

Product Benchmarking using Analytical Hierarchy Process and Fuzzy Analytical Hierarchy Process: A Case Study

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Abstract — With so many different types and brands of MP4 player with relatively low prices, it often casts doubt on the quality of these products compared to the similar products that have been known before. Will the relatively low price products can match, or at least close, to the quality of the branded products?

This study aims to compare some popular MP4 players with the similar product that has been established as an iconic product. To be able to compare products, it requires some relevant criteria. These criteria are determined through a review of several references and dimensions of quality. The methods used in this study are Analytical Hierarchy Process (AHP) and Fuzzy Analytical Hierarchy Process (FAHP). Data obtained by distributing questionnaires to the respondents. The results of analysis using AHP and FAHP are then compared.

From the comparison, it shows that there is no significant difference between the methods of analysis. All methods produce ranking of the observed products in the same order but with different total weights. The total weight of each product is then compared to the established brand to calculate the relative weight of each alternative product. Using the relative weight of each product, it will be known how good the product quality is, according to the consumers, and by comparing with an established product, it can be identified the relative quality of each product.

Index Terms — Analytical Hierarchy Process (AHP), benchmarking, Fuzzy Analytical Hierarchy Process (FAHP), MP4 player, multi-criteria decision making.

I. INTRODUCTION

MP4 player is a portable music and video player, which is usually equipped with radio and voice recorder. Several types of MP4 player are equipped with an internal speaker. Currently, there are many brands of MP4 player that are available in the market, including Apple iPod, Phillips, Samsung, ZTE, Sun, Advance, Lexus, and many more. Apart from the branded products, various MP4 players offer relatively low prices that can cast doubt on the quality of these products compared to the similar products that have been established before. Will the relatively low price products have the same quality as the branded products?

To find the best product, a comparative analysis between these products need to be carried out. Products are assessed based on several specific criteria using Multiple Attribute Decision Making (MADM). MADM is a method of

decision-making to determine the best alternative from several alternatives based on certain criteria [1]. Some MADM methods include Simple Additive Weighting Method (SAW), Weighted Product (WP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), and Analytical Hierarchy Process (AHP).

AHP method was developed by Saaty [2]. Each alternative has a score to each criterion. Scores are then added to calculate the final score. Alternative that has the highest score is the best alternative. Analysis using FAHP is selected because the consumers perception contains uncertainty. The method is based on weighting method using linguistic variables. Triangular fuzzy numbers are then used to obtain fuzzy assessment matrix through paired comparisons [3].

The purpose of this study is to compare the products of popular MP4 player on the market with product that has been established before and becomes an icon for this type of product. The comparisons are done using AHP and FAHP.

II. RESEARCH METHODOLOGY

In the first step of research, we need to determine the products that will be compared. The selection of MP4 players was based on the most popular products during a computer exhibition, held in Yogyakarta, Indonesia between November 1st – 5th, 2008. Four most popular MP4 players were Advance, STE, AX, and Lexus. STE brand was not available anymore in the market, therefore it was excluded.

Next step is to determine the level 1 of criteria that are price, brand image and product attributes (see [3], [4], and www.consumerreports.org), as shown in Figure 1. The product attributes consist of ease of use, quality of headphones, quality of speakers, image quality and video quality (level 2 of criteria). Data were collected using questionnaires and the data obtained from these questionnaires were used as inputs in the analysis of AHP and FAHP. There were three types of analysis conducted, the analysis using AHP method, FAHP analysis according to Chen [5] referred to as FAHP I, and FAHP analysis according to Kusumadewi *et al.* [1] referred to as FAHP II.

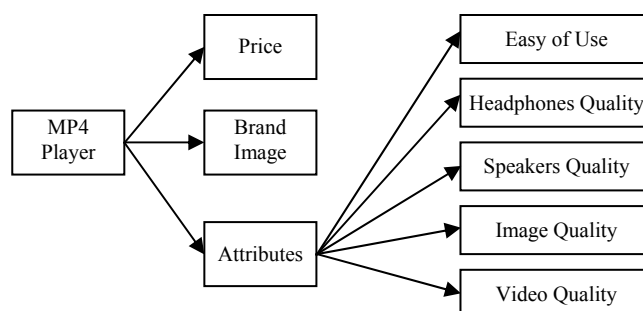


Figure 1. Criteria of comparison [6]

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To determine the respondents, a preliminary research was carried out during another computer exhibition at the JEC Yogyakarta, May 4th, 2009. From the preliminary research, the profile of MP4 users were known in term of the last education, study program, college/university, age, and gender. Based on the user's profile, questionnaires were distributed to the respondents. The profiles that were not significant were eliminated from the list. The total respondents in this study were 40.

Data collection was conducted on May 11th to June 7th, 2009. Initially, the respondents read the questionnaire and were then given four selected MP4 players, the same model but from different brands, i.e. MP4 player Advance, MP4 player AX, MP4 player Lexus, and an iPod nano. The iPod nano was included in the study as an established brand of MP4 player. Each respondent needs to compare two MP4 players at once and makes comparisons in pairs. However, each respondent tries MP4 players in different orders.

The questionnaire was divided into two parts. The first part was assessing the degree of interest of each criteria among others. The second part were questions that compared one alternative to the other alternatives in a single criterion. In the second part, Likert scale was used.

III. RESULTS AND DISCUSSION

From 40 samples obtained, data uniformity tests were performed. Data that were outside the upper and lower limits were removed. Next test was the consistency test, the data which were inconsistent will also be removed. After these two tests, 30 samples were obtained and will be analyzed using the AHP, FAHP I, and FAHP II. Characterization of methods that are used in this study are available in the reference [6].

Data were analyzed using a comparison matrix between alternatives that will produce the average value of each alternative against a criterion. The final step is to calculate the consistency ratio i.e. the consistency level of the assessments of the decision makers. Pair wise comparison was not carried out because the price is fixed. The price of the products were obtained from several stores that sold the MP4 players.

A. AHP Analysis

To determine the level of interest, we conducted the paired comparisons between the criteria. Each weight in the same row was averaged to produce an average weight. The average weights of the criteria of price, brand image and product attributes were 0.058, 0.291, 0.651 respectively. For level 2 criteria on product attributes, the average weight for ease of use, quality of headphones, quality of speakers, image quality, and video quality were 0.039, 0.497, 0.099, 0.172, 0.193 respectively.

Final score was calculated by multiplying the average rating with an average weight. The total weight obtained by adding the final weight of each criteria and also used to determine the rank of the alternatives. The total weight for each alternative were 0.097, 0.162, 0.079, and 0.662 for MP4 player AX, Advance, Lexus, and iPod nano respectively. Based on the final weight, the best product was iPod nano

and then followed by MP4 player Advance, AX, and Lexus.

B. Analysis with FAHP I

The FAHP I analysis is based on the method developed by Chen [5]. From the calculation, the average weights for criteria of price, brand image and product attributes were (0.046, 0.056, 0.073); (0.232, 0.371, 0.561); (0.412, 0.573, 0.814) respectively, while for the 2nd level the weights of ease of use, quality of headphones, quality of speakers, image quality, and video quality were (0.010, 0.020, 0.042); (0.120, 0.260, 0.594); (0.041, 0.083, 0.182); (0.028, 0.084, 0.188); and (0.052, 0.127, 0.335) respectively.

Using FAHP I, defuzzification process and ranking are done using TOPSIS method. After calculating the ideal solution and negative ideal solution, the relative closeness between the ideal solution and the negative ideal solution was known. The relative closeness was the total weight of the alternatives. The total weight of each alternative were 0.071, 0.153, 0.049, and 0.948 for MP4 player AX, Advance, Lexus, and iPod nano respectively. From these weight the best MP4 product was iPod nano and then followed by MP4 player Advance, AX, and Lexus.

Although the ranking produced by this method has no different with the ranking obtained by the AHP method, there are differences in the total weight calculated for each alternative. Using FAHP I, the confidence level of the decision makers is considered. The confidence level used in the research was $\alpha = 0.5$. In addition, because the method uses TOPSIS then the risk index is also specified. In this study, the risk index used was $\beta = 0.5$.

C. Analysis with FAHP II

The FAHP II analysis is based on the method developed by Kusumadewi *et al.* [1]. The FAHP II analysis is slightly different from the FAHP I. The fundamental difference is the defuzzification method used. In this analysis, Total Integral Value method is used to produce the final weight of the alternatives.

Paired comparison matrix for the average weight was made using 1-9 scale with triangular fuzzy numbers [2]. The average weight was then divided by 10, result in weight between 0 to 1. The average weight for level 1 for the criteria price, brand image and product attributes were (0.023, 0.026, 0.032); (0.099, 0.130, 0.202); and (0.412, 0.573, 0.814) respectively. For level 2 criteria, ease of use, quality of headphones, quality of speakers, image quality and video quality, the weight were (0.009, 0.011, 0.013); (0.099, 0.158, 0.163); (0.019, 0.027, 0.040); (0.034, 0.042, 0.055); and (0.040, 0.062, 0.088) respectively.

After the average rating and the average weight are calculated, the defuzzification can then be done. The results are the final weight that are then added to determine the total weight that can be used to produce the final ranking of the alternatives. The total weight of the four alternatives of MP4 products obtained using this method were 0.140, 0.227, 0.122, and 0.792 for MP4 player AX, Advance, Lexus, and iPod nano respectively. The best MP4 players according to this method was iPod nano, and then followed by MP4 player Advance, AX, and Lexus.

D. Comparison of Results

Comparison of the total weights after normalization is shown in Table 1 while the relative weight of each product to the iconic products, i.e. iPod nano, is shown in Table 2. From Table 1, it appears that each method produces different total weights for each alternative although it has the same rank order. MP4 player iPod nano is the best brand according to the analysis, followed by MP4 player Advance, AX, and Lexus.

Table 2 shows the relative quality of alternative products which are popular in the market at the time of the research with regard to the iconic product (i.e. iPod nano) for benchmarking purposes. It seems that the quality of the alternative products is still far behind the quality of the iconic product. The highest relative value of the alternative products is 0.2865 (MP4 player Advance, FAHP II) and the lowest relative value of the alternative products is 0.0511 (MP4 player Lexus, FAHP I). The quality discussed here includes the quality of audio (headphones and speakers), images, and videos and also ease of use. All these criteria are grouped into product attributes, which is the main criterion in the assessment as it has the dominant weight. However, the relatively cheap price of the alternative products is the main factor for the customers to buy the products and hence make them as the most popular MP4 players.

Table 1. Comparison of normalized total weight of AHP, FAHP I, and FAHP II analysis

Rank	Brand of MP4 Player	AHP	FAHP I	FAHP II
1	iPod nano	0.6622	0.7768	0.6186
2	Advance	0.1621	0.1253	0.1772
3	AX	0.0967	0.0582	0.1090
4	Lexus	0.0790	0.0397	0.0952

Table 2. Comparison of product weight relatives to the weight of the iconic product

Rank	Brand of MP4 Player	AHP	FAHP I	FAHP II
1	iPod nano	1	1	1
2	Advance	0.2448	0.1613	0.2865
3	AX	0.1460	0.0749	0.1762
4	Lexus	0.1193	0.0511	0.1539

IV. CONCLUSION

Based on the results of this study, conclusion can be stated as follows.

1. The best MP4 product obtained in this study was MP4 player iPod nano, followed by MP4 player Advance, AX, and Lexus. The three methods used in the study produce the same ranking of alternatives but with different final weights for each alternative observed.
2. Comparison of the quality of the alternative products to the iconic product produces relative weight which is far behind the quality of the iconic product. The highest weight of alternative product is 0.2865 and the lowest weight is 0.0511.

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