Fuzzy Logic Approach Applied into Balanced Scorecard

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Abstract. In this paper we propose to apply fuzzy logic methodologies for measuring key performance indicator into Balanced Scorecard (BSC) Customer Perspective. This study provide fuzzy key performance indicator (FKPI) to the customer experience management for uncertainty measures. The proposal is a step forward in terms of methodologies for creation of performance indicators in the field of marketing, where you have the opportunity to work with uncertain or vague data (human language). The significant contribution of the research is include qualitative data indicator, result from analysis the information that expresses the client in text format, to BSC. The methodology used is the model proposed by Mamdani fuzzy inference which is based on the fuzzy logic theory and fuzzy subsets. Software Matlab was used for the analysis.

Keywords: Fuzzy Key Performance Indicator · Fuzzy inference
Customer experience management · Balanced Scorecard
Mamdani inference method

1 Introduction

The management of a company needs to develop key performance indicators integrated in balanced scorecard, which considers financial measures that tell executives the results of actions already taken. And complements the financial measures with three other sets of operational measures related to the customer, internal processes, and the ability of the organization to learn and improve [20]. Thus, the availability of a consistent and coherent set of indicators is a prerequisite to make informed decisions, aligned with the goals of the organization [9, 11, 19].

Non-financial indicators that form an integral measuring system performance and associated with the BSC customer perspective are usually created based on quantitative data, the product of transactional relationships with customers. It is considered that mathematical approaches of the calculation of quality evaluation of the systems involving human factors do not reflect a significant feature of the processed data due to their natural vagueness. The appropriate theoretical background for the formalization of data vagueness is the fuzzy set and fuzzy logic theory [30].

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The study on "Fuzzy key performance indicator" (FKPI) is limited in the literature [24, 30, 47, 49].

Schmitt [44] is recognized by his contributions to customer experience management. In his proposed model, Customer Experience Management (CEM), he shows how to use the power of an experimental approach so as to be able to connect with the customer in each interaction or contact point. An agreement between many authors can be observed in terms of how customer experience management should include all of the contact points between the customer and the company [12, 14, 18, 32, 38, 44, 50].

Considering the importance that today reaches managing the customer experience, and provision for consumers to point at any social network their experiences with companies is that the empirical study focused on the analysis of the text given freely by the customers in a survey that evaluates this variable.

The aim of this paper is to advance within the Fuzzy Key Performance Indicators in customer experience theory. Thus, proposed to apply fuzzy logic methodologies for measuring indicators into Balanced Scorecard (BSC) Customer Perspective.

To clarify, "classic data" in this study refers to "numerical" format information that is traditionally analyzed by companies and the academic world, while "fuzzy data" refers to all the information in "linguistic" format.

In the following sections of this study, the theoretical framework and the methodology applied are explained, ending with the Fuzzy Key Performance Indicators (FKPI) for the Customer Experience Management model.

2 Conceptual Framework and Development of Hypotheses

In this section, we briefly review the Balanced Scorecard, key performance indicator; fuzzy set and fuzzy number.

2.1 Balanced Scorecard (BSC)

The balanced scorecard (Balanced Score Card), hereinafter BSC is a system of strategic planning and management that has been used extensively in business and industry, government, and nonprofit organizations worldwide in order to align business activities to the vision and strategy of the organization, improve internal and external communications, and monitor organization performance against strategic goals. It was developed by Kaplan and Norton [19] as a framework for performance measurement that adds non-financial strategic measures to traditional financial metrics, and delivery to managers and executives a more 'balanced' view of organizational performance [19, 20]. The BSC focuses primarily on the two major problems of modern organizations: the proper performance measurement and evaluation of the successful implementation of the strategy of the organization. Overall, the BSC system is considered to be simultaneously a performance measurement system, a system of valuation of the strategy and a communication tool [19], defined by four perspectives: financial, customer, process domestic business and, finally, learning and growth. For many researchers the BSC is not just a measurement system, but it is a management system that enables organizations to clarify their vision and strategy and transform them into action [34, 36, 39].

The BSC has been widely applied in the private sector. The "Gartner Group" estimated that at least half of the Fortune 1000 companies use BSC [36] methodology.

2.2 Key Performance Indicator

KPIs are meters that reflect the health of an organization [8]. A key performance indicator (KPI) is a performance measurement that evaluates the success of a particular activity. Success can be either the achievement of an operational goal or the progress toward strategic goals [5].

The goals to be measured in the realm of organizational performance are latent u objective constructs (e.g. customer satisfaction, employee loyalty, customer experience, profit, among others.). Similar to an instrument of mediation, a performance indicator measuring addressed some aspect of organizational performance with respect to a reference object. Therefore, a performance indicator is based on the hypothesis that properly represents a particular aspect of organizational performance [40]. Moreover, an indicator involves an epistemological principle only if their validity is successful it will serve its purpose.

An indicator is valid if it really measures the manifestations appearance to be measured; in other words, the validity implies objectivity and reliability [7]. An indicator is measurement target if not depends on the judgment of a particular person. And it will be reliable if repeat measurements produce the same result. Although the question of how to judge the validity of a measure is well known in the scientific philosophy, he has never been, nevertheless, properly answered. The validity of a performance indicator depends on the truth of the hypothesis after the indicator or in other words, how well it can be justified [7].

2.3 Fuzzy Set and Fuzzy Number

The origins of fuzzy logic are associated with investigations by Zadeh [51], professor at the University of California, USA, disseminated through his article titled "Fuzzy sets": where he presented a few sets with no clear or precise limits, playing an important role in pattern recognition, interpretation of meanings, and abstraction [48]. It is widely used to handle the imprecise and uncertain information in the real-world problems [52]. The main contribution of this theory is that it allows study of ambiguity, allowing more akin to express human expression, "natural language" logical relationships.

Thus, fuzzy logic suggests that in the field of social sciences provide technical management in an uncertain environment, which is based on the concept "gradual simultaneity", which can handle vague or difficult to specify, and to change the operation or status of a specific system [13].

Definition 1. Fuzzy set: $\tilde{A}$ in a universe of discourse X is characterized by a membership function $\mu_{\tilde{A}}(x)$ which associates with each element x in X a real number in the interval [0, 1]. The function value $\mu_{\tilde{A}}(x)$ is termed the degree of membership of x in $\tilde{A}$.

Definition 2. Triangular fuzzy number: A fuzzy number is a subset fuzzy, A, normal, convex and whose reference is the real numbers. It is the instrument par excellence of the Fuzzy Logic to represent amounts estimated or observed fuzzy.

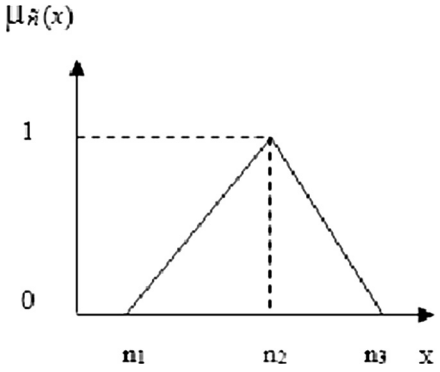
In change, for unordered referential domains can be defined labels or scalar. These labels can be a similarity function is defined for each pair of values of the domain D and establishes a relationship of similarity or proximity to measure the similarity or resemblance between two elements of the domain. Generally, the similarity values are normalized in the interval [0, 1], corresponding to "0" to the meaning such as "totally different" and "1" meaning "totally like," Urrutia [48].

A positive triangular fuzzy number $\tilde{n}$ can be defined as $\tilde{n} = (n1, n2, n3)$, where $n1 \leq n2 \leq n3$ and $n1 > 0$.

The membership function $\mu_{\tilde{n}}(x)$ of triangular fuzzy [52].

$$\mu_{\tilde{n}}(x) = \begin{cases} \frac{x-n1}{n1-n2} & n_1 < x < n_2 \\ \frac{n3-x}{n3-n2} & n_2 < x < n_3 \\ 0, & Otherwise \end{cases}$$

Definition 4 [46]: Linguistic Variable is a variable whose values are expressed in text terms. Linguistic variables are very useful in dealing with situations which are too complex or not well defined to be reasonably described in conventional quantitative expressions.



3 Methodology

This paper presents the first phase, exploratory character, of the study on performance indicators on the interactive customer experience. An online style of structured questionnaire was used as an information gathering tool. It was defined to be able to measure the interactive experience of customers with the company being studied, geared towards listening to the customer's voice, thus empirically proving the Customer Interactive Experience the analysis model proposed in this investigation with the gathered information.

The universe studied was made up of active company customers that have flown in the last year. The type of sampling was probabilistic, simple random sample, obtaining a final valid sample of 960 surveyed. Geographical Area: Spain.

So as to be able to solve the problem, a methodological sequence that covered from the choosing of the indicators for each experience, passing through the design of the general

architecture of the system, to the fuzzy model with the help of the MATLAB fuzzy logic toolbox, was used. In this case, the centroid in the Defuzzyfication method was used.

The proposed for measuring the fuzzy customer experience indicators are performed using the free text format, gathered with an open question on the survey applied to customers of airline company. Is defined as a grouping of graduated responses; fuzzy inference using the Mamdani model, its rules are of the IF – THEN kind. As observed, a rule from the set of rules or knowledge base has two parts: the antecedent and the conclusion, to see Fig. 1, software used MATLAB.

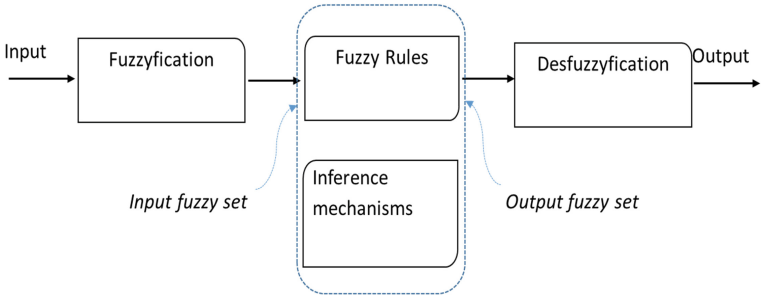


Fig. 1. Fuzzy inference using the Mamdani model

The analysis considered: data storage, with KNIME perform the extraction and transformation of data from the source, data filtering, storage of relevant words, This step is of great importance, here are beginning to think about the stage of opinion mining. Then JAVA relevant words are analyzed and finally developed in MATLAB a fuzzy indicator.

4 Empirical Results and Discussion

Fuzzy Indicators – Free Text

This stage of the investigation analyses free text, gathered with an open question on the survey applied to customers of the airline company. The text mining is done with the Knime software which takes every word and sees the number of coincidences it has within the text, thus "rescuing" those words that were more frequently mentioned in the comments. This information is organized for the purpose of knowing which words present a higher degree of frequency; these words will be used as search and analysis patterns later on. The analysis methodology used assigns a degree of belonging to the significant words found by the system, be it by positive or negative real numbers. This lets us infer how positive or negative customer experiences with the company actually are. See Fig. 2. At this stage of analysis we used JAVA software.

Figure 2 shows that the application requires three sources of information: the analysis of words of higher usage, the comments that contain these words and our dictionary made up of the adjectives. The analysis carried out with the help of these information entries results in the approval indicator, which is our main goal at this stage.

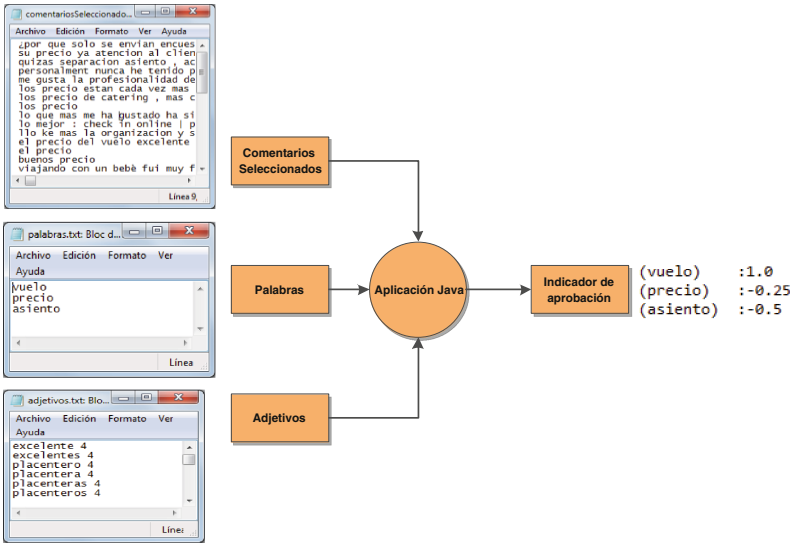


Fig. 2. Diagram: opinion mining

The indicators obtained, associated to the words obtained, are: flights (1.0), price (−0.25), and seat (−0.5). These results respond to the purpose of the investigation because the fact that they produce indicators that report on customer perceptions regarding their experiences with the company. The value of the indicators can be in the [−2, 2] interval, assigned values according to the degree of presence of an adjective in a word. This means that, for example, −0.25 is not a very critical indicator. However, it is a concrete value and more closely reflects the actual conditions of the company in terms of this indicator, supplying greater knowledge regarding the situation of the company.

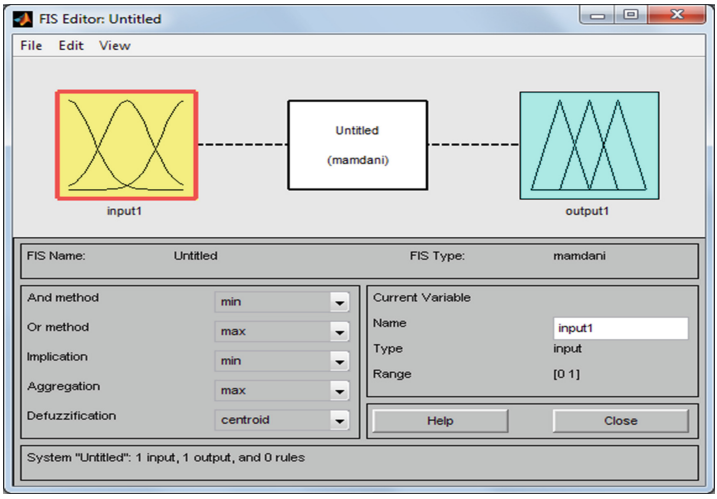


Fig. 3. Fuzzy interface module belonging to MATLAB

Next, once we already have the experience we have indicators represent those values in an indicator, to see Fig. 3.

The previous results revealed valuable information to the company, but this information can be "encapsulated", delivering a single guiding indicator in terms of the current company situation. The Matlab tool was incorporated because of this. This tools takes three significant words with their corresponding indicators, and gives us a global view regarding customer experience; a fuzzy indicator. Inference with the Mamdani (1975) process is carried out for this. This is a fuzzy, also known as linguistic, inference method that has a wider range of use than other fuzzy methodologies. The authors based themselves on the research of Zadeh (1965) regarding fuzzy algorithms for complex systems and decision making processes (Figs. 4, 5, 6 and 7).

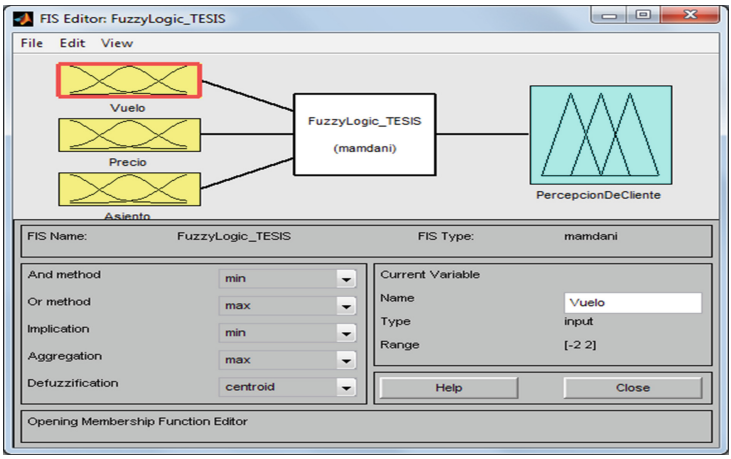


Fig. 4. Creation of linguistic variables

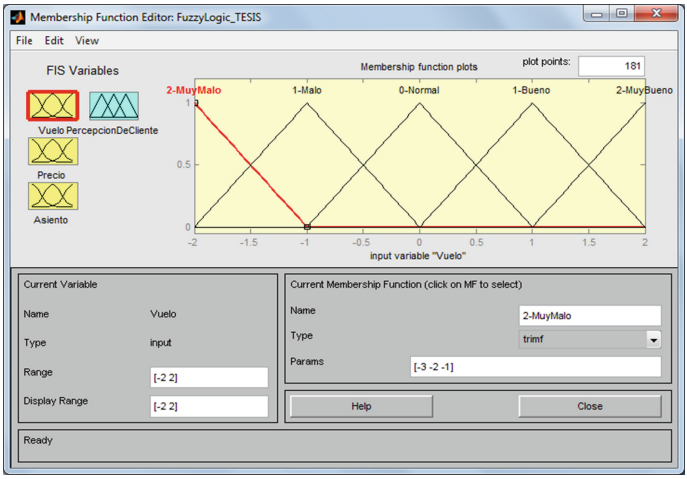


Fig. 5. Definition of linguistic labels and membership function to output variable

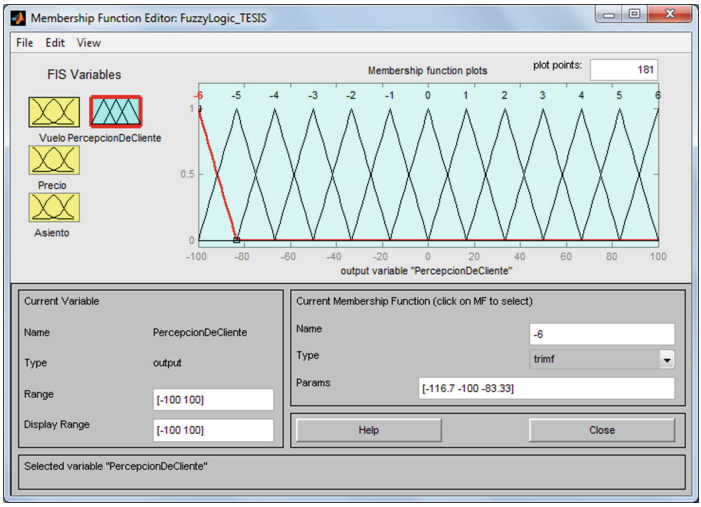


Fig. 6. Definition of linguistic labels and membership function for input variables

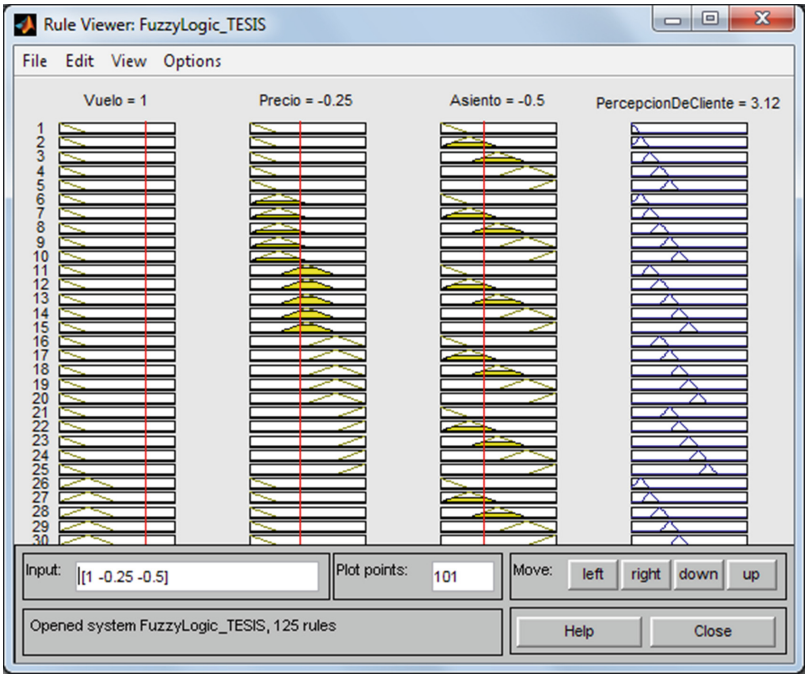


Fig. 7. Final fuzzy indicator of customer experience

Once the indicators are entered into the created model, they tell us that the level of customer experience regarding services rendered by the airline reaches 3.12%. This final indicator can take a value within the [−100%, 100%] range. We are therefore in the presence of a numerically positive indicator and, at the same time, a positive indicator for the company because people approve of their service. It's not an incredible number, but the fact that there are more positive comments than negative ones is evident. Or, maybe, the positive comments are more relevant than the negative ones in the comments done by customers, which is relevant for the company. This analysis paved the way for proposing fuzzy management indicators for customer experiences through the analysis of free text.

5 Conclusions

The organization has data provided by its clients in different formats (quantitative or qualitative). To extract information from the data and get knowledge is necessary to apply different methodologies. So, one option to achieve a better understanding of the linguistic data is through fuzzy logic methodologies.

After comparing the different methodologies used for the analysis of uncertain data, it was possible to see that defining key fuzzy indicators for the management of customer experience, formed through linguistic information contributed by the customers, is possible.

The results obtained, therefore, also allow us to indicate that after listening to and analyzing the voice of the customer, it's possible to create management indicators that form the customer's perspective in an Integral Control Panel.

The areas of marketing work a lot of linguistic information to measure the customer experience. Thus, methodologies for the management of uncertainty in the marketing areas of organizations are contributed.

The business implications presented are related to decision making. The development of an indicator relative to customer experience, to measure performance of the progress toward strategic goals and/or operational goals; allows the organization to be informed of customer feedback.

In future research, it is considered to create an indicator of customer experience, considering the analysis of free text, as for example comments on Twitter or Facebook, among other social networks.

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