*Full Length Research Paper*

# A study of cosmetic bundle by utilizing a fuzzy Analytic Hierarchy Process (AHP) to determine preference of product attributers toward customer value

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**Determining the preferences of product attributes for customer value is a crucial issue driven by multiple requirements on the customers. However, arising from mental and psychological phenomena factors, people's judgments on the importance of customer requirements is imprecise and vague. The fuzzy analysis hierarchy process (FAHP) with an extent analysis is utilized to determine preferences toward customer value to overcome this uncertainty in the Analytic Hierarchy Process (AHP). With this method, the researcher can use triangular fuzzy numbers for the pair wise comparisons and derive the weight vectors. Based on the calculations results, the manufacturers could implement product design and quality management to prioritize customer requirements; besides, retailers are also able to understand what kind of benefits or performances are customers prefer and thereby develop strategic appeal for them.**

**Key words:** Fuzzy AHP, product attributes, extent analysis, customer value.

## INTRODUCTION

Delivering value to customers is a critical issue in today's competitive market. Some retailers believe "price" is the core value for customers. However, beside price, if retailers could understand customers' preference based on the concept of customer value, the results will help them to focus on customers' needs in supplying, and also enhance the competitive advantages in sailing. In previous researches concerning customer value, most scholars have utilized trade-off concept to describe what value is. Sheth, Newman and Gross (1991) proposed five various dimensions of customer value—functional, social, emotional, epistemic, and conditional value; but, the causal relationships among them are not so clear.

Through Woodruff (1997) attempted to utilize the hierarchy concept to explain the customer value, concrete variables are not available. Thus, developing a systematic structure of customer value and determining the weight of product attributes is necessary for manufacturers and marketers to understand customers' preference.

But, by any measure, for manufacturers to understand customer's preference is difficult. The first reason is customers tend to consider multiple criteria among their alternatives at the time of decision-making. As the problem is the complex multi-criteria decision making (MCDM) problem, Saaty (1980) recommended decomposing it into hierarchical structure and proposed the Analysis Hierarchy Process (AHP) method to measure the relative weight of various attributes. The hierarchical structure of the AHP is a useful mechanism when it comes to identify the scope of decision problem, in which pairwise comparisons enable decision making  to  make

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precise decision between two alternatives with respect to upper level factors. For example, Ayag (2002) uses the AHP technique to evaluate of the hardware and software components of a targeted computer-aided system. The second reason is that human assessment and perception on qualitative attributes are always so subjective and imprecise that conventional MCDM methods cannot effectively handle problems with such uncertainty information. To deal with the above predicament, fuzzy set theory has been used for modeling uncertainty (or imprecision) arising from mental phenomena, which are neither random nor stochastic (Wu et al., 2004). A fuzzy set is an objects class with continues grades of membership which is characterized by a membership function. The membership grade for each object is ranging between zero and one.

About the application of fuzzy set theory, Vanegas and Labib (2001) proposed a method to determine the weights for the customer requirements by converting the weights from the AHP into fuzzy numbers using the concept of a "fuzzy line segment." Based on above statements and researches, the characteristics of fuzzy AHP are appropriate approaches to handle such a MCDM problem. Besides above, Hsu and Lin (2006) utilized fuzzy quality function deployment and entropy to determine the intensity of customer value to develop the competitive model. The resulting fuzzy values can be used to analyze the variance and the importance of customer value more effectively compared with the crisp values. In this research, by applying the fuzzy AHP with extent analysis (Chang 1996) one can obtain the importance weights of product attributes that customers require. The extent analysis is referenced to as a consideration of an object to be satisfied for the goal and the "satisfied extent" is defined by means of triangular fuzzy number of this research.

According to market research by Euromonitor International, in 2004, the sales amount of global cosmetic and toiletries (C&T) industry was about US$ 230 billion in the 52 main countries (which together account for 95% world GDP). In the future, Euromonitor International forecast the average growth rate to maintain 3.6 percent every year until 2009, when the market value of global C&T will be estimated at US$ 275 billion. To view individual performance, L'Oreal is the No.1 and its market share account for rate about 10%. The No.2—P & G (8.8%) and No.3— Unilever (8.2%) cling to L'Oreal like a leech closely. In the top 10 companies of global C&T industry, the summation of market share is nearly about 55%.

In the applications of promotion practice, department stores usually provide cosmetic bundles to attract customer for shopping. Thus, the C&T industry is an area well worth researching and product attributes of cosmetic is used throughout to help manufacturers and retailers for providing suitable value to customers.

## Structure development for customer value

To develop the construct the customer value framework of cosmetic, the author utilized Delphi method to gather the customers' requirements firstly. As an exploratory stage, this study relies on theoretical, purposeful, and relational sampling to expand theoretical concepts. The criteria here to select the participants for this study are experts with sufficient knowledge domain or consumption experience in cosmetics, especially those who understand the relationship between customers' needs and products' attributes. Besides, the customers who belong to the target group—females; 20 to 45 years old, and have regular purchase experience of cosmetics are also be considered. As Reid (1988) pointed out that one of the keys to success with the Delphi method is to have an appropriate selection of panel members: they should be selected for their capabilities, knowledge and independence. The number of participants about the ideal Delphi group size is comprised of 5 to 20 members (Rowe and Wright, 2001). Thus, to obtain the customer requirements with respect to cosmetics, twelve experts make up the panel, including 3 cosmetic retailers, 3 senior cosmetologists and 6 department VIPs of cosmetic. The background / profile of the respondents in this study were shown in Table 1. There are four reasons for adopting above experts' and VIPs' views but general customers. First, compared with general consumers, experts and VIPs have more complete product knowledge about cosmetic. Second, general consumers just focus on their own demand; however, experts have more experience to contact different cases. Third, compared with general consumers, these VIPs have more shopping experience and in purchasing different cosmetic bundles. Last, no matter scholars, sales clerks, and cosmetologists, their jobs are to provide the information to customers and/or satisfy customers' needs in using. Once the panel is created, a communication process is established as shown in Figure1.

This process is limited to 3 rounds, which is in accordance with Rowe and Wright's (2001) suggestions. Round one of the Delphi tried to shake down the key variables. The questions for the above experts focus on "when customers purchase a cosmetic bundle, what kind of benefits could enhance customer value?" and "when customers purchase a cosmetic bundle, what product attributes could provide related benefits to reach the desired value?" The results of round one were collected to perform analysis and generate the issues and relationships among values, benefits, and product attributes for the next round. In round 2, all the issues identified and proposed in the first round were consolidated into a list of relationships and delivery to the panel, which consisted of the participants who had answered the round-one questionnaire. In the second round, the panel was asked to rank and rate these  newly

**Table 1.** The background of research samples.

| Code | Title | Personal work experience |
|------|-------|--------------------------|
| CR1 | Sales manager | Area manager, 14 years in industry, class C national certification, responsible for the channel of department store |
| CR2 | Sales manager | Area manager, 11 years in industry, class C national certification, responsible for the channel of department store |
| CR3 | Sales manager | Store manager, 9 years in industry, class C national certification, responsible for customer service |
| SC1 | Cosmetologist | The member of a cosmetic council, 22 years in industry, class B national certification, director of personal workshop |
| SC2 | Cosmetologist | The member of a cosmetic council, 15 years in industry, class B national certification, director of personal workshop |
| SC3 | Cosmetologist | Senior manger, 18 years in industry, class B national certification, responsible for cosmetologist training |
| VIP1 | Manager | 42 years old, work for trading company 18 years, purchase cosmetic amount NT 11000 per month |
| VIP2 | Sales clerk | 37 years old, work for costume and accessories 15 years, purchase cosmetic amount NT 10000 per month |
| VIP3 | Office lady | 34 years old, work for publishing circles 11 years, consumption in cosmetic amount NT 7800 per month |
| VIP4 | Office lady | 30 years old, work for publishing circles 7 years, consumption in cosmetic amount NT 4000 per month |
| VIP 5 | Sales clerk | 28 years old, work for retail circles 5 years, consumption in cosmetic amount NT 6000 per month |
| VIP 6 | Office lady | 26 years old, work for trading company 4 years, consumption in cosmetic amount NT 5000 per month |

generated relationships, and the panelists had to provide comments about why they ranked them as they did. A Likert scale, which was designed to examine how strongly subjects agreed or disagreed with statements, was employed. Furthermore, a 6-point scale was used in this study. The 6-point Likert scale which read as (1) Extremely satisfied, (2) Very satisfied, (3) Somewhat satisfied, (4) Somewhat dissatisfied, (5) Very dissatisfied, and (6) Extremely dissatisfied. This study used 6-point scales to perform an even number of ratings in the scale to have respondents commit to either the positive or negative end of the scale instead of giving them a neutral or ambivalent answer choice (Chomeya, 2010). In the final round 3, a similar procedure was repeated. The ranked list with all anonymous comments was sent back to the panel. The panelists then were asked to reconsider their own rankings and revise any of their scores as they wished. The purpose of this round was to seek an agreement of opinions and for dissenting views to be confirmed. After 3 rounds of questionnaire, this study can finally obtain useful customer requirements. Through the process of Delphi method, experts reveal 4 desired values
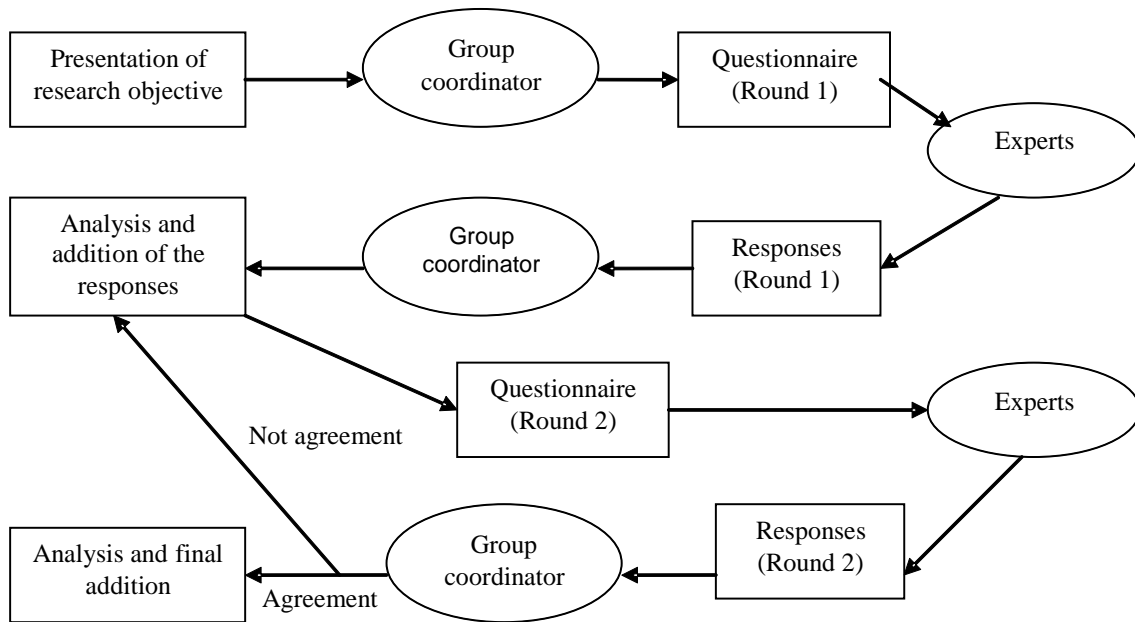
**Figure 1.** Communication process in the Delphi method

(V1 to V4), 10 expected performances (P1 to P10) and 25 product attributes (A1 to A25) for cosmetic design. Figure 2 shows a four-level hierarchy for the customer requirements for cosmetic bundle and the goal is "Customer value of cosmetic bundle."

## Construction of fuzzy judge matrix for AHP

After a hierarchical model is constructed, experts are asked to compare a series of pairwise comparisons and establish the relative importance of customer requirements to attain the upper level criteria. For example, the question asked to the expert is: "what is the relative impact of desired value A when compared to desired value B in using cosmetics on customer value?" In such comparisons, a linguistic scale is used to compare any two elements, namely equally, moderately, strongly, very strongly, or extremely preferred. The linguistic terms that people use to express their feelings or judgment are vague. In this paper, the widely adopted triangular fuzzy number technique (Chan et al., 1999) is used to represent a pairwise comparison of customer requirements.

## Triangular fuzzy numbers

A fuzzy number is a special fuzzy set $F = \{(x, \mu_F(x)), x \in R\}$, where $x$ takes its value on the real line $R_1$: $-\infty < x < +\infty$ and $\mu_F(x)$ is a continuous mapping from $R_1$ to the close interval

[0.1]. A triangular fuzzy number can be denoted as $M = (l, m, u)$. Its membership function $\mu_M(x)$: $R \rightarrow [0, 1]$ is equal to:

$$\mu_M(x) = \begin{cases} \dfrac{x}{m-l} - \dfrac{l}{m-l}, & x \in [l, \quad m] \\ \dfrac{x}{m-u} - \dfrac{u}{m-u}, & x \in [m, \quad u] \\ 0, & otherwise \end{cases}$$

where $l \leq m \leq u$, $l$ and $u$ stand for the lower and upper value of the support of $M$, respectively, $m$ is the mid-value of $M$. When $l = m = u$, by convention, it is a non-fuzzy number.

## Development of fuzzy scales for pairwise comparisons

In order to take into consideration the vagueness in an assessment of the pairwise comparisons for customers' requirements, linguistic variables are used to represent different assessments from "equally important" to "absolutely important." In this study, we utilize the extent analysis method and linguistic scales (Chang, 1996; Zhu et al., 1999) since the steps in this approach are relatively easier than those in the other fuzzy AHP approaches; nevertheless, they are still similar to those in the crisp AHP. Recently, Kwong and Bai (2003) used this method to prioritize customer requirements in quality function
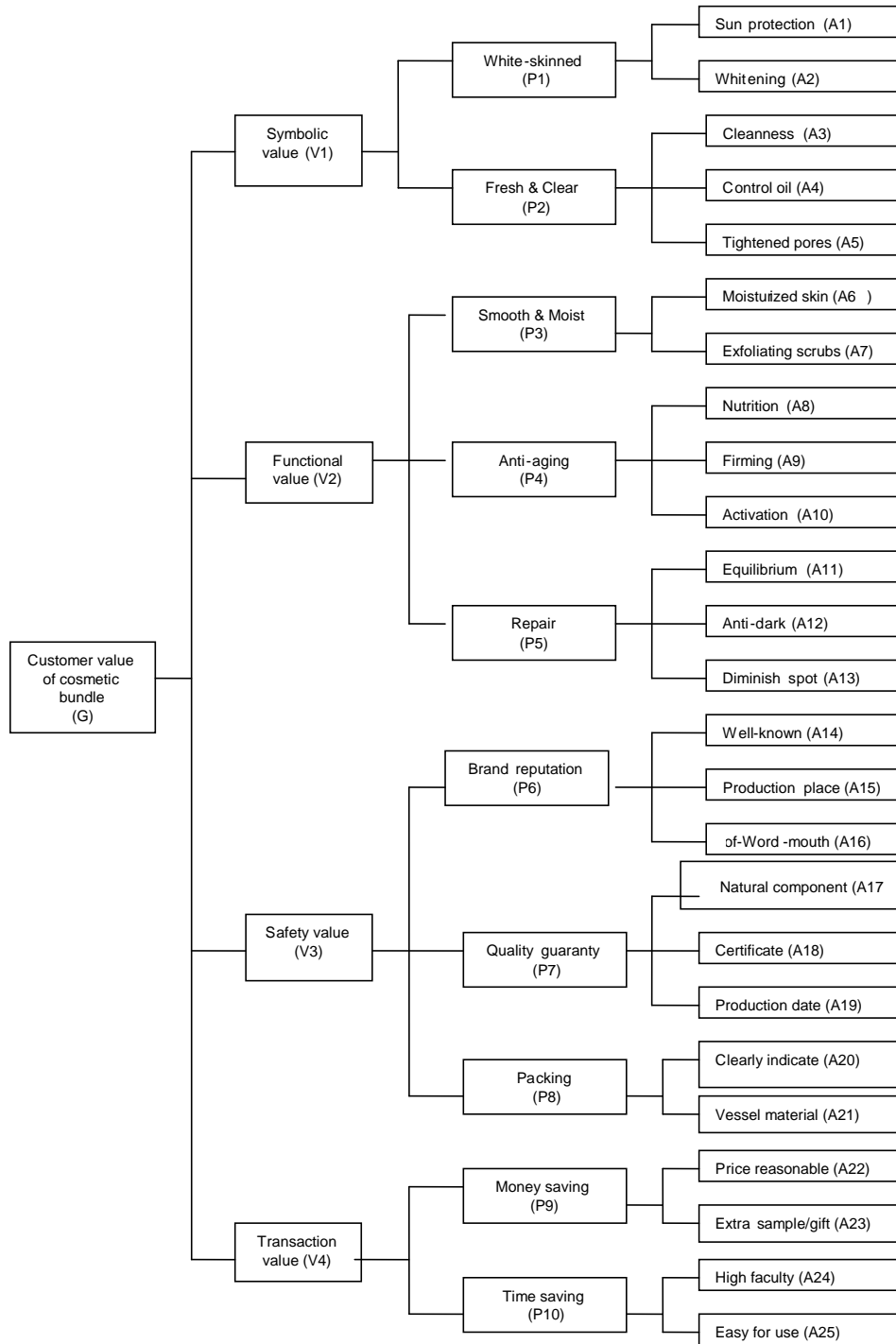
**Figure 2.** Hierarchy of customer value in cosmetic bundle.

deployment. Kahraman et al. (2006) also used it in quality improvement to optimize the fulfillment of customer needs. The fuzzy scale regarding relative importance to measure the relative weights is given in Table 2.

**Pairwise comparison and the fuzzy judgment matrix**

First, experts use the linguistic variables to express their preferences between options and covert  them  into  a

**Table 2.** Linguistic scales for importance.

| Linguistic scale for important | Triangular fuzzy scale | Triangular fuzzy reciprocal scale |
|---|---|---|
| Equally important (EI) | (1/2, 1, 3/2) | (2/3, 1, 2) |
| Weakly important (WI) | (1, 3/2, 2) | (1/2, 2/3, 1) |
| Strongly important (SI) | (3/2, 2, 5/2) | (2/5, 1/2, 2/3) |
| Very strongly important (VSI) | (2, 5/2, 3) | (1/3, 2/5, 1/2) |
| Absolutely important (AI) | (5/2, 3, 7/2) | (2/7, 1/3, 2/5) |

triangular fuzzy number. For example, someone may consider that element $i$ is strongly important when compared with the element $j$ under certain criteria; he or she may set $\mu_{ij} = $ (3/2, 2, 5/2). If the same individual considers element $j$ less important than element $i$, the pairwise comparison between $j$ and $i$ could be presented by using the triangular fuzzy number, $\mu_{ij} = $ (2/5, 1/2, 2/3). To integrate opinions from different experts, this study adopts the geometric mean to obtain the average of triangular fuzzy number. The advantage of geometric mean is not just avoiding the influence of extreme value; the more important implication is to deal with the synthesized judgment of reciprocals (Saaty, 2005). For example, after averaging opinions from 12 experts, the fuzzy comparison matrix (FCM) of the value level of the hierarchy is obtained as follows:

$$
G: FCM1 = \begin{array}{c} \\ V1 \\ V2 \\ V3 \\ V4 \end{array}
\begin{array}{cccc}
V1 & V2 & V3 & V4 \\
(0.50, 1.00, 1.50) & (1.30, 1.67, 2.06) & (1.10, 1.33, 1.63) & (1.22, 1.63, 2.33) \\
(0.49, 0.60, 0.77) & (0.50, 1.00, 1.50) & (0.80, 1.00, 1.39) & (1.50, 2.00, 2.50) \\
(0.61, 0.75, 0.91) & (0.72, 1.00, 1.25) & (0.5, 1.00, 1.50) & (1.67, 2.17, 2.67) \\
(0.43, 0.60, 0.82) & (0.40, 0.50, 0.67) & (0.38, 0.46, 0.60) & (0.5, 1.00, 1.50)
\end{array}
$$

Similarly, the other FCMs in each level of hierarchical model of customer requirements for cosmetic design can be obtained as shown in the Appendix.

**Calculation of the consistency index and consistency ratio**

The AHP methodology of Saaty (1980) provides a consistency index to measure any inconsistency within the judgments in each comparison matrix as well as for the entire hierarchy. The index can be used to determine whether or not the targets can be arranged in an appropriate order of ranking and how consistent the pairwise comparison matrices are. In this research, the defuzzification method with triangular fuzzy numbers is employed to convert the fuzzy comparison matrices into crisp matrices, which thereafter are used for the investigation of the consistency.

The consistency index, $CI$, and the consistency ratio, $CR$, for a comparison matrix can be computed using the following equations.

$$CI = (\lambda_{max} - n)/(n-1), \quad (1)$$

$$CR = (CI/RI(n))100\%, \quad (2)$$

where, $\lambda_{max}$ is the largest eigenvalue of the comparison matrix, n is the dimension of the matrix, and RI($n$) is a random index, that depends on $n$, as shown in Table 3. If the calculated CR of a comparison matrix is less than 10%, the consistency of the pairwise judgment can be considered acceptable. Otherwise the judgments expressed by the experts are considered to be inconsistent and the decision maker has to repeat the pairwise comparison matrix.

**Table 3.** Random index, RI (Golden et al., 1989).

| n | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|
| RI(n) | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 |

A triangular fuzzy number, denoted as $M = (l, m, u)$, can be defuzzified to a crisp number as follows:

$$M_{CRISP} = (4m + l + u)/6. \tag{3}$$

$$
G: FCM1_{CRISP} =
\begin{array}{c c c c c}
 & V1 & V2 & V3 & V4 \\
V1 & 1.0000 & 1.6704 & 1.3437 & 1.7037 \\
V2 & 0.6093 & 1.0000 & 1.0315 & 2.0000 \\
V3 & 0.7542 & 0.9950 & 1.0000 & 2.1667 \\
V4 & 0.6078 & 0.5111 & 0.4702 & 1.0000
\end{array}
$$

Based on our calculation, the largest eigenvalue of matrix FCM1, $\lambda$max, is 4.2169. The dimension of the matrix, $n$, is four and the random index. RI($n$), is 0.9 by reference to Table 3. Therefore, the consistency index and the consistency ratio of the matrix can be calculated as follows:

$$CI = (\lambda_{max} - n)/(n\text{-}1) = (4.2169 - 4)/(4 - 1) = 0.0723$$

$$CR = (CI/RI(n))100\% = (0.0723/0.9) = 0.0803 \le 0.1$$

After the consistency ratios of all the other comparison matrices are calculated, it is found that they are all less than 10%. Therefore, the consistency of the judgment in all the comparison matrices is acceptable.

## Results of Product Attributes

In the previous research, many scholars have engaged in the fuzzy extension of Saaty's priority theory; such as Netherlands's scholars Van Laarhoven and Pedrycg (1983) proposed a method, where the fuzzy comparing judgment is represented by triangular fuzzy numbers. They used fuzzy numbers with triangular membership function and simple operation laws. According to the method of logarithmic least squares (LLSM), the priority vectors were obtain. However, there is one defect in the calculating process. Researchers utilize fuzzy number to describe the "linguistic vagueness"; but, the crisp value could obtain by a "clear" defuzzification formula for calculating priority vector. It seems not match the original

When the comparison matrix FCM 1 is taken as the example, the corresponding crisp matrix can be obtained as shown below:

concept of ambiguity. The extent analysis method and the principles of the comparison of fuzzy numbers are employed to obtain estimates of the weight vectors for the individual levels of a hierarchy of customer requirements (Chang, 1996). The extent analysis method is used to consider the extent of an object that must satisfy the goal, that is, satisfied extent. In the method, the "extent" is quantified by using a fuzzy number. On the basis of the fuzzy values in the extent analysis of each object, a fuzzy synthetic extent value can be obtained, which is defined as explained in the following.

Let $X = \{x_1, x_2, ..., x_n\}$ bean object set, and $G = \{g_1, g_2, ..., g_m\}$ be a goal set. Based on Chang's (1996) extent analysis, each object is taken and the extent analysis of each goal, $g_i$, is performed individually. Therefore, $m$ extent analysis values of each object can be obtained, with the following signs:

$$\tilde{M}_{gi}^1, \ \tilde{M}_{gi}^2, ..., \ \tilde{M}_{gi}^m, \qquad i = 1, \ 2, ..., \ n.$$

where all the $\tilde{M}_{gi}^j (j = 1, \ 2, ..., \ m$ are triangular fuzzy numbers.

The extent analysis can be expressed as follows:

Step 1. The value of the fuzzy synthetic extent with respect to the $i$th object is defined as:

$$\tilde{S}_i = \sum_{j=1}^{m} \tilde{M}_{g_i}^{j} \otimes [\sum_{i=1}^{n}\sum_{j=1}^{m} \tilde{M}_{g_i}^{j}]^{-1}. \tag{5}$$
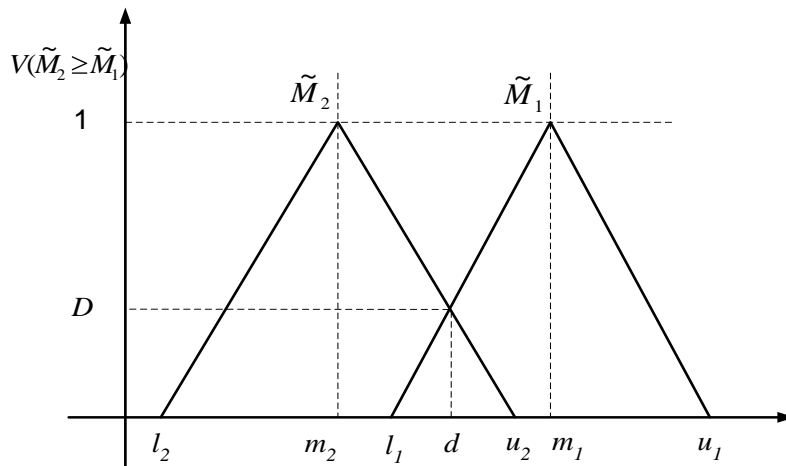
**Figure 3.** Intersection of between M1 and M2.

To obtain, $\sum_{j=1}^{m} \tilde{M}_{g_i}^{j}$ the fuzzy addition operation of *m* extent analysis values for a particular matrix is performed such that:

$$\sum_{j=1}^{m} \tilde{M}_{g_i}^{j} = (\sum_{j=1}^{m} l_j, \; \sum_{j=1}^{m} m_j, \; \sum_{j=1}^{m} u_j), \tag{6}$$

and to obtain $[\sum_{i=1}^{n} \sum_{j=1}^{m} \tilde{M}_{g_i}^{j}]^{-1}$, perform the fuzzy addition operation of $\tilde{M}_{g_i}^{j} (j = 1, \; 2, \dots, \; m)$ values such that

$$\sum_{i=1}^{n} \sum_{j=1}^{m} \tilde{M}_{g_i}^{j} = (\sum_{i=1}^{n} l_i, \; \sum_{i=1}^{n} m_i, \; \sum_{i=1}^{n} u_i),$$

and then compute the inverse of the vector in Eq.(6)such that

$$[\sum_{i=1}^{n} \sum_{j=1}^{m} \tilde{M}_{g_i}^{j}]^{-1} = (\frac{1}{\sum_{i=1}^{n} u_i}, \; \frac{1}{\sum_{i=1}^{n} m_i}, \; \frac{1}{\sum_{i=1}^{n} l_i}). \tag{7}$$

Step 2. The degree of possibility of $\tilde{M}_2 = (l_2, \; m_2, \; u_2) \geq \tilde{M}_1 = (l_1, \; m_1, \; u_1)$ is defined as:

$$V(\tilde{M}_2 \geq \tilde{M}_1) = \sup_{y \geq x}[\min(u_{\tilde{M}_1}(\text{)}, \; u_{\tilde{M}_2}(\text{))}] \tag{8}$$

and can be equivalently expressed as follows:

$$V(\tilde{M}_2 \geq \tilde{M}_1)$$
$$= hgt(\tilde{M}_1 \cap \tilde{M}_2) = u_{\tilde{M}_2}(d)$$
$$= \begin{array}{l} 1, \\ 0, \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} \end{array}, \begin{cases} if \quad m_2 \geq m_1, \\ if \quad l_1 \geq u_2, \\ otherwise. \end{cases} \tag{9}$$

where *d* is the ordinate of the highest intersection point *D* between $\mu_{M1}$ and $\mu_{M2}$ (Figure 3)

To compare $M_1$ and $M_2$, we need both the values of V $(M_1 \geq M_2)$ and V $(M_2 \geq M_1)$ are required.

Step 3.The degree of possibility for a convex fuzzy number to be greater than k convex fuzzy numbers $\tilde{M}_i (i = 1, \; 2, \; \dots, \; k)$ can be defined by:

$$V(\tilde{M} \geq \tilde{M}_1, \; \tilde{M}_2, \dots, \; \tilde{M}_k)$$
$$= V[(\tilde{M} \geq \tilde{M}_1) \; \cap \; (\tilde{M} \geq \tilde{M}_2) \; \cap \dots \cap \; (\tilde{M} \geq \tilde{M}_k)] \tag{10}$$
$$= \min \; V(\tilde{M} \geq \tilde{M}_i), \qquad i = 1, \; 2, \dots, \; k.$$

Assume that

$$d'(A_i) = \min \; V(\tilde{S}_i \geq \tilde{S}_k), \qquad k = 1, \; 2, \dots, \; n; \quad k \neq i \tag{11}$$

Then the weight vector is given by

$$W' = [d'(A_1), \; d'(A_2), \dots, \; d'(A_n)]^T \tag{12}$$

Where $A_i (i = 1, \; 2, \; \dots, \; n)$ are n elements.

Step 4.Via normalization, the normalized weight vectors

are:

$$W = [d(A_1),\ d(A_2),..., d(A_n)]^T \qquad (13)$$

where $W$ is a nonfuzzy number.

In the example of the cosmetic design, with the use of Step 1, the fuzzy synthetic degree values of all elements of the value level of the hierarchy can be calculated as shown below:

$$[\sum_{i=1}^{4}\sum_{j=1}^{4}\tilde{M}_{V_i}^{j}\ ] = (0.50, 1.00, 1.50) + (1.30, 1.67, 2.06)$$
$$+\cdots+ (0.50, 1.00, 1.50) = (12.61, 14.74, 23.59)$$

$$[\sum_{i=1}^{4}\sum_{j=1}^{4}\tilde{M}_{V_i}^{j}\ ]^{-1} = (0.04, 0.06, 0.08).$$

$$\sum_{j=1}^{4}\tilde{M}_{g_i}^{j} = (0.50, 1.00, 1.50) + (1.30, 1.67, 2.06) + (1.10,$$
$$1.33,1.63)+(1.22,1.63,2.33) = (4.12, 5.67, 7.52)$$

Hence the fuzzy synthetic degree values of element V1, $D_{V1}$ can be calculated as follows:

$$D_{V1} = \sum_{j=1}^{4}\tilde{M}_{g_i}^{j} \otimes [\sum_{i=1}^{4}\sum_{j=1}^{4}\tilde{M}_{g_i}^{j}\ ]^{-1} = (0.17, 0.32, 0.60)$$

Following a similar calculation, the fuzzy synthetic degree values of all elements of the value level of the hierarchy can be obtained as shown below:

G: $D_{V1}$= (0.17, 0.32, 0.60)

$D_{V2}$= (0.14, 0.26, 0.49)

$D_{V3}$= (0.15, 0.28, 0.50)

$D_{V4}$= (0.07, 0.14, 0.28)

Next, the following comparison results are derived following step 2 in order to calculate the weight vectors of the value level of the hierarchy.

$V(D_{V1} \geq D_{V2}) = 1,$

$V(D_{V1} \geq D_{V3}) = 1$

$V(D_{V1} \geq D_{V4}) = 1$

$$V(D_{V2} \geq D_{V1}) = \frac{(0.17-0.49)}{(0.26-0.49)-(0.32-0.17)} = 0.84$$

$$V(D_{V2} \geq D_{V3}) = \frac{(0.15-0.14)}{(0.26-0.49)-(0.28-0.15)} = 0.95$$

$$V(D_{V2} \geq D_{V4}) = 1$$

$$V(D_{V3} \geq D_{V1}) = \frac{(0.17-0.50)}{(0.28-0.50)-(0.32-0.17)} = 0.89$$

$$V(D_{V3} \geq D_{V2}) = 1$$
$$V(D_{V3} \geq D_{V4}) = 1$$

$$V(D_{V4} \geq D_{V1}) = \frac{(0.17-0.28)}{(0.14-0.28)-(0.32-0.17)} = 0.39$$

$$V(D_{V4} \geq D_{V2}) = \frac{(0.14-0.28)}{(0.14-0.28)-(0.26-0.14)} = 0.56$$

$$V(D_{V4} \geq D_{V3}) = \frac{(0.07-0.50)}{(0.14-0.28)-(0.28-0.15)} = 0.51$$

Based on Step 3, the weight vector W of the value level of the hierarchy can be calculated by using the following formula:

d(V1) = min V($D_{V1}\geq D_{V2}$, $D_{V3}$, $D_{V4}$) = min{1, 1, 1} = 1.00, d(V2) = min V($D_{V2}\geq D_{V1}$, $D_{V3}$, $D_{V4}$) = min{0.84, 0.95, 1} = 0.84, d(V3) = min V($D_{V3}\geq D_{V1}$, $D_{V1}$, $D_{V4}$) = min{0.89, 1, 1} = 0.89, d(V4) = min V($D_{V4}\geq D_{V1,}$ $D_{V2}$, $D_{V3,}$) = min{0.39, 0.56, 0.51}= 0.39, Wt = (d(V1), d(V2), d(V3), d(V4))$^T$ = (1.00, 0.84, 0.89, 0.39).

After normalization in Step 4, the normalized weight vectors of the value level are as shown below:
G: ($W_{V1}$, $W_{V2}$, $W_{V3}$, $W_{V4}$) = (0.32, 0.27, 0.29, 0.12)

Following a similar calculation, the weight vectors of performance ($W_{Pj}$, j=1~10) and attribute ($W_{Ak}$, k=1~25) can be calculated. Hence, as shown in Table 4, the total weights of the customer requirements for each product attribute can be derived by using the following equations.

$$TW_{Pj}=W_{Vi}\times W_{Pj} \qquad (14)$$

$$TW_{Ak}=W_{Vi}\times W_{Pj}\times W_{Ak} \qquad (15)$$

## Conclusions

This paper utilized triangular fuzzy numbers and the fuzzy AHP with extent analysis to determine the preference of product attributes for customer value. The fuzzy AHP with

**Table 4.** Importance weights for the customer requirements for a cosmetic design.

| Value | Performance | Attribute | Rank |
|---|---|---|---|
| Symbolic value ($W_{V1} = 0.32$) | White-skinned ($W_{P1} = 0.52$; $TW_{P1} = 0.1673$) | Sun protection ($W_{A1} = 0.55$; $TW_{A1} = 0.0921$) | 1 |
| | | Whitening ($W_{A2} = 0.45$; $TW_{A2} = 0.0752$) | 4 |
| | Fresh and clear ($W_{P2} = 0.48$; $TW_{P2} = 0.1542$) | Cleanness ($W_{A3} = 0.53$; $TW_{A3} = 0.0811$) | 2 |
| | | Control oil ($W_{A4} = 0.27$; $TW_{A4} = 0.0419$) | 10 |
| | | Tightened pores ($W_{A5} = 0.20$; $TW_{A5} = 0.0312$) | 15 |
| Functional value ($W_{V2} = 0.27$) | Smooth and moist ($W_{P3} = 0.38$; $TW_{P3} = 0.1019$) | Moisturized skin ($W_{A6} = 0.55$; $TW_{A6} = 0.0561$) | 5 |
| | | Exfoliating scrubs ($W_{A7} = 0.45$; $TW_{A7} = 0.0458$) | 8 |
| | Anti-aging ($W_{P4} = 0.36$; $TW_{P4} = 0.0962$) | Nutrition ($W_{A8} = 0.21$; $TW_{A8} = 0.0201$) | 22 |
| | | Firming ($W_{A9} = 0.45$; $TW_{A9} = 0.0438$) | 9 |
| | | Activation ($W_{A10} = 0.34$; $TW_{A10} = 0.0324$) | 14 |
| | Repair ($W_{P5} = 0.27$; $TW_{P5} = 0.0717$) | Equilibrium ($W_{A11} = 0.35$; $TW_{A11} = 0.0251$) | 17 |
| | | Anti-dark ($W_{A12} = 0.35$; $TW_{A12} = 0.0251$) | 17 |
| | | Diminish spot ($W_{A13} = 0.30$; $TW_{A13} = 0.0214$) | 20 |
| Safety value ($W_{V3} = 0.29$) | Brand reputation ($W_{P6} = 0.28$; $TW_{P6} = 0.0797$) | Well-known ($W_{A14} = 0.27$; $TW_{A14} = 0.0218$) | 19 |
| | | Place of production ($W_{A15} = 0.08$; $TW_{A15} = 0.0066$) | 25 |
| | | Word of mouth ($W_{A16} = 0.64$; $TW_{A16} = 0.0513$) | 7 |
| | Quality guaranty ($W_{P7} = 0.61$; $TW_{P7} = 0.1749$) | Natural component ($W_{A17} = 0.23$; $TW_{A17} = 0.0410$) | 11 |
| | | Certificate ($W_{A18} = 0.46$; $TW_{A18} = 0.0802$) | 3 |
| | | Production date ($W_{A19} = 0.31$; $TW_{A19} = 0.0537$) | 6 |
| | Packing design ($W_{P8} = 0.11$; $TW_{P8} = 0.0301$) | Clearly indicate ($W_{A20} = 0.52$; $TW_{A20} = 0.0157$) | 23 |
| | | Vessel material ($W_{A21} = 0.48$; $TW_{A21} = 0.0144$) | 24 |
| Transaction value ($W_{V4}=0.12$) | Money saving ($W_{P9} = 0.53$; $TW_{P9} = 0.0656$) | Price reasonable ($W_{A22} = 0.56$; $TW_{A22} = 0.0366$) | 13 |
| | | Extra sample/gift ($W_{A23} = 0.44$; $TW_{A23} = 0.0289$) | 16 |
| | Time saving ($W_{P10} = 0.47$; $TW_{P10} = 0.0584$) | High faculty ($W_{A24} = 0.64$; $TW_{A24} = 0.0375$) | 12 |
| | | Easy for use ($W_{A25} = 0.36$; $TW_{A25} = 0.0210$) | 21 |

extent analysis is an effective method that can be used to calculate the weights of importance of product attributes for customer requirements because it has the capability to capture the vagueness of human judgment. In addition, the algorithm of the fuzzy AHP with extent analysis makes it simple to determine the weight vectors. However, triangular fuzzy numbers may not be suitable to all industrial applications, which means determining the correct fuzzy numbers is necessary for a particular application.

From the results of the empirical example, a valuable cosmetic bundle should first and foremost provide symbolic value. Under the symbolic value, both two desired performances, "White-skinned" and "Fresh and Clear", play the important role to satisfy customer needs. Thus, manufacturers should use the evaluation results of product attributes to develop the priorities that customers are most concerned about. Next, the results also provide the information that safety value is the second value behind symbolic value. Especially, "Quality guaranty" is the greatest concern issue of the ten desired performances; hence, providing certification of the cosmetics will effectively enhance the safety value for customers. Besides above, "Production date" and "Natural components" also influence the safety value in customers' eyes. Manufacturers should stand in the position of customers by providing fresh products for use and think about the components of the cosmetic itself. Lastly, this study indicates that "Transaction value" makes the least contribution to customer value, a strong indication that manufacturers and retailers should not utilize "price" as the main competitive strategy for cosmetic painstakingly; by contrast, it is necessary that they deliver the strategic appeal vis-à-vis symbolic, functional and safety value to consumers and enhance the value image in their minds.

**Limitations and future study**

Although this study provides a systematic process for a product bundling model, there are still some research limitations as in the following:

(1) Research samples. To identify the customer preferences and desired requirements about cosmetics, expert samples (including cosmetic retailers, senior cosmetologists, and department VIPs of cosmetic) are considered as research samples. The main reasons are: experts have more complete product knowledge of cosmetics, experts have more experience in individual cases, and the experts' job is to provide the information to customers and/or satisfy customers' needs. However, the expert samples are not easy to obtain so that the number of research samples is limited.
(2) Generalization of research framework. On the

development of the research framework, this study draws on the literature review and interview results to construct a hierarchy framework of customer value and focuses on cosmetics bundles. However, to generalize for other product bundles requires some modifications. The main reason is that the variables under symbolic value and functional value will change according to particular research cases and targets. The product attributes under safety and transaction may also change for the same reasons. Nevertheless, information gained through a literature review and a systematic break down of customer value will provide a logical direction for application to other product bundles.

Delivering value to the customer is a common goal nowadays both in academic and industrial areas. Thus, this research utilizes "breaking down of value" to explore different dimensions of value and to give an emphasis on benefit maximization and cost minimization at same time. Focusing on the specific research area-cosmetics bundles, the main consumers are 20- to 45-year-old females, and they have a good financial standing in society. They hope cosmetics could provide the conesquences or attributes that cosmetics companies advertise no matter whether these consequences or attributes are either manifestly observable (such as functional value) or alternatively just an idealized concept (such as symbolic value). Each category of cosmetics has unique characteristics and provides different performance in the cosmetology process. Wanting to look good is a person's instinct, and so customers care little about the monetary expenditure and time needed for selection.

In addition, determining the relative weight of product attributes is a fundamental task of quality function development. In fact, there are two relevant lines of research that could be studied in the future. The first one is the design strategy of product bundles. Through building the relationship matrix between the product attributes (symbolic and functional value) and different categories of cosmetic (such as cleansers, lotions, serums, eye creams, and day & night cares), manufacturers not only obtain information as regards possible improvements in each attribute but also understand what product attributes are required to incorporate into specific categories. The second line of research involves the competitive strategy of operations. Through building the relationship matrix between the product attributes (safety and transaction value) and firm's capabilities (such as distribution, human resources, management information systems, marketing, manufacturing, and research & development), a firm could develop its core competence based on its advantages and overcome its weaknesses to catch up with its competitors.

**REFERENCES**

Ayag Z (2002). An analytic-hierarchy-process based simulation model

for implementation and analysis of computer-aided systems, in: Int. J. Prod. Res., 40(13): 3053-3073.

Chan LK, Kao HR, Ng A, Wu ML (1999). Rating the importance of customer needs in quality function deployment by fuzzy and entropy methods, in: Int. J. Prod. Res., 37(11): 2499-2518.

Chang DY (1996). Application of the extent analysis method on fuzzy AHP. Eur. J. Oper. Res., 95: 649-655.

Chomeya R (2010). Quality of Psychology Test between Likert Scale 5 and 6 Points. J. Social Sci., 6: 299-403.

Eraslan E, Kurt M (2007). Fuzzy multi-criteria analysis approach for the evaluation and classification of cognitive performance factors in flexible manufacturing systems. Int. J. Prod. Res., 45(5): 1101-1118.

Hsu TH Lin LZ (2006). QFD with fuzzy and entropy weight for evaluating retail customer values. Total Qual. Manage. Bus. Excel., 17(7): 935-958.

Kahraman C, Ertay T, Büyüközkan G (2006). A fuzzy optimization model for QFD planning process using analytic network approach. Eur. J. Oper. Res., 171: 390-411.

Khoo LP Ho NC (1996. Framework of a fuzzy quality function deployment system, in: Int. J. Prod. Res., 34: 299-311.

Kwong CK, Bai, H (2003). Determining the importance weights for the customer requirements in QFD using a fuzzy AHP with an extent analysis approach. IIE Transact., 35: 619-626.

Reid N (1998). The Delphi technique, Chapman Hall: London.

Rowe G, Wright G (2001). Expert opinions in forecasting: The role of the Delphi technique. In J.S. Armstrong (Ed.), Principles of forecasting: A handbook for researchers and practitioners Norwell, MA: Kluwer Acad. Publishers, pp. 125-144.

Saaty TL (1980). The Analytic Hierarchy Process. McGraw Hill: New York, NY.

Sheth JN, Bruce IN, Barbara LG (1991): Consumption value and market choices: Theory and Applications. Cincinnati. OH: Southwestern Publishing.

Vanegas LV, Labib AW (2001). A fuzzy quality function deployment (FQFD) model for driving optimum targets. Int. J. Prod. Res., 39(1): 99-120.

Van Laarhoven PJM, Pedrycz, W (1983). A Fuzzy Extension of Saaty's Priority Theory. Fuzzy Sets Syst., 11: 229-241.

Woodruff RB (1997): Customer value: The next source for competitive advantage. J. Acad. Mark. Sci., 25(2): 139-153.

Wu WY, Hsiao SW, Kuo HP (2004). Fuzzy Set Theory Based Decision Model for Determining Market Position and Developing Strategy for Hospital Service Quality, in: Total Quality Manage. Bus. Excel., 15(4): 439-456.

Zhu KT, Jing Y, Chang DY (1999). A discussion on Extent Analysis Method and applications of fuzzy AHP. Eur. J. Oper. Res., 116: 450-456.