USAGE OF GROUP AHP APPROACH IN SPORT SHOES SELECTION

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ABSTRACT

People often have a difficulty in selecting quality sport shoes because of many alternatives and multiple criteria that can cause conflicts in evaluating. The other words making decision for select the most appropriate sport shoes when a judgment of multi-criteria simultaneously is a part of the decision making often is difficult. Opinions from four experts were used to identify the essential criteria for sport shoes selection and finally five criteria have been determined as the main criteria by them. The criteria are qualitative and quantitative, two negative and three positive. They have been considered for selecting and ranking the best sport shoes among three of them. The purpose of this study is selecting the most appropriate sport shoes using one of the methods of Multi-Criteria Decision Making (MCDM) approach that it is called Analytic Hierarchy Process (AHP). To increase the efficiency and ease-of-use of the proposed model, simple software such as MS Excel has been used. To sum up, quality has been chosen as the most important criterion and Adidas brand is selected as the best sport shoe. The introduced method is used in a case study.

Keywords: Sport Shoe, Multi-Criteria Decision Making, Analytic Hierarchy Process.

1. Introduction

There are many important decisions in the life, such as which university to attend, where to live, and what to do for a living. People cannot survive without making decisions. Making good decision is an important technique for survival. The decisions people make every day affect their lives in the present and their life in the future.

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Many studies have been conducted on decision making to understand how people make decisions and to provide techniques for making good decisions. Decision making is the study of identifying and choosing alternatives based on the values and preferences of the decision maker. Making a decision implies that there are alternative choices to be considered, and in such a case we want not only to identify as many of these alternatives as possible but to choose the one that best fits with our goals, objectives, desires, values, and so on (Harris, 2008). The decision making process is directly related to information processing: how to collect information and analyze the gathered information (Sauter, 1997). When the alternatives and criteria increased, the problems will be complicated.

Multi-Criteria Decision Making

Most decision making involves complicated procedures in which decision makers rank the alternatives of a choice according to multiple criteria (Saaty, 2008). There have been many studies that have provided solutions for complicated decision making including multiple criteria. MCDM consists of three components: goal, criteria and alternatives. In making a decision, ranked alternatives are generated by evaluating criteria or subcriteria if there are any. Alternatives will be ranked regarding to the weights of criteria and subcriteria. The rank order can be applied for selecting the best alternative.

Analytic Hierarchy Process (AHP)

The AHP is a theory of relative measurement with absolute scales of both tangible and intangible criteria based on the judgment of knowledgeable and expert people (Ahmad & Qiu, 2009). It is introduced by Saaty (1980) and it is one of the widely used Multi- Criteria Decision Making approach. It resolves decision-making problems by structuring each problem into a hierarchy with different levels of criteria. In other words, AHP structures a decision problem into a hierarchy and evaluates multi-criteria tangible and intangible factors systematically. AHP also has been applied in numerous fields including many software selection decisions (Forman & Gass, 2001; Vargas, 1990; Zahedi, 1986).

According to major sales reports on sport shoes, most people do not care much about which brand sport shoes they buy for activity. In the sport shoe market, the design plays a major role in making market trends (The NPD Group Inc., 2007). Though consumers select various brands of sport shoes for physical activity, experts still recommend choosing proper sport shoes. Design and quality are two key factors that need to be considered in selecting sport shoes (Pribut & Richie, 2004). In addition to comfort and fit for quality, consumers can consider also other attributes such as weight, price, and flexibility.

Problems in Selecting Sport Shoes

Among technical features that sport shoe companies have developed to improve quality of shoes, most of those features are tricks that make sport shoes more expensive (Pribut & Richie, 2004). A high price is related more to technical features and fashion than high quality (Clinghan, Arnold, Drew, Cochrane, & Abboud, 2008). When consumers buy sport shoes, which have recent quality and design features developed by major sport shoe companies, they are perceived to buy shoes of good quality. Consumers actually purchase fancy and expensive shoes regardless of shoe quality. The possibility of discrepancy is expected between consumers' actual choices and perceived choices. This discrepancy between actual and perceived choices is closely related to the complexity of selecting quality sport shoes: too many alternatives and multiple criteria (or attributes such as quality, flexibility, design, weight and price). As the number of alternatives and criteria gets larger, decision making becomes harder and more complicated (Mintz, Geva, Redd, & Carnes, 1997; Olshavsky, 1979; Schwartz, 2000). There are too many sport shoes and their designs change too often for consumers to get enough information on sport shoes available in the market place. Also, they need to consider multiple criteria (or attributes such as quality, design, weight and price) in selecting alternative shoes to make a final choice. Consumers should simplify the decision making procedure by examining only relevant criteria (Johns, 1999). The solution for the problems and challenges in selecting sport shoes can be required in decision making studies. There have

already been many studies on "decision making," which provided solutions for problems and difficulties happening in various kinds of decision making situations. Selecting the best sport shoes is a typical consumer decision making situation, in which consumers make a choice among many alternatives by evaluating alternatives with respect to multiple criteria (Park, 2012).

The decision maker finds the best choice by ranking three alternatives across five criteria, which is a multi-criteria decision making. Alternatives are ranked according to accumulated priorities (preference weights) across the criteria (Stewart, 1991). The rank order can be used for selecting the best one. In selecting sport shoes, the types of data for the attributes, such as design, quality, flexibility, weight and price are very different from each other. AHP can be a good tool for solving this kind of problem. AHP has three major functions: structuring complexity, measuring on a ratio scale, and synthesis (Forman & Gass, 2001). Concerning complexity, Saaty (2001) found that the complicated issues can be solved by hierarchy forms that classify complex systems into several hierarchical levels and then compare elements of each level with respect to higher level. Related to the second function, measuring on a ratio scale, Saaty (2001) discussed that AHP is used to get ratio scales from both discrete and continuous paired comparisons in multilevel hierarchy structures." Due to the second function, measuring on ratio scales, different types of data can be dealt with together in AHP. About the third function, synthesis, Saaty (1994a) explained that people need a way to synthesize over many dimensions because complex and crucial decision situations often involve too many dimensions for humans to synthesize intuitively. Synthesis is necessary task for simplifying to rank alternatives and compute priorities according to their preferences.

2. Research Design

This research employs descriptive design. The most important aim of this design is to find the best brand sport shoe among available sport shoes. Descriptive research design is a valid method for researching specific subjects and as an antecedent to more quantitative studies. Although there are some valid concerns about the statistical validity, as long as the limitations are understood by the researcher, this type of study is a valuable scientific tool (Ary, Jacobs, Razavieh, & Sorensen, 2009).

2. Methodology

The AHP is a structured technique for organizing and analyzing complex decisions. Based on mathematics and Psychology, it was developed by Thomas L. Saaty in the 1970s and extensively studied and refined since then. It has particular application in group decision making and used the world in a wide variety of decision situations, in fields such as government, business, industry, healthcare, sports and education (Saaty & Peniwati, 2008). The research methodology involved two separate phases. The phases are described as follows:

Phase 1: The first phase of this paper is formed in order to explore suitable sport shoe and criteria of the shoe respectively. The instrument of data collection applied for this phase is questionnaire. By using comparison matrix that has been prepared by experts, the weights of criteria were calculated. Having gathered data from experts the consistency was determined. If the consistency is more than 0.1, the data must be refined until this number decrease to less than 0.1. This phase is important because it provides the knowledge platform for the next phase.

Phase 2: The applied methodology for this phase is based on the output of phase one and the approach used is AHP. In this phase, computing weights of criteria and also popular brand shoe with respect to each criterion was constructed. At the end of this phase, all of the criterion and

sport shoes which had been considered were sorted. A three level hierarchy model was used to choose the best sport shoe for walking.

Figure 1 shows the three-level hierarchy model. The first level presents the goal of the problem, which is to find the best sport shoe among three others. As shown in the second level, the criteria of the model are divided into five ones, namely Design, Quality, Flexibility, Weight and Price. The third level consists of three brand of shoes, which include Nike, Puma and Adidas. The tests are given at the final level of the proposed hierarchical model. In a hierarchy, the criteria are assumed to be independent among them. This is called independence case between criteria (Saaty, 1987).
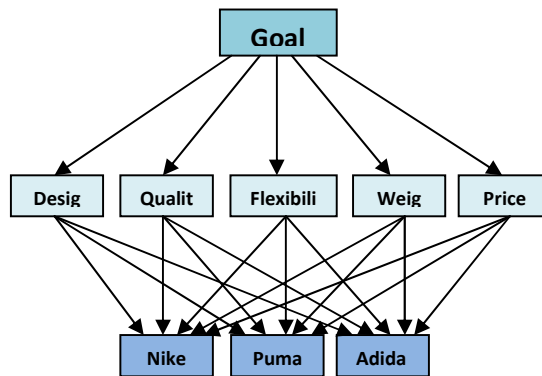

Figure 1. The Conceptual Framework of This Study

Generally the 11 steps to preparing comparison matrix described are as follow:

Step 1: to define the problem and specify the research objective (Usage of Group AHP Approach in Sport Shoes Selection)

Step 2: to construct a squared pairwise comparison matrix (n × n) for criteria with respect to objective by using Fundamental Scale's Saaty's 1-9 of paired comparisons which have been shown 1n Table 1.

Table 1: Saaty's 1-9 scale of pairwise comparisons	
Intensity of importance	**Definition**
1	Equal Importance
2	Weak Moderate
3	Importance
4	Moderate Plus
5	Strong Importance
6	Strong Plus
7	Very Strong
8	Very, very Strong
9	Extreme Importance

In this case, there are five criteria are called; Design, Quality, Flexibility, Weight and Price and three alternatives. Therefore, based on structure of matrix (n × n), the researcher makes a squared pairwise comparison matrix (5 × 5) shown in Table 2. The pairwise comparisons are done by experts in terms of which element is important than others. Where, there are four experts. Hence, we have four tables of

comparison matrix similar to Table 2. This table is aggregation of individual judgments. In this way, each expert completes a single matrix and then group decision making matrix is formed. The results of weighted geometric means are obtained from the same tables that have been completed by the four experts. The geometric mean is the best method for aggregation of individual judgment in AHP (Aczél & Saaty, 1983).

Table 2. Pairwise Comparison matrix of criteria Wrt Objective

Criteria	Design	Quality	Flexibility	Weight	Price
Design	1	0.21	1.32	0.27	0.22
Quality	4.82	1	4.68	3.16	2.71
Flexibility	0.76	0.21	1	0.29	0.23
Weight	3.66	0.32	3.46	1	1.00
Price	4.53	0.37	4.36	1.00	1
Total	14.77	2.11	14.82	5.72	5.16

Step 3: There are $\dfrac{n \times (n-1)}{2}$ judgments required to develop the set of matrix in step 2. It means, based on above formula $\dfrac{5 \times (5-1)}{2} = 10$. Each expert just has to answer or fill up 10 cells of 25 cells of squared comparison matrix which is shown by green colour in Table 2. Reciprocals are automatically assigned in each pairwise comparison which is marked with yellow colour in same table.

Step 4: Synthesizing the pairwise comparison matrix is performed by dividing each element of the matrix by its column total that is shown in Table 2.

Table 3. Synthesizing the pairwise comparison matrix

Criteria	Design	Quality	Flexibility	Weight	Price
Design	0.07	0.1	0.09	0.05	0.04
Quality	0.33	0.47	0.32	0.55	0.53
Flexibility	0.05	0.1	0.07	0.05	0.04
Weight	0.25	0.15	0.23	0.17	0.19
Price	0.31	0.18	0.29	0.17	0.19

For example the number of 0.32 in second row and third column in this table is obtained from 4.68 divided by 14.82 in Table 3.

Step 5: The priority vector of criteria can be obtained by finding the row averages.

Table 4. Priority vector of criteria

5

Criteria	Design	Quality	Flexibility	Weight	Price	Priorities of criteria
Design	0.07	0.1	0.09	0.05	0.04	0.07
Quality	0.33	0.47	0.32	0.55	0.53	0.44
Flexibility	0.05	0.1	0.07	0.05	0.04	0.06
Weight	0.25	0.15	0.23	0.17	0.19	0.2
Price	0.31	0.18	0.29	0.17	0.19	0.23

Where the number of 0.44 in priority vector of criteria is obtained as follows:

$$0.44 = \frac{0.33 + 0.47 + 0.32 + 0.55 + 0.53}{5}$$. The others will be computed by above formula. The following

five Tables show vector priority of alternatives with respect to each criterion. They are obtained similar to Table 4.

Table 5. To compare Alternatives Wrt Design

Design	Adidas	Nike	Puma	Priorities
Adidas	0.46	0.44	0.47	0.46
Nike	0.24	0.22	0.21	0.22
Puma	0.31	0.34	0.32	0.32

Table 6. To compare Alternatives Wrt Quality

Quality	Adidas	Nike	Puma	Priorities
Adidas	0.47	0.75	0.25	0.49
Nike	0.11	0.17	0.51	0.26
Puma	0.43	0.08	0.23	0.25

Table 7. To compare Alternatives Wrt Flexibility

Flexibility	Adidas	Nike	Puma	Priorities

Adidas	0.69	0.72	0.64	0.69
Nike	0.17	0.18	0.24	0.2
Puma	0.13	0.09	0.12	0.12

Table 8. To compare Alternatives Wrt Weight

Weight	Adidas	Nike	Puma	Priorities
Adidas	0.58	0.57	0.59	0.58
Nike	0.19	0.18	0.18	0.19
Puma	0.23	0.25	0.23	0.24

Table 9. To compare Alternatives Wrt Price

Price	Adidas	Nike	Puma	Priorities
Adidas	0.64	0.57	0.84	0.69
Nike	0.23	0.21	0.16	0.2
Puma	0.13	0.22	0.17	0.17

Step 6: Weighted alternatives is found by multiplying the vector priority of alternatives with respect to each criterion and priority vector of criteria. In this practical example, there are two kinds of criteria: positive and negative. Positive criteria are design, quality and flexibility and negative criteria contained weight and price. Therefore, the priorities vector of weight and price will be changed as following. The values priorities vector of weight are: 0.58, 0.19 and 0.24 and values of price priorities vector are; 0.69, 0.20 and 0.17. To normalize numbers of shoes weigh, perform the following is:

$1.00 - 0.58 = \mathbf{0.42}$ $\qquad$ $1.00 - 0.19 = \mathbf{0.81}$ $\qquad$ $1.00 - 0.24 = \mathbf{0.76}$

$0.42 + 0.81 + 0.78 = \mathbf{1.99.}$ $\quad$ $\dfrac{0.42}{1.99} = 0.21$ $\quad$ $\dfrac{0.81}{1.99} = 0.41$ $\qquad$ $\dfrac{0.76}{1.99} = 0.38$

To normalize the numbers of price priorities also is the same way.

$1.00 - 0.69 = \mathbf{0.31}$ $\qquad$ $1.00 - 0.20 = \mathbf{0.80}$ $\qquad$ $1.00 - 0.17 = \mathbf{0.83}$

$0.31 + 0.80 + 0.83 = \mathbf{1.94.}$ $\quad$ $\dfrac{0.31}{1.94} = 0.16$ $\quad$ $\dfrac{0.80}{1.94} = 0.41$ $\qquad$ $\dfrac{0.83}{1.94} = 0.43$

Table 10. The result of AHP

	Priorities of criteria

Design	Quality	Flexibility	Weight	Price		0.07		Weighted Alternatives
0.46	0.49	0.69	0.21	0.16		0.44		**0.3680** (Adidas)
0.22	0.26	0.2	0.41	0.41	×	0.06	=	**0.3181** (Nike)
0.32	0.25	0.12	0.38	0.43		0.2		**0.3145** (Puma)
						0.23		

Based on expert opinion and using AHP method, the outcome of Table 10, indicated that weight of Adidas is higher than others. Thus, "the best of shoe among three brand sport shoes is Adidas (0.3680)". The second one is Nike (0.3181) and the last one is Puma (0.3145). To calculate of Inconsistency Ratio (RI) continues the next steps.

Step 7: Determine the weighted sum matrix by multiplying the elements of the rows in a matrix with corresponding elements of priorities vector. Finally calculate the sum of these products and is show in Table 11.

Table 11. The weighted sum matrix

Matrix	Design	Quality	Flexibility	Weight	Price		Priorities vector		Weighted sum matrix
Design	1	0.21	1.32	0.27	0.22		0.07		0.29
Quality	4.82	1	4.68	3.16	2.71		0.44		3.12
Flexibility	0.76	0.21	1	0.29	0.23	×	0.06	=	0.32
Weight	3.66	0.32	3.46	1	1.00		0.2		0.81
Price	4.53	0.37	4.36	1.00	1		0.23		1.04

Where the number of 0.29 in weighted sum matrix is obtained as follows:

$(1 \times 0.07) + (0.21 \times 0.44) + (1.32 \times 0.06) + (0.27 \times 0.20) + (0.22 \times 0.23) = 0.29$

Step 8: Determine the consistency vector by dividing the weighted sum vector by the priorities vector determined previously. In this case, Lambda value is calculated as follows:

$$\lambda_1 = \frac{0.29}{0.07} = 4.14 \quad \lambda_2 = \frac{3.12}{0.44} = 7.09 \quad \lambda_3 = \frac{0.32}{0.06} = 5.33 \quad \lambda_4 = \frac{0.81}{0.20} = 4.05 \quad \lambda_5 = \frac{1.04}{0.23} = 4.52$$

Step 9: Compute the average of this value to obtain λ_{max}.

$$\lambda_{max} = \frac{\lambda_1 + \lambda_2 + \lambda_3 + \lambda_4 + \lambda_5 + ...\lambda_n}{n} \quad \lambda_{max} = \frac{4.14 + 7.09 + 5.33 + 4.05 + 4.52}{5} = 5.026$$

Here, because dimension of matrix is 5×5. Therefore $n = 5$

Step 10: Find the inconsistency Index (CI) as follows: $CI = \frac{\lambda_{max} - n}{n - 1}$.

Where n is dimension of matrix. $\quad CI = \dfrac{5.026 - 5}{5 - 1} = 0.065$

Step 11: Calculate the Consistency Ratio (CR) from dividing CI on RI .Where RI is the random index and depends on the number of elements being compared in Table 12.

Table 12. Random Consistency dInex

Order Of Matrix	1	2	3	4	5	6	7	8	9	10
R.I.	0	0	0.52	0.89	1.11	1.25	1.35	1.4	1.45	1.49

$$CR = \dfrac{CI}{RI} \qquad CR = \dfrac{0.065}{1.11} = 0.058$$

According to Saaty and Cillo(2008), If CR< 0.10, the ratio indicates is reasonable levels of consistency in the pairwise comparison, however, if CR ≥ 0.10, the values of the ratio indicates inconsistent judgments and judgments should be reviewed and improved. The CR of this case is acceptable.

4. Conclusion and recommendation

In this study, the finding of the best brand shoe was done using the group AHP tool. This method was applied in this using data from a real case. To increase the efficiency and ease-of-use of the proposed model, simple software such as MS Excel and Expert Choice can be used. The limitation of this article is that AHP ignores the uncertainty of executives' judgment during the decision-making process. In addition, some criteria were quantitative and some of them could have a qualitative structure or have an uncertain structure which cannot be measured precisely. In such cases, fuzzy numbers can be used to obtain the evaluation matrix, and the proposed model can be enlarged by using fuzzy numbers. For future research, the authors suggest that other MCDM approaches such as TOPSIS and ELECTRE with or without fuzzy methods be used, and to be compared as justification for brand shoes selection in sport. As a result of this paper, the best brand shoe is Adidas and it is followed by Nike and Puma respectively.

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