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ABSTRACT

This study focuses on building a framework which calculates the weights of FAHP (Fuzzy Analytical Hierarchical Process) method , then integrates the analysis tools such as FQFD (Fuzzy Quality Function Development) and FFMEA (Fuzzy Failure Mode and Effects Analysis) into the framework to construct a two-phase product specifications evaluation process. Therefore, this study builds a framework and process of the new product specification evaluation which integrates the marketing attributes (the evaluation of the customers' demands)、research attributes and development attributes and manufacture attributes (the evaluation of the failures and defects of the product specifications). It allows the product specifications which are produced by braining storm to be proceeded the evaluation before the prototype test phase and find the optimum product specification. It also can further the companies to optimize the organization resources. This research focuses on not only determining, but also transferring the market attributes to the product R&D specification in order to realize the relationship between the consumers' demands and the product specification. According to the methodologies represented, this study attempts to fill the gap in the literature by providing an integrative research framework and offers this framework to contribute the tasks and operations in the initial phase of the new product development and build the framework of multidimensional product specifications evaluation. Finally, an example of Notebook is used to illustrate the proposed approach.

Keywords: Marketing attributes, Fuzzy theory, AHP (Analytical Hierarchical Process), QFD（Quality Function Development）, FMEA（Failure Mode and Effects Analysis）, FQFD（Fuzzy Quality Function Development）

1. INTRODUCTION

Due to the increasing and more diversification of the consumers' demands for Notebook product, it offers an opportunity which the OEM/ODM Notebook companies transfer to OBM (Own Branding & Manufacturing) companies through building own brand. Besides, it also can develop new business model and business profits.
The related literatures about the product design concepts which focus on the demands of consumer are always refer to QFD (Quality Function Deployment). QFD is a structured approach to ensure customers' demands to be satisfied and transform into the product design and development process. And it can contribute to increase in customer satisfaction and shorten product design and development time. However, existing QFD implementations have limitations. Two main problems are summarized as follows:

1. QFD unable to evaluate and integrate the possible problems in advance during the design and manufacture period of product development.
2. In the evaluation process, experts often exhibit some forms which are often vagueness and uncertainty and hinder the experts' description of conceptual phenomena.

For this reasons, the main objective of this paper is to build a framework and process of the new product specification evaluation which integrates the marketing attributes (the evaluation of the customers' demands)、research and development attributes and manufacture attributes (the evaluation of the failures and defects of the product specifications) . It can allow the product specifications which are produced by braining storm to be proceeded the evaluation before the prototype test phase and find the optimum product specification. It also can further the companies to optimize the organization resources.

Through the framework of two-phase product specifications evaluation is represented. Firstly, it performs FAHP（Fuzzy Analytical Hierarchical Process）to collect marketing experts with regard to authority evaluation of demands of customer and integrates it into FQFD （Fuzzy Quality Function Development）to proceed first phase evaluation of 「the degree of the consumers' satisfaction」. Secondly, to collect the evaluation of FFMEA（Fuzzy Failure Mode and Effects Analysis）of the design and manufacture experts about the product specifications which is allowed into the second phase and integrate it into FQFD to proceed second phase evaluation of 「the degree of the assembly manufactured」. Finally, it is able to find the optimum product specifications and allow it into the prototype test phase.

According to the methodologies represented by the paper, this study attempts to fill the gap in the literature by providing an integrative research framework and offers this framework to contribute the tasks and operations in the initial phase of the new product R&D and build the framework of multidimensional product specifications evaluation. Finally, an example of

Notebook is used to illustrate the proposed approach.

2. LITERATURE REVIEW

2.1 The marketing attributes

Sung et al.[10] showed 48 dimensions of usability were identified, which were classified into two groups based on the new definition of usability. The first group includes performance dimensions that could be used to explain the performance side of the usability concept. The second one consists of image/impression dimensions that are related to the image and impression of the product perceived by the users. Besides, aesthetic attributes are evaluated concurrently with analytically obtained objective attributes of the product's characteristics. The interaction of these aesthetic and objective attributes, as it relates to the product's utility and manufacturing cost, is clarified [14]. Sethi [8] indicated new product quality has been found to have a major influence on the market success and profitability of a new product. His research founded that quality is positively influence on the product development process, and quality orientation in the firm. But, moreover, the results showed product innovativeness has a negative effect on quality. And functional diversity and time pressure have no effect on new product quality. The relationship between information integration and new product quality is weakened by quality orientation in the firm. Information integration mitigates the negative effect of product innovativeness on quality.

Based on the above, this study is purported to classify and form the marketing attributes of Notebook. Consequently, the definition of the marketing attributes for Notebook product will be proposed. It is composed of the quality of product performance, the dimension of image/impression , and the the dimension of price. The three dimensions will be discussed later.

2.2 AHP and FAHP

Saaty [7] showed the Analytic Hierarchy Process (AHP) that is known as an additive pair wise weights identification method. AHP is often applied to find the relative weighting of each criterion.

Nevertheless, there are many researches, which pointed out that the assumption of AHP may cause the evaluation results departure from the experts' opinions. Therefore, there are many researchers using FAHP (Fuzzy Analytical Hierarchical Process) to resolve the problem. Laarhoved and Pedrycz [5] used Fuzzy Sets Theory and Fuzzy Arithmetic . Buckley, Feuring and Hayashi [1] indicated that a new method of finding the fuzzy weights in fuzzy hierarchical analysis which is the direct fuzzification of the original method used by Saaty[7] in the analytic hierarchy process is presented. Fuzzy number is introduced in the pairwise comparison of AHP by Kwong and Bai [4]. An AHP based on fuzzy scales is proposed to determine the importance weights of customer requirements. They founded the new approach can improve the imprecise ranking of customer requirements which is based on the conventional AHP.

2.3 Failure Mode and Effects Analysis, FMEA

Thomas [11] pointed out that FMEA method could examine all potential causes or modes of failure, of critical processes and of methods designed to prevent failure of those processes. That is, FMEA examines all potential causes or modes of failure, of critical processes and of methods designed to prevent failure of those processes. Sharon [9] showed how key aspects of quality function deployment (QFD) and failure mode and effects analysis (FMEA) can be used in product and service development at a strategic level rather than in traditional engineering applications.

Pillay and Wang [6] evaluated the risk analysis tool FMEA assumes a failure mode, which occurs in a system/component through some failure mechanism; the effect of this failure is then evaluated. They described a risk ranking is produced in order to prioritize the attention for each of the failure modes identified. The traditional method utilizes the risk priority number (RPN) ranking system. This method determines the RPN by finding the multiplication of factor scores.

2.4 Fuzzy QFD

Yang et al.[13] presented the findings of a research effort to adapt House of Quality (HOQ) to meet the needs of buildable designs in the construction industry and to develop a fuzzy QFD system. They thought the differences between the proposed fuzzy QFD system and the traditional QFD methodology is that the QFD-relevant data are expressed and represented as linguistic terms rather than as crisp numbers, and the linguistic data is processed by algorithms embedded in the system's internal environment [13]. Chen et al. [2] determined the revised priority of the customer demands using a fuzzy logic inference because many tools did not offer specific methods to determine a revised priority for product redesign.

We transfer the market attributes to the product R&D specification in order to realize the relationship between the consumers' demands and the product specification.

3. METHODOLOGY

3.1 Marketing attributes of Notebook

Based on the literature review, we provide a definition of the marketing attribute for Notebook product, which is composed of the quality of product performance, image/impression , and price.

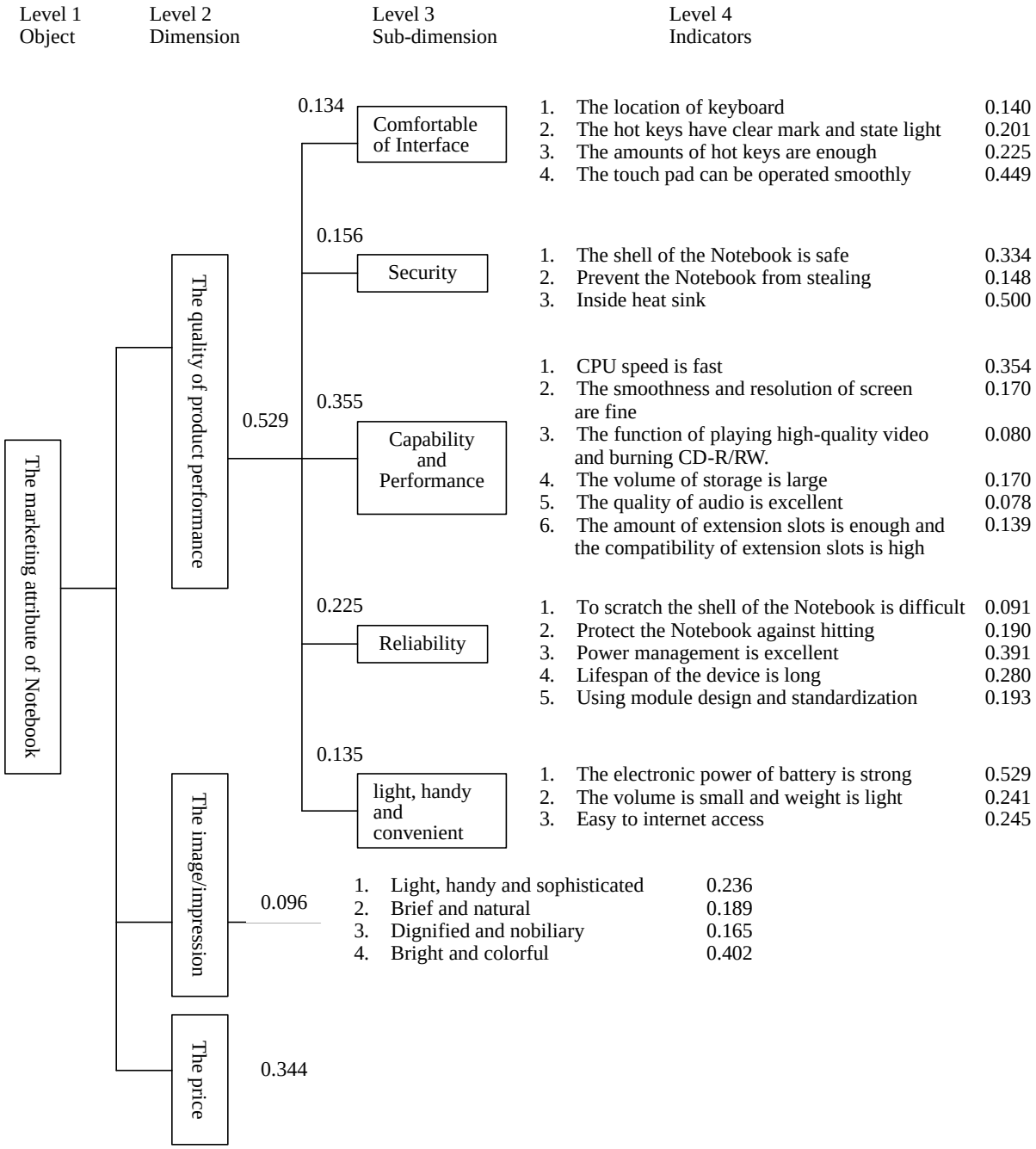

Figure 1 The weights of the marketing attributes

3.1.1 The quality of product performance

According to the researches made by Garvin[3] and Sethi[8]? Sung *et al.*[10] we defines the quality of product performances such as ? comfortable of interface? , ? security? , ? capability and performance? , 「reliability」 and? light, handy and convenient? .

3.1.2 The dimension of image/impression

Yamakawa *et al.* [12] indicated aesthetic attributes are very important while designing new product except high product performance and quality.

In order to develop the items of image/impression dimension in the Notebook market, study results from related areas were examined. This study follows the example of Sung et al.[10] to proceed extensive literature survey and find out the similes or metaphoric expressions to describe the image of the consumer Notebook products and various expressions about subjective feelings toward them. Also the experts and consumers opinions were collected, furthermore, the principal concepts used in the product design department were studied. Finally, we define the dimension of image/impression for Notebook products.

3.2 The integration of analysis methods

In order to complete the new product specification

evaluation , firstly, we use FAHP method to collect marketing experts with regard to authority evaluation of demands of customers, and integrates it into FQFD to proceed first phase evaluation of 「the degree of the consumers' satisfaction」. Secondly, to collect the evaluation of FFMEA of the design and manufacture experts about the product specifications and integrate it into FQFD to proceed second phase evaluation of 「the degree of the assembly manufactured」. Thus, we could find the optimum product specifications and allow it into the prototype test phase through the framework of two-phase product specifications evaluation.

This study defines the evaluation rules of consumer' satisfaction and assembly manufactured scores. The first phase evaluation of 「the degree of the consumers' satisfaction」 would be accomplished. The score of consumers' satisfaction in the first stage should not be under five points, otherwise it will be eliminated or corrected its specification. The equations (1) and (2) are listed below.

$$\overline{CS}_i^k = (\sum_{j=1}^{n} \overline{E}_j^k \times \overline{R_{ij}}) \times C_i \qquad 1 \le i \le m \qquad (1)$$

$$CS^k = \sum_{i=1}^{m} CS_i^k \qquad 1 \le i \le m \qquad (2)$$

$\overline{CS}_i^k$: the i item satisfaction of product k

$\overline{E}_j^k$: the j item specification degree of product k

$\overline{R}_{ij}$: standardization triangular fuzzy membership number of the i marketing attribute item and j specification item

C_i : the weights of the i marketing attribute item

CS_i^k :the total satisfaction of product k

According to the data evaluated at the first phase, we could proceed the second phase ,named evaluation of 「the degree of the assembly manufactured」. IF the result is not under five points, the product prototype can proceed pilot runs , otherwise the it will be eliminated or corrected its specification. The equations needed (3) and (4) are listed below.

$$\overline{AD}_i^k = (\sum_{j=1}^{n} \overline{E}_j^k \times \overline{R_{ij}} \times \overline{F_j^k}) \times C_i \; 1 \le i \le m \qquad (3)$$

$$AD^k = \sum_{i=1}^{m} AD_i^k \qquad (4)$$

$\overline{AD}_i^k$: the i item assembly manufactured degree of product k

AD^k : the total assembly manufactured degree of product k

4. EXAMPLE OF NEW PRODUCT SPECIFICATION EVALUATION

4.1 The weights of FAHP analysis for the marketing attributes

This study found six marketing experts to proceed the FAHP analysis about the multimedia entertainment style Notebook. The result is showed as Figure 1 (See Figure 1 for the weights of the marketing attributes).It indicates the most important dimension is the quality of product performance (0.529). In the next place, the price (0.344) dimension will be considered. The last one is 0.344 for the image/impression dimension. Furthermore, the sub-dimension named Capability and Performance is the most important, it got 0.355 points. So we may see the development direction in the future from the data.

4.2 The FQFD analysis for the marketing attributes and product R&D specifications

In order to transfer the market attributes to the product R&D specification, the FQFD method was proceeded. Six professional specialist in the R&D and assembly manufactured area participated the analysis process.

4.3 The first phase evaluation of 「the degree of the consumers' satisfaction」

Through survey of Notebook consumers, we got the comparison result of consumers' satisfaction and assembly manufactured between two kinds of products, and the table is presented as follows (See Table 1 for result). According to the data, the satisfaction score of product A is 5.598 and B is 5.682, so, these two kinds of products could proceed the second phase, the evaluation of 「the degree of the assembly manufactured」 because the satisfaction scores both these two products get are more than 5 points .

4.4 The possible problems evaluation in R&D and assembly manufactured

To find out the possible problems of these two kinds of products, six professional specialists in the R&D and assembly manufactured area participated the FFMEA analysis process. They transferred the possible problems in different conditions to the FRPN (Fuzzy Risk Priority Number) . The FRPN value is between 1 to 9. The higher the score, the more serious the problem. And table 2 illustrates the weighting of problems in two kinds of products.

4.5 The second phase evaluation of 「the degree of the assembly manufactured」

Finally, we integrate the FRPN of each possible problem into the specification to proceed second phase evaluation of 「 the degree of the assembly manufactured」. As table 1 shows, the degree of the assembly manufactured for product A is 4.964 and B is 5.135. It illustrates that product A should be corrected in

some specifications, even its satisfaction score is 5.598 there are still problems. Product B could proceed pilot runs. On the other hand, the total gap of satisfaction between A and B is 0.085 (1.5%), but the total gap of Assembly manufactured between A and B is 0.172 (3.5%). It conspicuously increases.

5. CONCLUSIONS AND SUGGESTIONS

The conclusions of this study are as follows:
According to the methodologies represented, this study attempts to fill the gap in the literature by providing an integrative research framework and offers this framework to contribute the tasks and operations in the initial phase of the new product development and build the framework of multidimensional product specifications evaluation. Besides, we provide a methodology to integrate the FAHP, FQFD and FFMEA methods. So, through considering the consumers' demands and the new product specification evaluation, companies could integrate the opinions of different departments.

This research focuses on not only determining, but also transferring the market attributes to the product R&D specification in order to realize the relationship between the consumers' demands and the product specification so that it can further the companies to optimize the organization resources.

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Table 1 The comparison of consumers' satisfaction and assembly manufactured between two kinds of products

Dimension	Sub-dimension	Consumers' satisfaction score		Assembly manufactured score		The gap of consumers' satisfaction	The gap of Assembly manufactured	Corrected value
		NB A	NB B	NB A	NB B			
Comfortable of interface	The location of keyboard	6.124	5.572	4.535	4.268	0.552	0.267	0.285
	The hot keys have clear mark and state light	6.136	5.791	5.133	4.874	0.345	0.259	0.086
	The amounts of hot keys are enough	6.242	5.693	5.338	4.807	0.549	0.531	0.018
	The touch pad can be operated smoothly	6.262	5.034	3.813	3.885	1.228	(0.072)	1.300
Security	The shell of the Notebook is safe	5.459	5.902	5.459	5.902	(0.443)	(0.443)	0.000

	Prevent the Notebook from stealing	5.366	5.542	5.366	5.542	(0.176)	(0.176)	0.000
	Inside heat sink	4.730	5.909	4.500	5.909	(1.179)	(1.409)	0.230
Capability and Performance	CPU speed is fast	4.441	6.510	4.235	6.282	(2.069)	(2.047)	(0.023)
	The smoothness and resolution of screen are fine	4.809	6.745	3.756	5.805	(1.936)	(2.049)	0.113
	The function of playing high-quality video/burning CD	5.167	5.674	3.420	1.962	(0.507)	1.459	(1.965)
	The volume of storage is large	5.343	6.368	2.312	5.324	(1.025)	(3.012)	1.987
	The quality of audio is fine	3.636	6.457	2.234	4.214	(2.821)	(1.980)	(0.840)
	The amount of extension slots is enough and the compatibility of extension slots is high	5.082	6.070	3.905	4.288	(0.988)	(0.384)	(0.604)
Reliability	To scratch the shell of the Notebook is difficult	5.389	5.926	5.389	5.926	(0.537)	(0.537)	0.000
	Protect the Notebook against hitting	5.523	5.919	4.779	5.259	(0.396)	(0.479)	0.083
	Power management is fine	4.449	5.869	2.949	4.932	(1.420)	(1.982)	0.563
	Lifespan of the device is long	5.408	5.643	5.408	5.643	(0.235)	(0.235)	0.000
	Using module design and standardization	5.805	5.905	5.805	5.905	(0.100)	(0.100)	0.000
light, handy and convenient	The electronic power of battery is strong	4.507	5.671	2.868	4.489	(1.164)	(1.621)	0.456
	The volume is small and weight is light	5.129	5.748	3.953	4.605	(0.618)	(0.653)	0.034
	Easy to internet access	5.545	5.693	5.545	3.306	(0.148)	2.239	(2.387)
image/impression		5.834	5.645	4.706	4.723	0.189	(0.017)	0.206
price		6.448	5.403	6.448	5.403	1.045	1.045	0.000
Total of score		5.598	5.682	4.964	5.135			
Total of gaps						(0.085)	(0.172)	0.087
Percentage of gaps						(1.5 %)	(3.5 %)	

Table 2 The weighting of problems in two kinds of products

Problem weighting / product specification		Product A		Product B	
		R&D problem weighting	Assembly manufactured problem weighting	R&D problem weighting	Assembly manufactured problem weighting
Display module	LCD specification	35.318	33.744	5.760	26.416
Operation interface	LED	5.7605	0	5.760	0
	Keyboard device	5.7605	5.480	8.718	5.4780
	Touch pad device	13.703	0	0	5.949
Storage device	Hard disk device	9.923	8.251	0	0
	CD-ROM device	2.962	2.211	20.992	7.964
Motherboard	Extension slots	5.949	12.975	9.689	12.975
	System BIOS	4.453	4.453	4.453	4.453
	Power management	5.949	5.480	0	0
	Battery	26.228	12.859	13.307	6.653
Device	Sound card module	7.412	7.412	5.949	5.4780
	Network device	0	0	11.899	10.401