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Fuzzy sets as means of measurement on social sciences

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Abstract:

This paper aims to present a number of alternatives to best evaluate objectively linguistic terms in social sciences. As one of the means with high interest lately on the field of analyzing linguistic data sets, has been found to be fuzzy logic and fuzzy sets. We as humans most easily express ourselves through linguistic terms and therefore the objectivity of our responses in surveys is highest when we do so. Most of the softwares that currently are offered, push scientists to measure customer perceptions through a numbering scale, which would mean score in numbers out feelings. That answer would be subjective and might cause invalidity of the findings. In this paper the alternative is presented, where respondents can respond their feelings, perceptions, experiences with linguistic terms. The paper focuses on the service quality theories and the analysis between the expectations and experiences that customers face. A number of formulas are presented on how to measure expectations and experiences, fuzzy averaging and lastly presenting the formula to measure the difference between the two, which would provide the gap in service quality offering.

Key words: fuzzy sets, social sciences, service quality theories

INTRODUCTION

Fuzzy sets a theory of the Boolean algebra has been firstly introduced by Lotfi Zadeh in 1965. One of his motives on

launching this theory was to provide a mathematical approach that could help formalize linguistic concepts subject to vagueness degree. Its applicability has been seen across various research fields: computer science, decision theory, logic, management science, operations research as well as pattern recognition (Bojadziev and Bojadziev 2007). In general investigation with the Likert scale, it used crisp values to present their feelings and subjective perceptions of service quality. In fact, due to intangible and subjective information often appearing in the evaluation process, crisp values are inadequate to present the evaluation ratings of customers, so people would have difficulties in understanding the difference and uncertainties in human's semantic expression. Some research has proven that the Fuzzy linguistic scale works better than the Likert scale in terms of reliance and effectiveness. But until now, much less research has explored the Fuzzy linguistic scale instead of the Likert scale to measure service quality. Therefore, this study proposed a conceptual model to assess the perceived service quality properly using Fuzzy linguistics, to explore whether it is a better solution than on the Likert scale and to more effectively evaluate feedback.

FUZZY SETS AS MEANS OF ANALYZING LINGUISTIC TERMS

The pioneer in fuzzy logic and fuzzy sets, Lotfi Zadeh (Jacoby and Kyner 1973) referred to this traditional logic as when "*the complexity of a system increases, our ability to make precise and yet significant statements about its behavior diminishes until a threshold is reached beyond which precision and significance [or relevance] become almost mutually exclusive characteristics.*"

In real life, this is rarely the case, considering that mostly an attribute can be considered as member for a certain amount to a certain group and as well there could be a possibility of being member to another group. The downfall of the crisp set theory and bivalent logic that probability theories

use are that, in real life, variables might be partly members of a set or outcome (Rihoux and Ragin 2009). The theory of fuzzy sets allows partial membership to a given condition between a full nonmember denoted by 0 and a full member denoted by 1; in order to describe the gradual transitions between the two continuums. As a theory it consists of this strong point that based on the analysis, it allows an attribute or condition to be a partial member of the outcome (Zimmermann 2001). For ex. if A is the set of expectation degree between the eTail Quality attributes and brand loyalty types, fuzzy set $\tilde{A}$ represents the set of ordered pairs $\tilde{A} = \{(x, \mu_A(x)) \,|x \epsilon X\}$ where $\mu_A(x)$ is the membership function of x in $\tilde{A}$. This membership function can vary in between the two continuums of being a nonmember up to being a full member of the outcome that is studied (Zadeh 1965).

The benefit of fuzzy sets is that it enjoys the possibility on using the same arithmetic calculations as conventional sets such as union, intersection and negation (Rihoux and Ragin 2009), which provide a good background on finding cause-effect relations and pattern recognition in the variables that are studied. It can apply to cases where we need to collect data which is linguistic in nature; and furthermore this data can be interpreted in fuzzy sets which could be analyzed through mathematical calculations. According to Zimmermann (2001), words as such that are used in our everyday life language, have an uncertain description in order to infer from them. That being said based on fuzzy logic; this is referred as the fuzziness issue. Linguistic terms as expectation and experience are not deterministic compared to a linguistic term as height, which can be measured based on a certain set of scales such as meter, feet etc. The fuzziness on defining the concepts makes the conditions that are being studied to be adequate for a fuzzy sets study. Let's suppose that the study is trying to measure the expectations and perceptions from a certain purchase. These two represent the gap analysis which is used to measure the gap in service quality (Parasuraman and Berry 1988). The

Expectations are score in 5 levels: Very much Not Satisfying, Not Satisfying, Fair, Satisfying, Very Satisfied. There are as well 5 levels of providing scores for the measurement of Experience, being: Very much Not Satisfying, Not Satisfying, Fair, Satisfying, Very Satisfied. The difference between the two is that consumers are asked about expectations, prior to their purchase; and about experiences: after their purchase (Gustafsson et al. 2005).

The fuzzy arithmetic imply that, let the universe of discourse X be the subset of real number R where $X = \{x_1, x_2, x_3, ..., x_n\}$. A fuzzy set $\tilde{A} = \{(x, \mu_A(x)) \mid x \in X\}$ in X is a set of ordered pairs where $\mu_A(x)$ is called the membership function where

$$\mu_A(x) : X \rightarrow [0,1]$$

Through the various types of fuzzy number representations, this study uses the triangular fuzzy numbers which are proved to have wide applications in social sciences (Bojadziev and Bojadziev 2007). The membership degree of expectation and experience conditions, in terms of triangular fuzzy number Fig. 1, lays between a_1, meaning full nonmember of a set; a_2 denoting a full member of the set and a_3 denoting full nonmember of the set. The triangular fuzzy numbers are denoted by $\tilde{A} = (a_1, a_2, a_3)$. The v_A score in Fig. 1, is the point that divides the bounded area of a triangular fuzzy number $\tilde{A}$ into two equal parts.

CONCLUSIONS

Using the method used by Chien and Tsai (2000), which applies based on previous findings from Dubois and Prade (1985), Peter, Churchill Jr, and Brown (1993), Klir and Yuan (1995) we could proceed in analyzing data through four stages, being:

Firstly, if the variables we are trying to measure are linguistic by nature we could use Chien and Tsai (2000) formula to fuzzify the degrees, which are shown as μ_A [for the expectation degree] and μ_B [for the experience degree]. The process of fuzzifying the expectation and experience degree is shown in Eq. [1]. The same procedure is applicable for μ_B, μ_C, and μ_D.

$$\mu_A(x) = \begin{cases} y_a^L(x) = \dfrac{x - a_1}{a_2 - a_1}, & a_1 \le x \le a_2 \\ y_a^R(x) = \dfrac{x - a_3}{a_2 - a_3}, & a_2 \le x \le a_3 \\ 0, & otherwise. \end{cases} \quad [1]$$

In order to understand the general descriptive part within the surveyed groups I use the average fuzzy number denoted by A_{ave} for the n triangular numbers, Eq [2].

$$\tilde{A} = A_{ave} = \frac{\tilde{A}_1 + \tilde{A}_2 + ... + \tilde{A}_n}{n} = \frac{(\sum_{i=1}^{n} a_1^{(i)}, \sum_{i=1}^{n} a_2^{(i)}, \sum_{i=1}^{n} a_3^{(i)},)}{n} = (a_1, a_2, a_3) \quad [2]$$

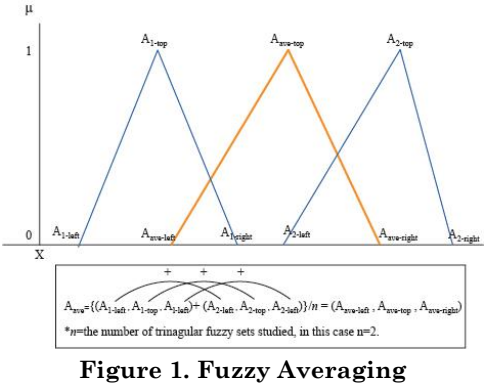

Figure 1. Fuzzy Averaging

Clarify weak and/or conditions for each etail quality attribute with regards to the two types of brand loyalty Eq. [3]; Eq. [4]; Eq [5]. Furthermore understanding the implications that local

brands vs global brand has on positioning a specific attribute as sufficient for the outcome to happen.

$$v_A = (a_1 + 2a_2 + a_3)/4 \quad [3]$$

$$v_B = (b_1 + 2b_2 + b_3)/4 \quad [4]$$

$$v = v_B - v_A \quad [5]$$

Through this analysis I am after to find whether the expectations or experiences degree is greater or smaller when compared to one another. Using the theory from Chien and Tsai (2000), In the findings section I will present which eTail Quality attribute appears to be sufficient for behavioral intentions to happen.

As the last step of the process I use the v scores Eq. [3] and Eq. [4], to defuzzify the sets, and give them the approximate linguistic term. This type of deffuzification procedure has been proved to work very well in studies where triangular fuzzy numbers are used (Zimmermann 2001, Chien and Tsai 2000, Bojadziev and Bojadziev 2007), which is the case in this study.

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