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Three-way decomposition of weighted log-odds ratio for customer satisfaction analysis

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Abstract

In literature several methods have been proposed for the service quality assessment. A large number of models have been proposed to evaluate Service Quality (Servqual, Normed Quality, Servperf etc.). Starting from the SERVPERF paradigm, in this paper we propose to use Odds Ratio analysis to evaluate Customer Satisfaction. In particular the data has been collected in three-way contingency tables in which the crossed variables are perception evaluations, importance evaluations and dimensions. For each slice we computed the Odds Ratio. Thus a weighted version of log-Odds Ratio Analysis for three-way is proposed and analyzed by the Parafac/Candecomp algorithm. A case study on Patient Satisfaction (PS) survey that was carried out at a Neapolitan government hospital is presented in the last part of the paper in order to show the proposed methods.

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Keywords: Odds ratio, Three-way contingency table, Parafac/Candecomp method, Customer Satisfaction

1. Introduction

During the last twenty years, the strategy of firms has gradually shifted from marketing to Total Quality Management to Customer Satisfaction (CS). Particularly, for a company, the knowledge of the customer evaluation

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of a given service represents an important starting point for every business strategy. In fact CS matters not only to the customer, but even more so to the business because it directly impacts a company's bottom line profits. Furthermore, it is one of the most important components of a company's positive brand image. In literature several methods have been proposed for the service quality assessment and many of them are based on the Gap Theory of Service Quality, which was proposed for the for-profit sector by Parasuraman et al. (1994). Cronin and Taylor (1992) were the first to offer a theoretical justification for discarding the expectations from the Servqual and consider only the performance, and this model is known as Servperf. The Servperf model considers twenty-two items and five quality dimensions, and such dimensions are: (1) the reliability of the service provider, (2) the responsiveness of the service provider, (3) the tangible aspects of the service, (4) the assurance provided by the service staff, and (5) the empathy shown to consumers.

Starting from the Servperf paradigm, in this paper we propose to use Odds Ratio analysis to evaluate CS. In particular the data has been collected in three way contingency tables in which the crossed variables are the evaluation of the perception and importance for each dimension. Thus, Odds Ratio of perception and importance for each dimension are arranged by rows and columns in IxJ slices of a three-way table $IxJxK$.

The odds ratio (OR) is one of the main measures of association in $2x2$ contingency tables. Also for IxJ tables the ORs are commonly used to describe the relationship between the row and column variables. Starting from the selected data table, several OR methods have been proposed. For example, Aitchison (1990) and Greenacre (2009) proposed to analyze contingency tables. On the other hand, De Roiij and Anderson (2007) proposed to analyze two-way tables with the ORs, which has a total number of ORs equivalent to $[I(I-1)/2]x[J(J-1)/2$. Nevertheless the number of ORs needed to capture the association structure may still be too large for one to gain insight into the nature of the relationship between the variables. Also a general framework for connecting all these methods has been proposed by D'Ambra and al. (2013).

In the statistical literature, the analysis of association for variables placed in IxJ two-way contingency tables is a topic widely discussed. On the other hand, the analysis of the association in a three-way contingency table by ORs is rather limited. Several variants of the Parafac/Candecomp method (CP - Harshman, 1970; Caroll and Chang, 1970) has been proposed for the ORs by De Rooij and Anderson (2007). Following this approach, we focused our attention on the OR as association measure (Agresti and Coullb, 2002) and proposed to use a weighted log-odds ratio. Finally, to show that this new approach give richer results a full interpretation of a case study is presented in the last part of the paper.

2. The association in a two-way contingency table through Odds Ratio

Let $\mathbf{N} = (\boldsymbol{n_{ij}})$ be a two-way contingency table that cross-classifies n units according to I row categories and J column categories of two crossed variables. Let X_i and Y_j be the i-th and j-th categories of X and Y. The matrix of proportions is denoted by $\mathbf{P} = \boldsymbol{n^{-1}}\mathbf{N}$ with general term p_{ij}. The marginal relative frequencies of the i-th row and j-th column of $\mathbf{P}$ are $p_{i\circ}$ and $p_{\circ j}$ and they may be represented in vector form, particularly the vector $\mathbf{r}$ (resp. $\mathbf{c}$) consists of $p_{i\circ}$ (resp. $p_{\circ j}$), for $i = 1, 2, \dots, I$ (resp. $j = 1, 2, \dots, J$).

Let $OR_{ii'jj'} = n_{ij}\, n_{i'j'}$ $(1 \le i \le i' \le I, 1 \le j \le j' \le J)$ be the OR, the complete set of ORs for table $\mathbf{N}$ can be placed in a two-way table, called $\mathbf{S} = [\boldsymbol{s_{\tilde{\imath}\tilde{\jmath}}}]$, of dimension $\tilde{I}\ x\ \tilde{J}$, where $\tilde{I} = I(I-1)/2$ and $\tilde{J} = J(J-1)/2$.

Starting from the data tables $\mathbf{N}$ and $\mathbf{S}$ two different statistical methods have been developed. These methods are linked between them and with Altham association measure. Moreover for improving the performance a weighing system can be considered. The main characteristics of these methods are summarized in table 1.

The first is the unweighted Log Ratio Analysis (LRA), which is proposed by Aitchison (1990). It starts from the logarithms of the matrix $\mathbf{N}$, called $L(\mathbf{N})$, and 0.5 is added when an element of $\mathbf{N}$ is equal to 0. Then, let $\mathbf{1}$ be a vector of ones of appropriate order in each case, an SVD of the following matrix is performed

$$\mathbf{Z}^U = \mathbf{D}_r^{1/2}(\mathbf{I} - \mathbf{11}^t/I)L(\mathbf{N})(\mathbf{I} - \mathbf{11}^t/J)\mathbf{D}_c^{1/2} \quad (1)$$

$\mathbf{Z}^U$ is a double-centered matrix respect to the geometric mean and with uniform weights.