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Applying Fuzzy ANP to Construct an Analytical Model for Product Bundles

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Abstract: Many researches on how price bundling affects bundle purchasing in the marketing field have been discussed, but an analytic evaluation of customer value offered by product bundles is still lacking. By combining 'Delphi method', 'Fuzzy analytical network process' (FANP) and 'Extent analysis', an integrated decision making method has developed and applied in evaluating cosmetic bundles. Based on the results, a valuable cosmetic should firstly provide functional performance, and then symbolic and safety performance should follow functional performance. Lastly, transaction performance should have the least contribution for customer value. That means manufacturers and marketers should not utilize "price" as a main marketing strategy for product bundles; instead, the more appropriate strategy for manufacturers and marketers is to deliver functional, symbolic and safety performance to consumers and enhance the value image in their minds.

Keywords: Analytical network process, Delphi method, extent analysis, product bundle

1 Introduction

Product bundling is widely practiced in today's marketplace. For example, McDonalds offers "value meals" that includes a hamburger, a soft drink and French fries. Paun argued that bundling is a strategic marketing variable [1]. Firms could utilize product bundles to increase performance and create a competitive advantage by increasing customer value. Thus, delivering value of bundling will enhance overall evaluation of a product bundle. Concerning previous research about value, most scholars have described the concept in terms of a trade-off. Sheth, Newman and Gross proposed the dimensions of customer value—functional, social, emotional, epistemic, and conditional value; however, the causal relationships are scanty [2]. Woodruff attempted to use the hierarchy concept to explain customer value; however, the concrete variables are not available [3]. Thus, developing a systematic structure and a comprehensive methodology for product bundles is necessary for marketers, so as to understand the preferences of customers and to create a competitive advantage.

However, to understand the customer preference is difficult to achieve in marketing. The first reason is that customers will consider multiple criteria for their alternatives at the same time in the decision making process. In this process there is likely to be interaction among the different criteria. Thus, the evaluating process is complex. The second reason is that human assessment of qualitative attributes is always subjective and imprecise. Thus, the descriptions of customer requirements are usually linguistic and vague. To deal with the possible interaction situation, this research suggests utilizing ANP as the method to analyze research data. The ANP captures interdependencies among the decision attributes and allows a systematic analysis. It also allows inclusion of all the relevant criteria that have some bearing in attending to the best decision [4]. For the question of facing the uncertainty due to customers' imprecision and vagueness, fuzzy set theory is suggested as a suitable tool to deal with such a situation [5]. Furthermore, the fuzzy multiple criteria decision making approach can deal with qualitative information in addition to the quantitative data [6]. In fact, the major characteristic of fuzzy set theory is its capability in representing vague data. In particular, the human brain interprets imprecise and incomplete sensory information provided by perceptive organs. Fuzzy set theory provides a systematic calculus to deal with such information linguistically, and it performs numerical computation by using linguistic terms stipulated by membership function. Thus, this study will utilize fuzzy ANP (FANP) in order to capture the subjective and imprecise perceptive data from customers.

According to research by Euromonitor International in 2008, the market worth of the global cosmetics and toiletries (C&T) industry is about US$ 330 billion in the 52 main countries (which account for 95% of the world's GDP). In the three major areas of the C&T market, Europe (31%), Asian-Pacific area (25%) and North American (22%), the Asian-Pacific area is the second largest market and its growth rate is up to 28% per year. In the practice of C&T sales, single function product could not satisfy multiple requirements of customers. Cosmetic bundles have been provided and play more important role in the C&T market to satisfy multiple needs of customers. In the context of such a high growth industry, this study chose cosmetic bundles as a suitable set of alternatives for testing the analytic model and for providing suggestions to manufactures and marketers.

2 Conceptual Framework

2.1. Product bundle

Marketers utilize joint pricing for the sale of two or more products and/or services in a single package [7,8,9]. Most researchers have been interested in issues of how customers are affected by price information and suggest that price bundling is a pricing and promotion tool to decrease price sensitivity and increase purchase likelihood for customers [10,11,12]. Simonin and Ruthutilized a quasi-experimental procedure to investigate the effects of bundling influence on consumers' evaluations and reservation price judgments [13]. They found product bundling also could be a strategy for new product introduction through bundling with an existing product. Beside price information about bundling, Mulhern and Leone, Harlam, Krishna and Mela observed complementary effects in their study [14,15]. Bundles composed of complements will have higher purchase intentions than the bundles of unrelated products. Sarin, Sego and Chanvarasuth applied product bundling as a strategy to reduce the perceived risk with new high-tech products [16]. From the above literature, the value of a product bundle is not only in the momentary savings, but it also involves other attributes for customers. Besides price factor, this study want to find the other influential factors and understand the preferences of customers, which will help manufacturers to focus on the product attributes that concern customers.

2.2. Customer value

In 2004, American Marketing Association offered the formal definition: "Marketing is an organizational function and a set of processes for creating, communicating and delivering value to customers and for managing customer relationships in ways that benefit the organization and its stakeholders." Based on this definition, the customer value plays an important role for firms to develop customer relationships. However, what is customer value? It may bring to mind two different concepts. Firstly, some authors might think of personal values—the shared, central beliefs about right and wrong, good and bad, which guide behavior, and this sense is also the key point of this study. Secondly, the concept refers to the economic (e.g., profit) value to a seller of patronage by a customer over a lifetime. Besides above, some scholars proposed the dimensions of customer value - function, social, emotional, epistemic, and conditional value [2]; but the cause-result relationships are scanty. Although Woodruff proposed the "conceptual" customer value hierarchy model, the components of each level is not available [3]. In fact, value is the consumer's overall assessment of the utility of a product, based on perceptions of what is received and what is given [17]. Based on these views, customer value is the trade-off between what the customer receives and what the customer gives up in acquiring and using a product. Thus, if customers want to obtain higher value from a product, there are two basic strategies which could be used: maximum benefit and/or minimum cost.

2.3. Multiple attribute decision making

Decision making can be described as the process of making an appropriate choice from options in order to realize one or more aims. Thus, multiple criteria decision making (MCDM) is used to balance the conflicts or tradeoff among different aims. There have been many studies on decision making algorithms and methods in recent years. There are two general approaches which can be used to solve an MCDM problem: multiple objectives decision making (MODM) methods, and multiple attributes decision making (MADM). The objectives are sometimes in conflict with one another, meaning an optimal solution of one objective does not meet the optimal solution of another. The planner should then make a compromise between the objectives to come up with the best solution. This gives rise to an infinite number of compromised solutions, usually called Pareto-optimum solutions [18]. These types of models employ decision variables that are determined in a continuous domain with either an infinite or a large number of choices. The best decision is then made so as to satisfy both the planner' preference information as well as the problem constraints and objectives.

The MADM approach, the focus of this research, can be used in selection problems where decisions involve a finite number of alternatives and a set of performance attributes. The decision variables can be either quantitative or qualitative. The key difference in MADM models, as compared to MODM models, is that they include discreet variables with a number of pre-specified alternatives and, more importantly, they do not require an explicit relation between input and output variables. Concerning MADM problems, the following methods could be utilized when the information of attribute preference is available from the decision maker: (1) The simple additive weight (SAW) method; (2) The weighted product method (EPM); (3) The Elimination et Choice Translating Reality method (ELECTRE); (4) The technique for order preference by similarity to ideal solution (TOPSIS); and (5) The analytic hierarchy process (AHP). Although the above methods can be used to solve complex problems when we face the need to make decisions with multiple attributes, the assumption of independency is the limitation for these methods as they do not deal with the interdependence among criteria. To deal with the interdependence among criteria, the Analytic Network Process (ANP) was proposed as a new method by Saaty and is introduced in next section [19].

2.4. Fuzzy analytic network process

Facing the uncertainty due to customers' imprecision and vagueness, Zadeh introduced the fuzzy sets theory to deal with uncertainty due to imprecision and vagueness [5]. In a mathematical view, a fuzzy set is an object class with a continuum of membership grades. Such a set is characterized by a membership function, which assigns to each object a membership grade ranging between zero and one. Numerical data obtained across a range of human subjectivity are called fuzzy data. The motivation for using words or sentences rather than numbers is that linguistic characterizations are, in general, less specific than numerical ones [20]. Based on above characterizations, many researchers combine fuzzy set theory and another well-known decision theory - Analytic Hierarchy Process (AHP) - in multi-criteria decision researches [21,22,23]. However, in the application of AHP, the most important research restriction or limitation is researchers have to assume criteria are independent with no interaction in decision process. This assumption reduces the explanation capability and cannot match the situation in real world. To overcome above defect, Saaty develops Analytic Network Process (ANP) in year 2003 as a new and comprehensive decision theory.

The ANP is a multi-criteria measuring theory used to derive relative priority scales of absolute numbers from individual judgments (or from actual measurement normalized to a relative form) that also belong to a fundamental scale of absolute numbers [19]. These judgments represent the relative influence of one of two elements over the other, in a pair-wise comparison process, on a third element in the system, with respect to an underlying control criterion. Through its super-matrix, whose entries are themselves matrices of column priorities, the ANP synthesizes the outcome of dependence and feedback within and between element clusters. The Analytic Hierarchy Process (AHP), with its independence assumptions on upper levels proceeding from lower levels, and the independence of the elements within a level, is a special case of the ANP.

The ANP is a two-part coupling. The first consists of a control hierarchy or network of criteria and sub-criteria controlling the interactions in the system under study. The second is an influence network among the elements and clusters. A decision problem analyzed with the ANP is often studied through a control hierarchy or network. A decision network is structured of clusters, elements, and links. A cluster is a collection of relevant elements within a network or sub-network. For each control criterion, the clusters with their elements are determined. All interactions and feedbacks within the clusters are called inner dependencies, whereas interactions and feedbacks between the clusters are called outer dependencies [24]. Inner and outer dependencies are the best way that decision-makers can capture and represent the concepts of either influencing or being influenced, between clusters and between elements, with respect to a specific element. Then pair-wise comparisons can be made systematically including all the combinations of element/cluster relationships. ANP uses the same fundamental comparison scale (1~9) as the AHP. This comparison scale enables the decision-maker to incorporate experience and knowledge intuitively and to indicate how many times an element dominates another with respect to the criterion in question [25]. If an element has weaker impact than its comparison element, the range of the scores will be from 1 to 1/9, where 1 indicates indifference and 1/9 represents an overwhelming dominance by a column element over the row element.

In recent research, Leung, Hui and Zheng designed a compatibility test for interdependent matrices between two clusters of attributes [26]. They show that ANP is useful in solving multi-criteria selection problems containing interdependence. Leung, Lam and Cao use ANP in multi-attribute evaluation of the balanced scorecard (BSC) to overcome the traditional problems of BSC implementation, such as dependency relationships between measures and the use of subjective versus objective measures [27]. Wu and Lee apply ANP to evaluate and select knowledge management strategy and indicate that ANP is a relatively new multi-criteria decision making method which can deal with all kinds of dependences systematically [28]. Aragonés-Beltrán, Aznar, Ferrís-Oñate and García-Melón base on ANP to develop a comparative methodology for the valuation of urban properties and indicate that more information is taken into account in relation to the interdependences between criteria and alternatives, ANP enables to obtain the greater the accuracy of the results [29]. However, the empirical study about Fuzzy ANP is still few in research. This study will combine fuzzy set and ANP to understand the preferences of customers.

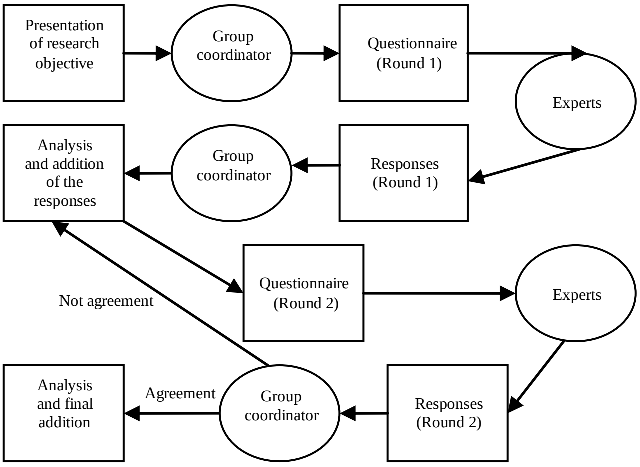

Fig. 1. Communication process in the Delphi method

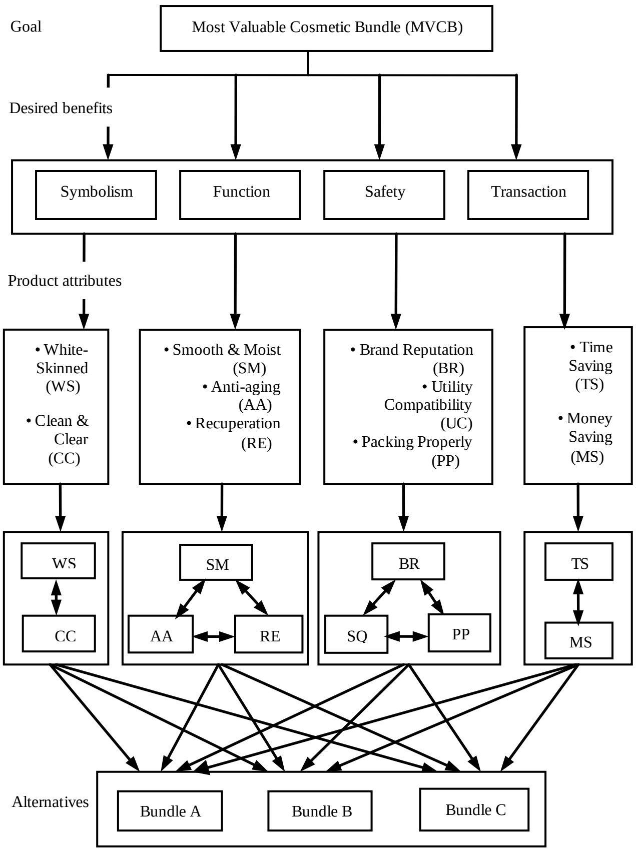

Fig. 2. Evaluation model of "Most Valuable Cosmetics Bundle"

3 Development of Evaluation Model

The customers' requirements are gathered by the Delphi method. Reid points out that one of the keys to success in the Delphi method is an appropriate selection of panel members: they should be selected for their rich capabilities, knowledge and independence [30]. In this research, 9 specialist (working experience of at least 10 years, including scholars, sales clerks, and senior cosmetologists) and 3 very important persons (VIPs) of cosmetic comprise the expert panel. There are four reasons for adopting above experts' and VIPs' views. First, compared with general consumers, experts and VIPs have more complete product knowledge about cosmetic. Second, general consumers just focus on their own demand. 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. To obtain the customer requirements about cosmetics, a communication process is established as shown in Figure 1. The questions for the experts are concentrated on "when customers purchase cosmetic bundles, what kind of performance could enhance customer value?" and "when customers purchase cosmetic bundle, what kinds of beneficial attribute could provide related performance to reach the value?" Through sorting, classifying, structuring the customer requirements, from three rounds of questionnaires, this research can finally obtain customer requirements (including goal, performances and beneficial attributes) and are initially structured into 3 different hierarchical levels. Finally, three different cosmetics bundles (Bundle A, B, C) from a department store are selected as the alternatives for testing this model (see Figure 2).

4 Application of Extent Analysis Method

4.1. Extent Analysis

In previous research, many scholars have engaged in the fuzzy extension of Saaty's priority theory; for example, van Laarhoven and Pedrycg in the Netherlands, proposed a method, where the fuzzy comparison judgment is represented by triangular fuzzy numbers [31]. 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 obtained. However, there is one defect in the calculation process. Researchers used fuzzy numbers to describe the "linguistic vagueness", and the crisp values could then be obtained by using a "clear" defuzzification formula for calculating the priority vector. However, this does not seem to match the original concept of ambiguity. In a better alternative, the extent analysis method and the principles for comparing fuzzy numbers are employed to obtain weight vectors of individual levels for customer requirements [32]. The extent analysis method is used to consider the extent to which an object can satisfy the goal, that is, satisfaction extent. In this method, the "extent" is quantified by using a fuzzy number. On the basis of the fuzzy values for the extent analysis of each object, a fuzzy synthetic degree value can be obtained, which is defined as follows.

Let X $=\{x_1, x_2, ..., x_n\}$be an object set, and G $=\{g_1, g_2, ..., g_m\}$be a goal set. According to the method of Chang's extent analysis, each object is taken and the extent analysis for each goal, g_i, is performed respectively [32]. Therefore, m extent analysis values for each object can be obtained, with the following Eq. (1):

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

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

4.2. Pair-wise comparison of inner-dependency

To reflect the inner-dependencies in a network, pair-wise comparisons among all benefit attributes are conducted. Table 1 illustrates the inner-dependent case between "White-Skinned" (WS) and "Clean & Clear" (CC) after application of fuzzy extent analysis.

Table 1. Pair-wise comparison for beneficial attributes between WS and CC

Under WS	WS	CC	e-Vector
WS	(1.00, 1.00, 3.00)	(0.42, 1.11, 1.84)	0.5079
CC	(0.54, 0.90, 2.39)	(1.00, 1.00, 3.00)	0.4921
Under CC	WS	CC	e-Vector
WS	(1.00, 1.00, 3.00)	(0.44, 1.15, 2.05)	0.5642
CC	(0.49, 0.87, 2.29)	(1.00, 1.00, 3.00)	0.4358

Table 2. Super matrix of inner-dependence after convergence (M^{15})

	WS	CC	MS	AA	RE	BR	SQ	PP	TS	MS
WS	0.53	0.53								
CC	0.47	0.47								
MS			0.47	0.47	0.47					
AA			0.24	0.24	0.24					
RE			0.28	0.28	0.28					
BR						0.43	0.43	0.43		
SQ						0.49	0.49	0.49		
PP						0.08	0.08	0.08		
TS									0.40	0.40
MS									0.60	0.60

Table 3. The index and evaluation results of cosmetic bundle

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)

Performance	Pj	Attribute	A^D_{kj}	A^I_{kj}	TWA_k	S1	S2	S3	Bundle A	Bundle B	Bundle C
Symbolism	0.30	WS	0.71	0.53	0.113	0.06	0.59	0.35	0.007	0.068	0.041
	0.30	CC	0.29	0.47	0.041	0.07	0.23	0.70	0.003	0.010	0.030
Function	0.36	SM	0.61	0.48	0.105	0.40	0.35	0.25	0.041	0.036	0.026
	0.36	AA	0.28	0.24	0.024	0.39	0.39	0.22	0.010	0.010	0.006
	0.36	RE	0.11	0.28	0.011	0.18	0.31	0.51	0.002	0.003	0.005
Safety	0.27	BR	0.46	0.43	0.053	0.37	0.29	0.34	0.020	0.015	0.018
	0.27	QA	0.46	0.49	0.061	0.39	0.39	0.22	0.023	0.023	0.013
	0.27	PP	0.08	0.08	0.002	0.15	0.50	0.35	0.000	0.001	0.001
Transaction	0.07	TS	0.51	0.40	0.014	0.43	0.43	0.14	0.006	0.006	0.002
	0.07	MS	0.48	0.60	0.020	0.38	0.26	0.36	0.008	0.005	0.007
Desirability index *Dia*									0.119	0.177	0.148
Normalized Desirability index, Dia_N									0.268	0.399	0.333
Rank									3	1	2

4.3. Super matrix formation and analysis

Super matrix *M*, detailing the results of the relative importance measures for each of the MVCB beneficial attributes. Since there are 10 pair-wise comparison matrices, one for each of the interdependent MVCB beneficial attributes in this research, there will be 10 non-zero columns in this super matrix. Each of the non-zero values in the column in super matrix *M*, is the relative importance weight associated with the interdependently pair-wise comparison matrices. In this model there are four super matrices, which need to be evaluated. The Super matrix is converged to obtain a long-term stable weight set. For this, the power of the super matrix is raised to an arbitrarily large number. In this research, convergence is reached at the 15th power. Table 2 illustrates the value after convergence.

4.4. Evaluating the most valuable product bundle

The equations for total weight of attribute (TWA_k) and desirability index (*Dia*) for alternative *i* are defined as Eq. (2) and Eq. (3) [33]:

$$TWA_k = P_j A^D_{kj} A^I_{kj} \quad (2)$$

$$D_{ia} = \sum_{j=1}^{J} \sum_{k=1}^{Kja} P_{ja} A^D_{kja} A^I_{kja} S_{ijka} \quad (3)$$

where *Pj* is the relative importance weight of performance *j* on the MVCB, A^D_{kj} is the relative importance weight for beneficial attribute *k* and performance *j* for the hierarchy dependency (*D*) relationships between attributes levels, A^I_{kj} is the stabilized relative importance weight for beneficial attribute *k* of *j* performance for inner-dependency (*I*) relationships within the attribute component level, S_{ikj} is the relative impact of alternative *i* on product attribute *k* of desired benefit *j* for the MVCB, *Kj* is the index set of beneficial attributes for performance *j*, and *J* is the index set for the performance *j*.

Table 3 shows the calculations for the desirability indices (*Di*) for alternatives obtained from the pair-wise comparisons of the alternatives, with types of performance and weights of beneficial attribute taken from the converged super matrix. These weights are used to calculate a score for determining cosmetic bundle improvement desirability for each of the alternatives being considered. The second column in Table 3 presents the relative impact of each performance type. The relative impact of the attributes on the performances of MVCB is presented in the fourth column. The values in the fifth column are the stable inner-dependent weights of attributes obtained through super matrix convergence. The values in sixth column are the calculation results of total weight of attribute (TWA_k). The relative weights of three alternatives for each beneficial attribute are given in the seventh, eighth and ninth columns. These weights are obtained by comparing each beneficial attribute of cosmetic performance. The final three columns represent the weight of each alternative for beneficial attributes. The last three rows in Table 3 are the overall evaluation results of the product bundle. The results show that the top 5 beneficial attributes are "White-Skinned" (0.113), "Smooth & Moist" (0.105), "Quality Assurance" (0.061), "Brand Reputation" (0.053), and "Clean & Clear" (0.041); thus, these results suggest that manufactures and marketers of cosmetics need to prioritize on these 5 beneficial attributes. Besides, in this research, the most valuable cosmetic bundle is Bundle B (0.177) followed by Bundle C (0.148) and Bundle A (0.119). This result also implies that Bundle A needs more effort to improve beneficial attributes in order to catch up with competitors.

5 Conclusions and Suggestions

The FANP model proposed in this research is an aid for manufacturers and marketers to understand customers in making prudent decisions when the complexities make their decision task quite complicated. Besides, the model is capable of taking into consideration both qualitative and quantitative information. Thus, the weights of desirability index also provide the product attributes and priority to manufacturers for making improvements. Furthermore, this FANP model is used for evaluating the most valuable cosmetic bundle could serve as a competitive forecast for marketers.

From the results of the empirical example, a valuable cosmetic should firstly provide functional performance. Next, symbolic and safety performance follow functional performance. Lastly, transaction performance has the least contribution for customer value. That means manufacturers and marketers should not utilize "price" as a main marketing strategy for cosmetic bundles; instead, the more appropriate strategy for manufacturers and marketers is to deliver functional, symbolic and safety performance to consumers and enhance the value image in their minds.

Focusing on beneficial attributes, "White-skinned" and "Smoothness & Moisture" are two critical issues for cosmetics. Compared with the other competitors, Bundle A has a good assessment in "Smoothness & Moisture" and obtained 6 "number one" in the 10 beneficial attributes; however, the worst evaluation of "White-skinned" and "Clean & Clear" provide the critical attributes that gave Bundle A the lowest rank in this study. Thus, from the position of Bundle A, the manufacturer needs to enhance the attribute of "White-skinned" and "Clean & Clear" in order to reduce the gap with competitors. On the other hand, marketers could select the components with rich "White-skinned" and "Clean & Clear" attributes in bundling in order to increase the competitive advantage of Bundle A.

"Brand Reputation" and "Quality Assurance" are ranked the 3rd and 4th in importance of beneficial attributes. These two beneficial attributes may be not directly related to product utility; however, they are related to the product safety issue. Especially since customers' skin directly contacts with the product when using cosmetics, selecting good brand reputation is a safe way to reduce risk. Thus, modifying product ingredients (e.g. natural abstracts) and packaging (e.g. opaque glass) of cosmetics in the R&D process can ensure product quality and build brand reputation. Marketers also need to develop a communication strategy about the R&D efforts in relation to customer concerns, so that customers' safety-image of the products can increase.

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