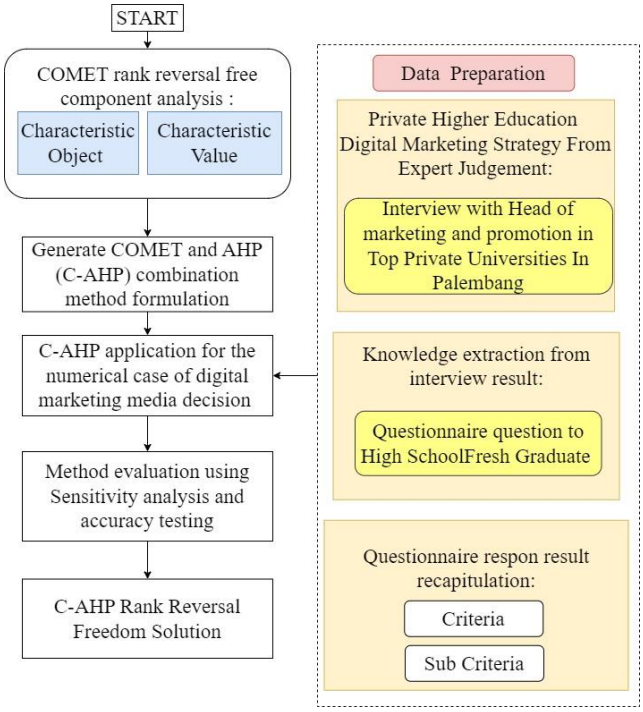

Fig. 4. Framework for C-AHP combination.

Data preparation for the higher educational marketing strategy started with interviewing the head of marketing and public relations in a private University, to collect the digital marketing strategy and criteria according to their wants and needs. After the interview result is a recap and the resulting knowledge about the digital marketing strategy and criteria, the next step is the question questionnaire will be made, which refers to the interview result and will be given to newly graduated high school student, to check whether the criteria is the same between those two parties. After the questionnaire is given to high school graduate students, the result will be a recap and the final criteria and sub-criteria for digital marketing will be established. To prove the rank reversal paradox avoidance in the C-AHP Method, the data from the questionnaire and interview results will be integrated and used in the C-AHP method for the numerical calculation. An additional step is added at the beginning of the C-AHP step after the criteria are determined, then will be building the characteristic value for each criterion. After defining the characteristic value, a characteristic object is created according to its characteristic value, using the formula as follows:

A. Characteristic Value of Criteria

In this concept, by using the number r of criteria to define the size of the problem and establish its dimensionality,

B. $C_1\ C_2\ ,...,C_r$.

The selection of the triangular fuzzy numbers for each criterion is made.

C_i, as example $C_{i1}\ C_{i2}\ ,...C_{ic}$

The result of this is as follows::

$$C_1\{C_{11},C_{12}\ ,...,C_{1c1}\}$$

$$C_2\{C_{11},C_{12}\ ,...,C_{1c1}\}$$

$$\ldots\ldots\ldots\ldots\ldots\ldots..$$

$$C_r\{Cr_1,Cr_2\ ,...,C_{rcr}\}$$

C1, C2,..., Cr for all criteria, are numbers of fuzzy numbers. After obtaining the triangular fuzzy number, and then a linguistic model has been created.

C. Generating Characteristic Object (CO)

CO $C(C_1)$ x $C(C_2)$ x...x$C(C_r)$

The next step is to define all of the set values for a given characteristic object as a result.

$$CO_1 = \{C(C_{11}),C(C_{21}),\ldots,C(C_{r1})\}$$

$$CO_2 = \{C(C_{11}),C(C_{21}),\ldots,C(C_{r2})\}$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

$$CO_t = \{C(C_{1c1}),C(C_{2C2}),\ldots,C(C_{rcr})\}$$

t is a number of CO [31]

$$t = \prod_{i=1}^{r} c_i$$

D. Pairwise Comparison of Characteristic Objects

Before we carry out an evaluation and a final ranking, a comparison of characteristic Objects between Characteristic Object (CO) for each criterion will be implemented. With the scale of:

$$\alpha \text{ is } = f(COi, COj) = \begin{cases} 0{,}0,\ f_{exp}(COi) < f_{exp}(COj) \\ 0{,}5,\ f_{exp}(COi) = f_{exp}(COj) \\ 1{,}0,\ f_{exp}(COi) > f_{exp}(COj) \end{cases}$$

This step is the normalization step that will make sure that each alternative and criteria have the same consistent numeric calculation even though there is a new alternative added or deleted.

E. Previous Related COMET and AHP Research

The previous works regarding to COMET and AHP, or one of the method, which related to the combination of those method, analyzed in this paper. The result of latest work related to this research is started in 2016 in the research about the rank reversal paradox in management decisions: the comparison of the AHP and COMET methods, the result is COMET is free of

rank reversal in compare to AHP on the Problem of Selecting Providers. COMET method is very easy to use, and the simplest models given reliable results. in 2020, intuitionistic fuzzy sets in multi-criteria group decision making problems using the characteristic objects method, resulting the case is academic problem of selection of the best mobile company using fuzzy set. In this research, on 2023, the case in digital marketing strategy decision for private higher education in South Sumatra, Palembang, Indonesia, combining COMET and AHP for the Rank Reversal Phenomenon free.

IV. C-AHP Implementation in Digital Marketing Private Higher Education Decision

A. Digital Marketing Private Higher Education Decision

Data sample for digital marketing private higher education is taken in two ways; first interview with the head of marketing and/or public relations in private higher education, University in Palembang City is done. The interview questions about digital marketing strategy are Table I:

TABLE I. Interview Questions

Question	Answers
Is there a specific target or niche targeted at the prospective student market segment?	SMA & SMK
Is the marketing strategy model used the same for all study programs/faculties?	All the same
How big is the comparison between the amount of conventional/offline marketing compared to digital / online at your university?	50% offline - 50% Online
Is there a strategy for when to use conventional marketing media and when to use digital marketing at your university?	No
What are the criteria or conditions to be considered when determining which digital marketing media to use? In meaning, what are the criteria for choosing marketing media at your university?	No
What are the strategies and/or media used for digital marketing strategies at your current university? is one of these lists - SEO - Content marketing - Paid search - Social media - Marketplaces - Paid advertising media, banner ads - Media chat - Emails - Influencer - Affiliate marketing	SEO FB IG TIKTOcK WA Blast Marketplace Paid Advertising
Which do you use most of all the digital marketing media mentioned earlier?	
Which digital marketing media has an impact in terms of: - Easily measurable results - Increasing customer loyalty, which ensures the most retention of customers - Cost-effectiveness - Conversion rate: the percentage of your website's visitors who do business on your company's page, actions they take during their visit and steps that lead them to make transactions	All the same
You agree that the needs and benefits of digital marketing in the field of education should be summarised as follows: t's measurable IEasy to Access impactful Instant Feedback System Brand awareness reach	Yes
Demographics, age or other characteristics are usually the criteria which you will be considering when it comes to a particular Digital Marketing.?	No we come to every school which accept us

As shown in the methodology, from the interview results, knowledge about the targeted and planned digital marketing strategy of a private higher education institution's Marketing Director or Public Relations and promotion Department is created. The next step is to collect data from the questionnaire with the question using the Likert scale, where the data of the questionnaire is taken from 325 respondents, who are high school graduate students in Palembang city. Using the Slovin formula, this research uses a population of 420 with the error of tolerance e=0,05 and using the Slovin formula:

$$n = \frac{N}{1+Ne^2} \quad (1)$$

The sample from the formula is 204 respondents, but from the questionnaire responses, 325 respondents fill and answer the questionnaire. So minimum sample is n=325. From this sample result, the validity and reliability test are conducted, and the result for validity with the tolerance of error is 0,05, resulting in the r count being bigger than the r table for every aspect of the question which means all the value is valid. The reliability test for the graduated high school student is shown in Table II and Table III:

TABLE II. Reliability Test Result

		N	%
Cases	Valid	325	100,0
	Excluded[a]	0	0,0
	Total	325	100,0

TABLE III. Reliability Cronbach Result

Cronbach's Alpha	N of Items
0,732	39

To the answers of the interviewed person, it is concluded that the criteria and sub-criteria for the digital marketing strategy in the decision of which media to choose, is as shown in Table IV:

TABLE IV. Criteria and Sub Criteria

Criteria	Name	Sub Criteria
C1	Advertising Type	Video, Photo, short video
C2	Advertising content	Program explanation, campus facilities, tuition fee and scholarship, campus performance
C3	Marketing Period	Anytime, April-june, October-December, Januari-March, July-September

From the questionnaire and interview result comparison, the alternatives for this research are Google ads, Instagram, WhatsApp blast, and YouTube.

The C-AHP method will be used to avoid rank reversal paradox in this digital marketing for private higher education decision, following the C-AHP method framework combination in Fig. 4, with these steps:

1) Problem and decision hierarchy: As the first step in C-AHP still follows the AHP stages, the problem domain definition starts with the hierarchical structure format, as shown in Fig. 8.

2) Determination of characteristic value: To generate a characteristic object, characteristic value is the first thing to settle. Characteristic value is different for each criterion it depends on the data and assumption. In the agreed and very agreed choice, use the triangular fuzzy number and the number of answers chosen by the respondent, The characteristic value of the criteria is set out in this case as presented in Table V:

TABLE V. CHARACTERISTIC VALUE

Criteria	Sub Criteria	Value
C_1 (Advertising type)	Video	65
	Photo	92
	Short Video	193
C_2(Advertising content)	Campus Performance	47
	Scholarship	48
	Tuition Fee	61
	Campus Facilities	67
	Program Explanation	70
C_3 (Marketing Period)	July-September	11
	October-December	17
	Januari-March	18
	April-june	21
	Anytime	32

There is a minimum possible value and a maximum possible value for each characteristic value. For instance, video 65 is the minimum possible value for advertising type and the highest possible value can be the shortest video 193, and a medium value is photo 92. After the characteristic value Triangular Fuzzy number for each criterion is conducted next step is to result in the linguistic model of the characteristic value which shown in Fig. 5, Fig. 6, and Fig. 7.

C_1 Advertising type, linguistic model

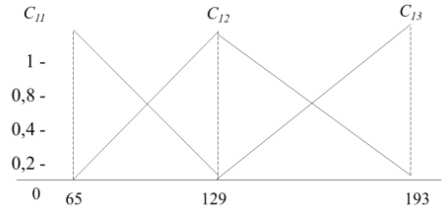

Fig. 5. Characteristic value type.

C_2 Advertising content, linguistic model

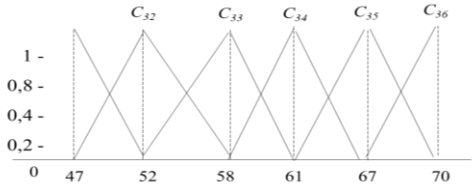

Fig. 6. Characteristic value advertising content.

C_3 Period, linguistic model

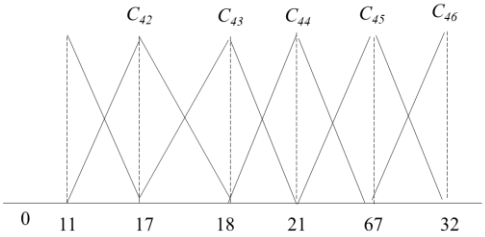

Fig. 7. Characteristic value period.

B. Generate Characteristic Object Value

From the characteristic value, the characteristic object can be generated using the formula to generate, and then from the characteristic object, with the limitations of maximum possible and minimum possible it will limit the additional aspect of criteria, and when a ranking result of digital marketing is obtaining, and another alternative in example TikTok occurred, the rank result difference will not be too far because the limitations of the character of the criteria are works in C-AHP model since the comparison of the criteria in pairs with another criterion. After the Criterion value is determined, the pairwise comparison with the generated score 0, 0,5, and 1 is entered in the criteria and sub-criteria value and the result of the final ranking is obtained.

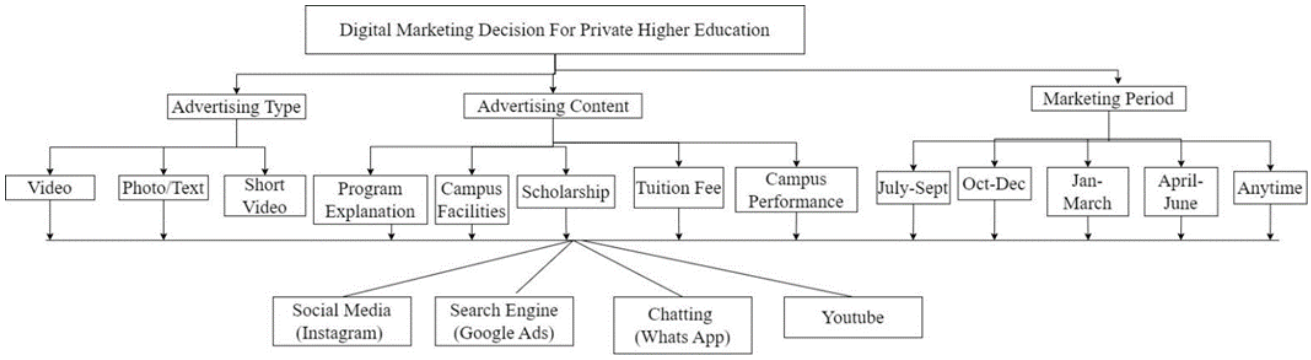

Fig. 8. Decision hierarchy digital marketing strategy.

V. Result and Discussion

From the C-AHP numeric calculation, with additional characteristic value and object in the criteria formulation, in the digital marketing for higher education case study, the Consistency Ratio (CR) results for criteria and sub-criteria is consistent with the score of Criteria is -0,66 and sub-criteria is -1,00 for C1, -0,50 for C2, and -0,67 for C3. This CR result shows because the result is under 1,00 shows that it is acceptable to implement. After all, it is stable and reliable. This research result has shown that C-AHP is reliable in keeping the criteria value stable even when the changes of alternatives are done. The addition of the same alternative and the reducing alternatives is done, and the result is the rank not changing for A1, A2, A3 and A4 as the alternative for the digital marketing higher education strategy case. The rank of the alternative remains the same. The case study has proven that C-AHP in the digital marketing strategy is affected by the characteristic object and value generation. This statement is proven by the accuracy and sensitivity analysis conducted on the variable chosen as the characteristic object in the criteria and sub-criteria, which changed with the adding of one point, and deduction of one point and the result is the sensitivity analysis acceptable. Adding a point to this research in the future will be the implementation of C-AHP in another case outside digital marketing for higher education strategy. As the same with the previous research conducted, the Rank Reversal phenomenon is eliminated for the comparison with other free rank reversal methods already conducted but there is no test to the result in the previous research using accuracy and sensitivity analysis.

VI. Conclusion

The rank reversal paradox in AHP with the combination of COMET and C-AHP was able to reduce the RRP in the decision to the digital marketing strategy for private higher education in Palembang city. The key combination for C-AHP is characteristic value and characteristic object which brought new weight to the criteria and sub-criteria in decision making, and also when generated it brings limitations to any addition or changes of the alternatives in the digital marketing strategy for private higher education.

Future studies can be conducted for the specific possibility of C-AHP implementation in another case study and can also be conducted for the same case with changes in the weight of the criteria from characteristic objects and values. The decision in this research is conducted by an individual; the future research can use C-AHP for the group decision support system in the group decision maker.

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