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A Refined Quality Attribute Classification Model for New Product and Service Strategic Design

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Abstract

The Kano requirement model is based on the need to provide superior quality to clients. Thus, it classifies different product attributes based on their contribution to perceived quality. Nevertheless, in the case of new products or services their value is not perceived, but demanded by consumers. Therefore, literature presents the HWWP (Health, Weapon, Wealth, and Prospect) four quadrant model as an alternative for first time right design. The authors analyse the HWWP’s value-added and customer importance principles and provide a refined model with a natural distribution of information and a strategic orientation. This refined perspective of customer needs evaluation is based on mathematical modelling and a thorough delimitation of quality attributes for managerial thinking by using elasticity curves from the economic domain in a previous case study. The present article aims to provide logical classification criteria for customer requirements as a first step towards strategic decision support in new product or service design. The refinement of the HWWP model deepens its position in the theory of attractive quality and transforms it in an innovative strategic tool for new product and service design.

Keywords: Kano model; HWWP model; customer satisfaction coefficient; strategic decision support criteria; quality attributes.

1. Introduction

In the present extremely competitive business environment, successful companies must differentiate their offer and provide a valuable and desired output. Quality is not enough anymore. The starting point of product design resides in consumer requirements [1]. Thus, understanding customer demands determine the need to differentiate and manage them.

Consumers have certain intrinsic or extrinsic requirements but want also to be surprised by an offer. This situation has led to the development of the theory of attractive theory which tries to classify the different roles

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quality attributes play for customers. The presumed linearity of this theory considered that consumer assessment increases or decreases linearly as a product attribute is improved or worsens. However, Anderson and Mittal (2000) state that a linear modeling of performance-satisfaction link can incorrectly estimate attribute importance weights and present literature cases that have proven otherwise, where attributes which produce satisfaction are not the same as those which produce dissatisfaction.

The Kano model ([4]) has demonstrated co-existing linear and non-linear attributes, being the first to thoroughly address the non-linear relationship between quality attribute performance and overall customer satisfaction ([5]). Thus, this model can comprehensively analyse user demands and obtain the relevant requirements for product design ([6]). [7] argues that the Kano model provides a unique way of distinguishing the impact of different customer needs (also known as the voice of the customer – VOC) on total customer satisfaction in the early stage of product or service development, leading to a much higher degree of effectiveness and efficiency in the subsequent processes.

Over time the Kano method has been widely used, analysed and critiqued. [8] address some weaknesses and [9] argues a certain degree of inefficiency of the model in identifying the rate of importance of each quality attribute.

Regarding the need to assess quality attributes in relation with the importance for customers, [10] classified quality attributes emphasizing the importance of customer wants. [11] redefined Kano categories by transforming the four traditional categories into eight: highly attractive and less attractive, high value-added and low value-added, critical and necessary, and potential and care-free. He also discarded reverse and questionable categories with no strategic importance. [12] proposed an IPA-Kano model with three series of attribute dimensions: must-be, one-dimensional and attractive.

After understanding the qualitative nature of the Kano model, [8] suggested an analytical Kano (A-Kano) model which introduces Kano indices, Kano classifiers and evaluation criteria for quantification of customer satisfaction.

As a first deduction, we see a wide variety of Kano related models trying to refine the methodology for a better quality attribute classification. The majority of the work is focused on discussing customer satisfaction with a requirement (quality attribute) versus performance of the same attribute.

Thus, the relationship between the degree of sufficiency and customer satisfaction can be classified into five categories of perceived quality: attractive, one-dimensional, must-be, indifferent and reverse quality. The performance (sufficiency) factor and the perceived quality indicate an earlier customer assessment of quality attributes after consumption of a product/service.

But little research has been undertaken regarding new products and services which do not benefit from earlier consumption assessment. In this situation we do not have previous performance or customer satisfaction (perceived value), but possible added-value and importance of quality attributes (desired value). In this line of reasoning, the HWWP model has been developed for new product and service first time right design, not taking into consideration previous performance ([13]).

Founded on Maslow’s hierarchy of needs and introduced by two variables: the value-added potential and importance of customer wants for new attribute offerings, the HWWP model responds to managerial demand for relevant and easy to understand value of possible new product/service attributes. It is constructed on four main domains: Health (eloquent for functional needs), Weapon (envisaging performance needs), Wealth (expressing delight needs) and Prospect (mainly research and development needs), each with four suggestive dimensions, as it can be seen in Figure 1.

Wherever quality attributes are first located, the model offers future improvement strategies for enhancement of the importance degree through promotion/customer education and an increased value added to the offer through continuous renewal.
The voice of potential customers is identified through a standard importance questionnaire which uses the following scale: 1 (Not at all Important)... 9 (Extremely Important), and a Kano questionnaire which provides the basic information for appreciating the value-added characteristics with the help of the customer satisfaction coefficient ([14]). However, the current HWWP model has a uniform partition without a transition phase. For example, two quality attributes situated in the weapon quadrant, associated with the shield dimension, one in the upper left and the other in the lower right are considered equal, which is not entirely correct.

By discussing three statistical techniques the present paper rejects the uniform hypothesis of the current HWWP model and proposes a refined one separated by several elasticity curves, an idea extracted from the economic domain of price elasticity. Through elastic and inelastic areas, the quality attributes are more clearly separated and adequately classified for a strategic understanding of their future dynamics.

2. The HWWP non-uniform distribution

In an attempt to explain why the HWWP model should be refined, three statistical techniques are furthermore studied because they are known to be representative when analysing the concentration of records in the unit square and rejecting the hypothesis of uniformness.

a) Interquartile range - in descriptive statistics, the interquartile range (IQR), also called the mid spread or middle fifty, is a measure of statistical dispersion, being equal to the difference between the upper and lower quartiles, $IQR = Q_3 - Q_1$. In other words, the IQR is the first quartile subtracted from the third quartile. These quartiles can be clearly seen on a data box plot. It is a trimmed estimator, defined as the 25% trimmed range, and is the most significant basic robust measure of scale. For establishing if the HWWP model should have a non-uniform distribution, the concentration of the statistical series should be tested. Thus, if we encounter a concentration of results, the uniform distribution is proved to be incorrect (a uniform distribution means no concentration; all points have the same quota). In fact, the analyst should check if the amplitude is greater than the semi-interquartile range – IQR/2, and then take the decision based on the distribution seen as a concentration ([15]).
b) **Gini coefficient** - measures the inequality among values of a frequency distribution ([16]). To test the concentration of a statistical distribution (and then, to test the non-uniform aspect of the HWWP model) we should compare the Gini coefficient to 1/3 which represent the value of this coefficient for the uniform distribution ([17]).

c) **Concentration of measure**--if previous techniques are not widely used for a bi-dimensional space, the concentration of measure presents an important argument against the HWWP bi-dimensional uniform model. In mathematics, concentration of measure (about a median) is a principle that is applied in measure theory, probability and combinatorics ([18]). Informally, it states that "a random variable that depends in a Lipschitz way on many independent variables (but not too much on any of them) is essentially constant". From a probabilistic perspective, let us agree that a random variable $Z$ defined on some probability space satisfies a concentration inequality if for some constant $m$, which will typically be $EZ$ or the median of $Z$, we have for every $u \geq 0$, as in relation (1):

$$P\{ |Z - m| \geq u \} \leq c \cdot \exp \left( - \frac{u^2}{2 \cdot v} \right)$$

(1)

or equivalently, as in relation (2)

$$P\{ |Z - m| \leq u \} \leq 1 - c \cdot \exp \left( - \frac{u^2}{2 \cdot v} \right)$$

(2)

where the constant $v$ is usually related to the variance of $Z$, and where $c > 0$ should be a small numerical constant (see [19]).

From a more geometric perspective, we can say that a measure $\mu$ on some metric space $(X, d)$ satisfies a measure concentration principle if, for any set $A$ such that $\mu(A) \geq 1/2$, we have, as in relation (3):

$$\mu(A_r) \geq 1 - c \cdot \exp \left( - \frac{r^2}{2 \cdot v} \right)$$

(3)

where $A_r$ denotes the $r$-enlargement of $A$: that is, points $x \in X$ within distance $r$ of $A$. This point of view should be of some use to the combinatorists and analysts (see [19]).

For an uniform distribution on a unit square the concentration measures is half square root of 2, hence, a non-uniform distribution can be found for a concentration measure less than this value.

All three techniques have been computed for the HWWP model in a previous practical example, providing statistical arguments to reject the uniform hypothesis, as we will furthermore see. Therefore, a correction of the classical model is necessary and any development of a new model must begin with a non-uniform partition of a unit square.

3. **The Refined HWWP model based on elasticity curves**

The current HWWP model is represented by a SC coefficient variable which ranges from 0 to 1 and a stated importance variable from 0 to 9. The range from 0 to 9 is advised to be normalized for a tight square-like model. In this way the suggested mathematical modelling is easier to compute, understand and visualize.

Using the arguments from the previous chapter, we are motivated to make some corrections regarding the classical HWWP model which describes the relation between (normalized) stated importance and value added.
(SC), in four uniform squares. The new non-uniform refined model is based on a supplementary partition with elasticity curves. They are constructed upon the equation: \( y = a \cdot x^b \), which uses a similar idea given by price elasticity. The constant elasticity demand function is represented as: \( Q = a \cdot P^b \) ([20]).

Such an approach sections two variables (in the case of price elasticity we have price and quantity) through a diagonal or a point of unit elasticity where \( ED \) (demand) =1. All above region (\( ED >1 \)) is considered as elastic and the below region (\( ED <1 \)) as inelastic.

Similarly, when we divide the HWWP model through the coefficients \( a \) and \( b \), computed in such a way as to obtain seven equidistance elasticity curves with respect to the added-value and importance of wants variables (the top and the right side of the unit square), we project a diagonal (curve 4) which separates an elastic and an inelastic region. In the elastic region any small change in a quality attribute influences positively or negatively customer satisfaction, unlike in the inelastic region where a value improvement has a reduced influence on customer satisfaction.

Therefore, the HWWP model is partitioned in a non-uniform way through seven elasticity curves which are furthermore presented in Figure 2.

![Fig.2 The representation of the customer stated importance and value-added variables as a non-uniform model with elasticity curves](image-url)

The labels of the seven elasticity curves are inspired by [11]’s integrated Kano categories:
- the curve denoted \( c_1 \) for higher delight: \( y = 11.31 \cdot x^{1.75} \) (elastic region)
- the curve denoted \( c_2 \) for lower delight: \( y = 2.82 \cdot x^{1.5} \) (elastic region)
- the curve denoted \( c_3 \) for higher performance: \( y = 1.43 \cdot x^{1.25} \) (elastic region)
- the curve denoted \( c_4 \) for proportional performance: \( y = x \) (regions’ divider)
- the curve denoted \( c_5 \) for lower performance: \( y = 0.75 \cdot x^{0.75} \) (inelastic region)
- the curve denoted \( c_6 \) for higher functionality: \( y = 0.5 \cdot x^{0.5} \) (inelastic region)
- the curve denoted \( c_7 \) for lower functionality: \( y = 0.25 \cdot x^{0.25} \) (inelastic region)

The nine areas thus formed are: eight limited by seven curves and one in the left-bottom side of the unit square where the crossing of the curves occurs and it is not possible to make a decision. This area is included in the HWWP "up in the air" dimension, pointing to the fact that it has a very low sensitivity and irrelevant results.

The basic idea is that quality attributes in a new product or service can be associated to the closest curve according to the formula of distance. We use the minimum Euclidian distance between a point and a curve from a plane XOY. More precisely, this distance denoted with \( d(P,c) \) is computed using the following
assertions:
- first step, use the Euclidian distance, as in relation (4):

\[ d(P(x_0, y_0), c(x))^2 = (x - x_0)^2 + (a \cdot x^b - y_0)^2 = S(x) \]  

(4)

- second step, find the minimum of this distance using the mathematical analysis technique, i.e. using differential of the function \( S(x) \), as in relation (5):

\[ S'(x) = 2 \cdot x + 2 \cdot a \cdot b \cdot x^{(b-1)} \cdot (ax^b - y_0) \]  

(5)

- third step, find the solution of the (non-linear) equation \( S'(x) = 0 \), using a Newton-Raphson procedure, choosing an initial value closed to \( x_0 \).

Our model is not limited to nine areas, a more partitioned model can be made using the same technique, but for a good visualization of the graph we have chosen this number of areas and curves. As a future research direction, the optimum number of curves can be determined with the help of specific statistical techniques, as for example the informational criteria of Akaike - AIC ([21]).

4. Discussion of the refined model – a clearer viewpoint of a new marketing contest case study

[13]'s HWWP model has been applied to a new personalization service for a Romanian shoe manufacturing company. In that case study, we had 14 quality attributes illustrated in a rectangular shape. As we have explained, a normalized importance of wants is necessary for a square shape model and for mathematical calculations. Therefore, we represent the old results in a square shaped HWWP model in Figure3, where the added-value variable is illustrated as \( Y \) and the importance variable as \( X \).

![Fig.3 The quality attributes of the contest computed in a HWWP model with normalized importance of wants (X)](image-url)
If the old model was represented by Y, X from which a HWWP stage was denoted, the refined model takes into consideration the distance to the closest curve and the elasticity curve direction (Table 1) for a strategic understanding of a quality attribute’s present and future value in a new product/service lifecycle.

Table 1 – The 14 attributes of a personalization service with their coordinates, traditional Kano categories, HWWP dimensions, elasticity curve distances and directions

<table>
<thead>
<tr>
<th>Customization requirements</th>
<th>Y Value-added(SC)</th>
<th>X Stated importance</th>
<th>Traditional Kano category</th>
<th>HWWP stage</th>
<th>Distance to the closest curve</th>
<th>Elasticity curve direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  information clarity and concision</td>
<td>0.37</td>
<td>0.81</td>
<td>M</td>
<td>Health/ Assurance</td>
<td>0.67</td>
<td>C6-Higher functionality</td>
</tr>
<tr>
<td>2  ease of use</td>
<td>0.68</td>
<td>0.80</td>
<td>O</td>
<td>Weapon/Shield</td>
<td>0.29</td>
<td>C5-Lower performance</td>
</tr>
<tr>
<td>3  loading time optimization</td>
<td>0.58</td>
<td>0.63</td>
<td>O</td>
<td>Weapon/ Helping hands</td>
<td>0.31</td>
<td>C4-Proportional performance</td>
</tr>
<tr>
<td>4  fast order confirmation</td>
<td>0.57</td>
<td>0.67</td>
<td>O</td>
<td>Weapon/ Helping hands</td>
<td>0.10</td>
<td>C4-Proportional performance</td>
</tr>
<tr>
<td>5  modern design</td>
<td>0.73</td>
<td>0.51</td>
<td>A</td>
<td>Weapon/ Helping hands</td>
<td>0.54</td>
<td>C3-Higher performance</td>
</tr>
<tr>
<td>6  product 3D format</td>
<td>0.75</td>
<td>0.54</td>
<td>A</td>
<td>Weapon/ Tactical device</td>
<td>0.31</td>
<td>C3-Higher performance</td>
</tr>
<tr>
<td>7  image rotation</td>
<td>0.72</td>
<td>0.48</td>
<td>A</td>
<td>Wealth/ Precious jewelry</td>
<td>0.75</td>
<td>C2-Lower delight</td>
</tr>
<tr>
<td>8  customization storage</td>
<td>0.63</td>
<td>0.43</td>
<td>O/A</td>
<td>Wealth/ Precious jewelry</td>
<td>0.65</td>
<td>C2-Lower delight</td>
</tr>
<tr>
<td>9  view of other’s customized orders</td>
<td>0.43</td>
<td>0.41</td>
<td>I</td>
<td>Prospect/Potential</td>
<td>0.31</td>
<td>C4-Proportional performance</td>
</tr>
<tr>
<td>10 large number of customizable shoes</td>
<td>0.67</td>
<td>0.42</td>
<td>A</td>
<td>Wealth/ Precious jewelry</td>
<td>0.48</td>
<td>C2-Lower delight</td>
</tr>
<tr>
<td>11 customizing color</td>
<td>0.74</td>
<td>0.85</td>
<td>O-&gt;A</td>
<td>Weapon/Shield</td>
<td>0.59</td>
<td>C5-Lower performance</td>
</tr>
<tr>
<td>12 customizing leather material</td>
<td>0.67</td>
<td>0.77</td>
<td>O-&gt;A</td>
<td>Weapon/Shield</td>
<td>0.58</td>
<td>C5-Lower performance</td>
</tr>
<tr>
<td>13 customizing accessories</td>
<td>0.70</td>
<td>0.70</td>
<td>O-&gt;A</td>
<td>Weapon/ Helping hands</td>
<td>0</td>
<td>C4-Proportional performance</td>
</tr>
<tr>
<td>14 payment options</td>
<td>0.56</td>
<td>0.71</td>
<td>O-&gt;A</td>
<td>Weapon/ Helping hands</td>
<td>0.14</td>
<td>C5-Lower performance</td>
</tr>
</tbody>
</table>

We have applied the refined model for the old case study to see if it indeed brings explanations and corrections to the results. The records (blue points) represent the 14 quality attributes. It’s not difficult to observe the concentration of quality attributes around the point M(0.6236, 0.6286). The model together with all points is given in Figure 4.

In our case, the semi-interquartile range is smaller than the amplitude (0.3050 for y coordinate and respectively, 0.2950 for x coordinate), therefore, we can sustain the concentration of empirical distribution of the records.

The computed Gini coefficient for both coordinate of the analysis is less than 0.15, hence, we can reject the uniform hypothesis of the record (in the uniform distribution the Gini coefficient is 0.3). For the case study, the concentration of measure with respect to the half part of the unit square is less than 0.3 and this confirm a non-uniform (2-dimensional) distribution (where the concentration of measure is 0.5).
The 14 quality attributes are modelled in the refined HWWP model, corresponding to one of the seven elasticity curves after a thorough computing of the distance between the point and the closest curve. In this way, a point situated between two categories can be classified with precision for management decision support. In addition, by associating a quality attribute to an elasticity curve, the design and management team can foresee a strategic developing path ascending the direction of the curve.

As an example, the quality attribute with the number 13- customizing accessories from Table 1 had an initial one-dimensional and attractive Kano category, being a little bit vague for decision making. The classical HWWP model recommended a "helping hands" (weapon) dimension. The problem was that also number 14 - payment options (an ambiguous Kano category) has been considered as having a "helping hands" dimension. No major difference can be outlined at this point between them. The management team is not able in this moment to clearly evaluate the quality attributes’ value for their new product or service and envisage future strategic decisions.

With the refined non-uniform HWWP quality attribute classification model we can assign the 13 point to the C4 elasticity curve. Thus, customizing accessories is a proportional performance feature which can be developed strategically as "strategic advantage" in correlation with the direction of the curve 4. Unlike point 13 (customizing accessories, which adequately developed can become a very important feature in a company), point 14 regarding payment options is associated to the curve 5 denoted as lower performance and a more inelastic region. Therefore, point 14 - payment options has a lower degree of performance than point 13, even if in the classical HWWP model they were the same. As a strategic development, point 14 can reach a "shield" dimension in correlation with the direction of the curve 5.

Same discussion can occur for all 14 quality attributes of the previous case study, the new insight can facilitate decision making and strategic forecast of potential development lifecycle.
5. Conclusions

Due to the fact that the traditional Kano model has a qualitative nature and limited decision support in engineering design (see for a thorough literature analysis [8]), the HWWP (Health-Weapon-Wealth-Prospect) model emerged as an explanatory paradigm and a more useful option in decision making.

The present study has normalized the importance of wants variable of the HWWP model and rejected its classical uniform partition based on three statistical techniques: the interquartile range, the Gini coefficient and the concentration of measure. Thus, it has been demonstrated that a uniform reparation of results in square dimensions does not provide enough information for subtle decision making. In the uniform HWWP model a quality attribute’s dynamics could be seen as a precipitous jump from one dimension to another with high financial repercussions for the firm. Instead, the non-uniform partition with the help of elasticity curves first sections the model in elastic and inelastic regions and then provides a natural strategic trajectory (the direction of the curve) for improvement.

The non-uniform proposed partition has been realized with the help of seven elasticity curves inspired from the price elasticity of demand principles. The number of curves is not limited to seven, the refined HWWP model can be adapted to each situation, depending on the concentration of quality attributes.

The proposed elasticity curves have been applied to [13]’s case study to refine the results and prove the new model’s applicability. In the discussion section the authors have argued the fact that elasticity curves overlapping the HWWP dimensions facilitate a clearer understanding of potential customer needs and a strategic overview of the possible quality attribute’s development opportunities. By allocating each quality attribute to an elasticity curve we can delineate a potential lifecycle path for that specific characteristic. In this way, the new product or service will be accurately designed to fit customer needs. Additionally, managers will be able to plan future development stages of each quality attribute with precision.

In conclusion, the refined HWWP model based on a non-uniform partition with elasticity curves wishes to integrate the understanding and classification of customer needs as an important decision-making tool in new product or service design. Future research will focus on adapting the refined HWWP model to take into consideration also the producer’s capability to fulfil prioritized and classified customer needs.

References