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ESTIMATING THE IMPORTANCE OF THE ATTRIBUTES OF A NEW PRODUCT IN DEVELOPMENT PROCESS

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Abstract: *In this paper our intent was to go through a theoretical study of estimating the importance of the attributes of a new product in development process and the methods for decision making. Also we shortly presented modern methods like: Fuzzy, Pahl and Beitz , QFD Matrix, AHP, or EVA, used in analysis and selection of multivariable concepts .*

Key words: *attributes, concepts, conjoint analysis, consumer, fuzzy methods, QFD Matrix*

1. INTRODUCTION

In general, an attribute is said to be important if a change in the consumer's perception of that attribute leads to a change in the attitude toward the product having it [1]. Once these important attributes are determined, their role can be emphasized in advertising tactics (short term strategy) and product development strategy (mid-long term strategy) [2].

In multi-attribute analysis it is assumed that consumer makes product choice by evaluating product alternatives on a certain number of attributes [3]. In particular, after evaluating the importance of attributes compounding the product, consumer uses an "integration rule" or multi-attribute utility function to form an overall evaluation of each product alternative. Then, the alternative with the highest evaluation or utility is chosen.

There are several types of consumer choice models [4]. One of the most used models is the simultaneous compensatory model, in which the values of all attributes of an alternative are simultaneously combined into one linear on non linear function score. The highest scoring alternative is assumed to be the one selected by the consumer [5].

2. CONTENT

Approaches proposed for identifying determinant attributes might be broadly classified as direct questioning and indirect questioning [6]. In the former the respondent is asked to give evaluation on attributes or motivation to product purchase. Attributes are then classed as determinant if they have the highest average importance rating in a set of rated attributes.

In indirect questioning a respondent is not asked directly which attributes are important for the purchase. Indirect methods range from qualitative techniques of motivation research (third person projective questioning) to statistical techniques such as discriminant analysis and multiple regression models. The differences between direct and indirect questioning can be formalized through the concepts of compositional and decomposition approach [7]. A typical compositional approach is performed into three steps:

1. The consumer evaluates the importance of the levels of the studied attributes on a rating scale;
2. The consumer evaluates the importance of each studied attribute on a rating scale. Part worth is then constructed assuming a multiplicative relation between the attribute importance and the evaluation of its level.
3. The utility of a product alternative is calculated by an utility function connecting the part worth's associated with attributes compounding alternative. A widely used rule for attribute integration process is the simple

additive model [3]. Let suppose that the deterministic value given by consumer i to the attribute x included in the product alternative k, can be written as:

$$V_i(x) = \sum_{j=1}^{S_j} W_{ix} S_{ij} \quad (1)$$

where:
W_{ix} is the attribute weight for individual i, reflecting the relative importance of attribute x
S_{ij} is the score given by individual i to the j-th level of attribute x.

$$V_i^k = \sum_{x \in E_k} V_i(x) \quad (2)$$

where *k E* is the set of attribute compounding the product alternative *k*. Decompositional models are those in which a part-worth is defined as the regression weight associated with each predictor variable, expressing the presence of the attribute in the evaluated product alternative (product concept).

2.1. CONJOINT ANALYSIS

Conjoint Analysis is an example of decompositional multiattribute utility measurement approach broadly use in marketing research.
Conjoint Analysis is a family of techniques for estimating the value consumers attach to the attributes or features of product and services. Conjoint analysis was first suggested within psychometric research [8] and only later introduced in marketing research by Green and Rao [9]. Recently, conjoint analysis was included among the seven product planning tools [10].

A flow diagram, adapted from Green and Srinivisan [11], of the different steps involved in conjoint analysis is following given:

1. Selection of the preference function, i.e. the function linking attribute values to consumer preferences. Alternative models are [12]:
   - Partial benefit value model;
   - Ideal vector model;
   - Ideal point model.
2. Selection of data collection method. Four major types of data collection procedures have been implemented for conjoint analysis [13]:
   - *Tradeoffs matrices*: respondents are asked to state their preferences for the cells of matrices in which each column and each row represents a level of two attributes;
   - *Profile techniques*: each respondent evaluates (by a ranking or a rating procedure) a set of product alternatives (product profiles) with a full or partial presence of attributes;
   - *Hybrid techniques*: it combines a direct (compositional) part of the survey in which the respondents have to give direct judgments about the importance of individual attributes [14] and an indirect (decomposition) part of the survey that represents the actual conjoint interview with the selected combinations of attributes.
   - *Adaptive Conjoint Analysis*: the questions asked to respondents are adapted to their previous answers in a computer-aided data collection process.
3. Selection of data collection design. According to the number of attributes to evaluate, the number of attribute levels and the resources (time and money) available for experimentation, it is possible to arrange a:
   - *Full profile design*: all combination of the attribute levels are evaluated by using full factorial design;
   - *Reduced design*: it is common to reduce the design systematically in such a way that orthogonality, i.e. the independence of attributes weights estimate, is retained. Then it is possible to choose between symmetrical and asymmetrical types of fractional factorial design and also among designs for accounting the interaction effects among attributes.
4. Selection of the way product alternatives are presented:
   - *Verbal description*: the product alternatives can be presented on product information sheets using key words, descriptive sentences, or a combination of those;
   - *Visual representation*: the product alternatives can be presented by graphical representations using drawings or photographs and by physical or virtual prototypes.
5. Selection of data collection procedure:
   - Person to person interview;
   - Mail survey;
   - Computer interview.
6. Selection of the method for the evaluation of product alternatives. Two classes of methods

can be distinguished according to the used scale:

- *Metric scales*: even if rating scales are often non-metric in nature (ordinal for example), it is often assumed that the respondents will perceive scale spacing as being similar, so that preference statements are used as metric data;
- *Non-metric procedure*: it includes ranking procedure and paired profiles comparison.

7. Estimation of benefit values. The methods available for analysis depend on decision made in steps 1-6 of conjoint analysis procedure. A preliminary distinction can be made by the nature of dependent variable [11]:

- *Ordinally scaled*: MONANOVA, PREFMAP, LINMAP
- *Intervallic scaled*: OLS, MSAE (minimizing sum of absolute errors);
- *Paired-comparison*: Logit and Probit models, Johnson trade-off procedure.

Extensive descriptions of conjoint Analysis techniques could be found in [14] and also in companies' technical papers and webpage.

2.2. Attribute importance estimation in product concept development phase

Concept selection is one of the most critical decision-making problem in the whole design process since it heavily affects the future success of product. Usually, the large number of generated concepts are reduced by qualitative methods such as go/no-go screening or Pugh's evaluation matrix. However, in order to minimize the possibility of selecting wrong concept, attribute evaluation and concept selection should be carried aut in a structured way. The most used methods in product development phase are:

- *Pahl and Beitz method;*
- *EVA method;*
- *Analytic Hierarchy Process (AHP);*
- *QFD matrix;*
- *Fuzzy set;*

2.2.1. Pahl and Beitz method

This method is a direct adaptation of utility theory to product design. It can be divided into six steps:

1. Identification of evaluation criteria;
2. Weighing of evaluation criteria;
3. Definition of evaluation parameters for concept comparison;
4. Scoring of parameters;
5. Calculation of concept value by an utility function;
6. Ranking of concept

The concept value is often determined with linear additive model (sum of each parameter score multiplied by each criteria weighting).

2.2.2. EVA method

This method provides a quantitative measure of the individual contribution of different product/service attributes (categorized according to the Kano model) to the overall quality level of different product alternatives. For must-be an attractive attributes only a full agreement of respondent implies their effectiveness in improving quality level of product alternatives. In particular for must be attributes, the quality index can be calculated as:

$$Q_m = \prod_{i=1}^{n_m} \Pr\{\varepsilon_{m_i} = 1\} \tag{3}$$

where m_n is the total number of must-be attributes and $\Pr\{\varepsilon_{m_i} = 1\}$ is an estimate of the probability of effectiveness for the i-th must-be attribute. For attractive attribute the quality index can be calculated as:

$$Q_a = 1 - \prod_{i=1}^{n_a} [1 - \Pr\{\varepsilon_{a_i} = 1\}] \tag{4}$$

where n_a is the total number of attractive attributes and $\Pr\{\varepsilon_{a_i} = 1\}$ is an estimate of the probability of effectiveness for the i-th attractive attribute.

One-dimensional attribute elicit consumer's satisfaction proportionally to their performance. For these attributes a sum pooling scheme is suggested. In formulas:

$$Q_0 = \sum_{i=1}^{n_0} \sum_{j=0}^{3} j \cdot Pr\{\varepsilon_{0_i} = 1\} \tag{5}$$

where n_o is the total number of one-dimensional attributes, $Pr\{\varepsilon_{0_i} = 1\}$ is an estimate of the probability of effectiveness for the i-th one-dimensional attribute and j is the coded value given from respondent to i-th one-dimensional attribute ($j = 0,1,2,3$).

Finally, a global index of quality for product alternatives is defined as:

$$E[Q] = Q_m \cdot Q_o \quad (6)$$

EVA method is a useful methodology to quantitatively evaluate new concept prototypes in Virtual Reality.

2.2.3. Analitic hierarchy process

It was developed by Saaty as a multicriteria decision making approach in which product factors are arranged into a hierarchic structure (see figure 1).

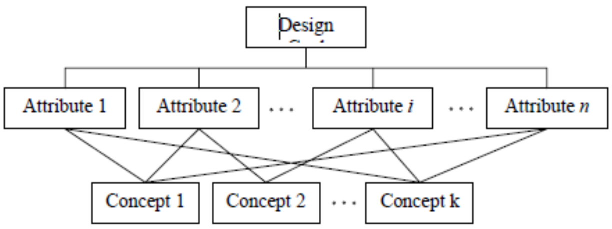

Figure 1. Hierarchic structure

The top level is the overall design goal. The second level is represented by all possible attributes that contribute to the goal. The third level is a list of product alternatives, constructed by several combinations of the attributes of the second level.

2.2.4 QFD MATRIX

Quality function deployment (QFD) is a consumer-oriented approach to product innovation. It is a tool for translating consumer requirements into technical requirements in each stage of product development. QFD has been widely applied also to the major aspects of decision-making: measurement, selection/ determination, and evaluation.

The building block of QFD process is the House of Quality matrix. It weights the individual contribution of technical requirements for the satisfaction of consumer needs by analyzing differences in respondents preferences between companies and competitors products alternatives.

2.2.52 FUZZY LOGIC

Fuzzy logic works in a similar way of Rough set analysis. In fact, it is used for modeling concepts that are approximate rather than precise, as the case of respondents' evaluations. It was developed in the field of electronics but it was used also as concept selection method. In fuzzy logic, the degree of truth of a statement can range between 0 and 1 and is not constrained to the two truth values {true, false} as in classic predicate logic. Let's suppose that an attribute is evaluated by a linguistic variable as "Very high important", "medium important" and so on. Then, the value (weight) of an attribute, according to an evaluation criterion, can be considered equivalent to a fuzzy membership set.

2.3. Limitations in traditional methods for measuring attributes importance

Each of the developed models made strong assumptions only rarely verified. Some of the strongest assumptions are:

1 Consumers exactly know what gives them most satisfaction;
2 Consumers form judgments based only on that which is observed, making no inference about the value of missing attributes;
3 Consumers evaluate the attribute of an alternative in a simultaneous compensatory manner;
4 The utility function linking the attribute measures of importance to the overall value of a product alternative is linear.

However, the complexity of decision making science and the uncertainty in cognitive mechanism are only a part of difficulties with those methods. Many practical problems affect both direct and indirect methods for attribute importance estimation.

In practice, for example the attribute importance weights inferred from conjoint analysis results may be influenced by the number of levels on which an attribute is defined, while a direct questioning procedure can be affected by many factors as the nature of instructions, the number of attributes to rank, the consumers' familiarity with the attributes of the task, the form of required response, etc. [3]. The methods prevalently used in product concept development phase are instead or too qualitative (Pugh's graphical method) or too complex and long (AHP).

3. CONCLUSION

The term proper stands for a correct identification of the voice of consumer. A wide variety of characteristics such as technology, quality, ergonomics, price, functionality, reliability, and so on, have been found to be correlated with product success.

Modern consumers not only place importance on a product's physical quality, but also employ their sentimental responses when deciding whether or not to buy a particular product.

Designers' ability to meet and exceed consumers' affective and emotional needs becomes the key factor that leads to success. Kansei Engineering is a newly emerged product development technique developed by the Japanese to deal with consumers' subjective feelings for a product. The improvement of the Kansei Engineering methodology is at the basis of almost all the research work carried out hitherto.

The term systematic instead stands for a full integration of consumers into the design process and a structured use of statistical methods able to minimize intuition in design decisions. Virtual reality technologies offer not only many possibility to shorten development time and to cut cost of prototyping but they can be used also for establishing effective communication between consumers and design team. An efficient and reliable use of consumer' information can be achieved by employing new tools for capturing his/her preferences.

The search for statistical methods able to support designer in all phases of a Kansei Engineering process has brought to the identification of efficient experimental designs and reliable methods for data analysis.

If statistical methods are very often employed in this area, few works used such designs for constructing product concepts to evaluate from a Kansei point of view. Always in those articles, ordinal logistic regression and categorical regression are proven to work well in Kansei Engineering context where usually QT1 or Rough Set analysis is employed. Even if, the results of the two procedures seem to be similar, categorical regression is a modification of multiple regression analysis and so its conclusions are maybe easier to interpret. Quantitative methods can support the design process above all in cases where the interaction with consumer is problematic.

Traditional Kansei Engineering approach use product semantic as a tool for translating emotions into product design features. However, human's emotions are very complex and can be schematized in several dimension, not just in the language dimension. Facial and body expression as well as physiological response and consumer' behavior can be used as inputs for understanding emotions in a reliable way.

Traditional Kansei Engineering has three data dimension: products, consumers and emotions. It does not consider the time dimension. This is because the process is too lengthy and not repetitive. The reduction of the process-time and the development of statistical methods for the analysis of time-dimension (change in emotional response tracked over time), can contribute to a new use of this methodology.

A Robust Design approach to Kansei Engineering can be fruitful employed for improving the emotional performance of a product while simultaneously reducing its susceptibility to highly individualized characteristic.

An investigation on a possible application of non parametric approach to the Kansei Engineering data may be an interesting research area. The simplicity of non parametric methods and their statistical properties together with the availability of statistical packages implementing them, turn in favor of the applicability of such methods in many complex real situations, where distributional assumptions cannot be preliminarily verified.

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Estimarea importantei atributelor in procesul dezvoltarii unui nou produs

În această lucrare intenția autorilor a fost să treacă printr-un studiu teoretic importanța estimării atributelor unui produs nou, în procesul de dezvoltare, precum şi a metodelor de luare a deciziilor. De asemenea, s-a prezentat pe scurt metode moderne, cum ar fi: Fuzzy, Pahl și Beitz, QFD Matrix, AHP, sau EVA, utilizate în analiza și selectarea conceptelor multivariabile.

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