Graphic representation of the competitiveness model developed under a fuzzy characterization.

Darwin Young[1], Pedro Pérez[1], Alberto Ochoa[2], and Jöns Sanchez[3]

[1]Corporación Mexicana de Investigación en Materiales,
[2]Universidad Autónoma de Ciudad Juárez
[3]Centro de Innovación Aplicada en Tecnologías Competitivas, León Guanajuato, México
megamax8@hotmail.com, dyoung@comimsa.com, pperez@comimsa.com
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Abstract. Currently it is extremely important for businesses to identify their strengths and weaknesses in the presence of competitors and open global markets; for which, there is interest in determining the level of competitiveness that companies can achieve and how define and prioritize the improvement actions for the sustained growth. This paper presents the development and use of graphical representations for the implementation of competitiveness model that generate the strategic profile of a company that considers qualitative variables under a fuzzy approach with the application of modified triangular membership functions. This is the continuation of a research project involving the development of a competitive model for the diagnosis and prediction, and whose future researches consider evolution strategies for optimization and contrast with the field data.

Keywords: Competitiveness, fuzzy variables, graphic representation, quantitative variables.

1 Introduction

The interest in determining the competitiveness of businesses has generated numerous researches that are focused on different groups of variables. Some variables examine the strategic management of information for acquiring a competitive advantage in order to maintain flexibility and business innovation [1]. Emphasizes the creation and sustenance of knowledge from internal and external business environment, rather than intervening directly to the operational characteristics of the company. Given that information and its management are necessary to provide a competitive advantage, business strategy focuses on knowledge management tools and methods. As suggested in [2], the dynamics and distribution of knowledge and skills can result in a competitive advantage.

During the first part of this investigation, the process to define the variables used to determine the overall indicator of competitiveness is under triangulation of data

obtained from different companies to identify those factors that include the main functions of operation and administration. Qualitative variables are treated under the definition of fuzzy variables that are correlated to a self-assessment system used within a group of participating companies [3].
The model generates a functional analysis that identifies and describes the key variables that are specified on the strengths and weaknesses of the company, developing a strategic operating profile, which has as main objective, assess the potential of the company in each of the key variables, so as to make more clear their activities should be concentrated where the actions and strategies to achieve a sustainable improvement of key aspects of the company to reach a level of world-class company [3].

The problem faced during the implementation of the model is the lack of knowledge or expertise that makes it inoperable the use of graphics fuzzy variables and multivariate analysis graphs by operators or employees of companies, which causes the model's potential is limited for use and decision making. Therefore, the objective of this paper is to show the development process to match the graphics of the model to the understanding of company personnel.

The paper is organized as follows. Section 2 presents the proposed methodology to define the kind of graphics use by the model. Section 3 describes the general outline of the competitiveness model and its overall efficiency index. Section 4 presents the definition of graphical representations. Section 5 shows the results obtained by applying the evaluation model to various companies participating in the study. Section 6 presents conclusions and future work.

2 Methodology

The results and information obtained from any investigation usually must be displayed in graphical form to improve understanding of these results; otherwise, there is the problem of abandoning those models. The best type of graph is one that conveys the message most effectively. It can be a complex or simple graphics, lines, points or segments of a circle, even a combination of various types, and many more types of graphics are observed and tested, you can choose the most appropriate type for your purpose. If you select the most effective type of graph, the data will be clearer, solid and generate support for decision making.

With the use of graphics can identify possible correlations between data, even find hidden relationships between them, which then could be accompanied and tested using statistical techniques. It is important to note that graphical representations are often neglected by its apparent simplicity with other techniques, they take relevance to an audience that does not have knowledge of the subject, and it can support its conclusions to work with appropriate graphics. In fact, there are complex multivariate analysis techniques such as multidimensional scaling or self-organized neural maps, whose final product is a graph or set of them.

A chart can analyze and report information of any kind of process commercial, financial and operational, where understanding of the graph may exceed the use of tables, yet they have not been given much importance to identify which should be the ideal type of graph, to show evidence of an analysis, because the designer usually develops, the graph according to their academic level, but rarely tries to identify if the graph is understood by the target audience.

On this basis, the process of identification of graphic representations for the competitive model is developed under the following steps:

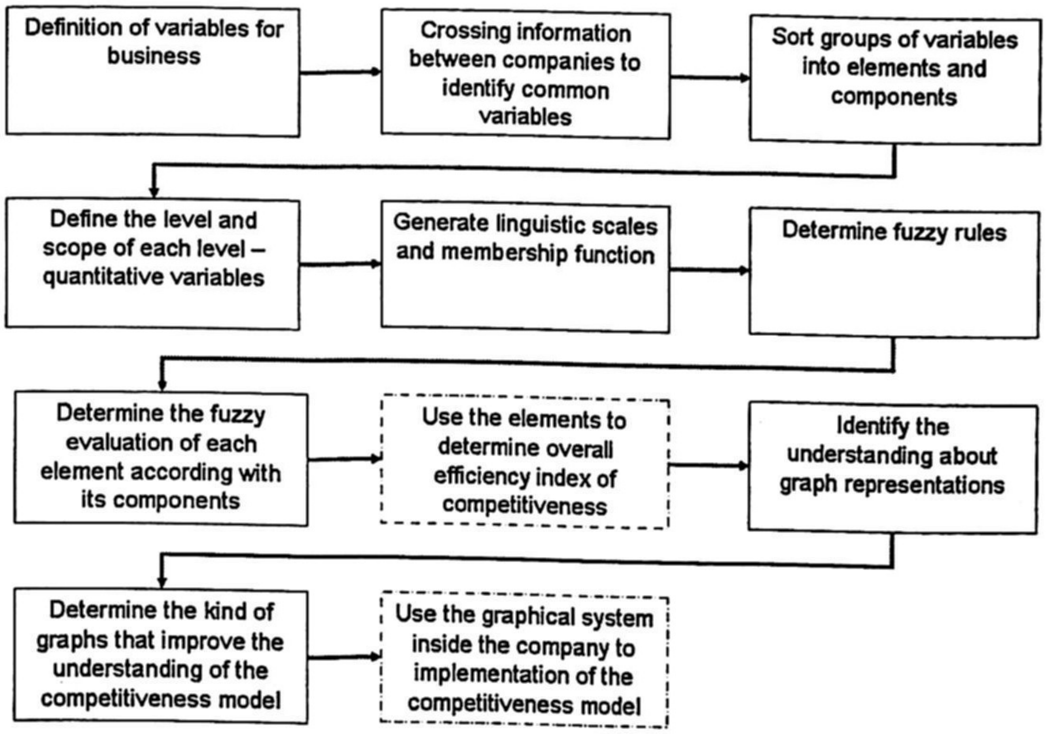


Fig. 1. *Process to determine the graphical system of the competitiveness model (Flow down).*

The importance of this process is to identify the influence of the shape of the graphics on the perception that analysts have on the competitive model information for decision making, planning of activities and strategies.

3 Competitiveness Model

Each element is represented by a fuzzy variable, under a scale of 1 to 10. And that group of components in each element determines the fuzzy set of entries in a scale of 1 to 10, rescale it to a table of values of 5 levels, under the following relationship. In figure 2, the first component of the element "Leadership and Commitment" is transformed in a set of equivalent membership functions.

1.0 Leadership and Commitment					
	Levels				
Component	**1**	**2**	**3**	**4**	**5**
1.1 Deployment of competitive systems	Competitiveness system is known by the management team of the Business. The organization has not conducted its assessment of their position in the competitive model	Self-evaluation of competitive system was conducted but have not communicated the results to all levels of employees. It defines the elements that are the business priorities. The competitive system has been disseminated at the level of managers, supervisors and department heads.	The system has been released to the supervisor level and facilitators. The results of the self-assessment have been communicated to all employees. It has set targets for profitability and targets for all indicators of the business scorecard. (BSC) The staff employee has been informed of the goals to achieve in these indicators. There are specific plans and projects, as defined by the Self Assessment.	It has spread the competitive system to all workers with the use of different media, in simplified form, they know the system and how they participate in their work areas. Employees and operators understand the actions of the system of competitiveness and they are aware of how they participate in achieving the goals of the indicators that they are involved.	There is a clear understanding of how outcomes are linked workspace with the results of the overall efficiency index of competitiveness and Balanced Scorecard indicators (BSC). All employees know the goals to achieve, progress and action plans to address the priorities found in the self-assessments and participate in continuous improvement projects through work-teams.

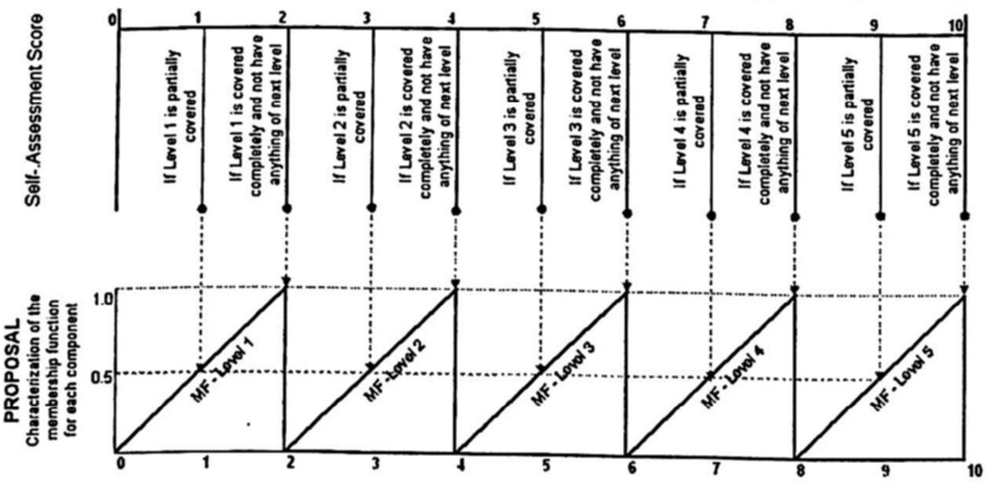


Fig. 2. Relationship between the qualitative variable and Membership Function for a component.

Each component is scored individually using a scale of 1-10. Two possible ratings for each of the 5 semantic levels. That is, grades 1 - 2 to level 1, grades 3 - 4 for level 2, grades 5 - 6 for Level 3, grades 7 - 8 for level 4 and 9 - 10 for level 5.

Level 1: 1 If it is partially covered, 2 It is covered completely and not have anything of next level
Level 2: 3 If it is partially covered, 4 It is covered completely and not have anything of next level
Level 3: 5 If it is partially covered, 6 It is covered completely and not have anything of next level

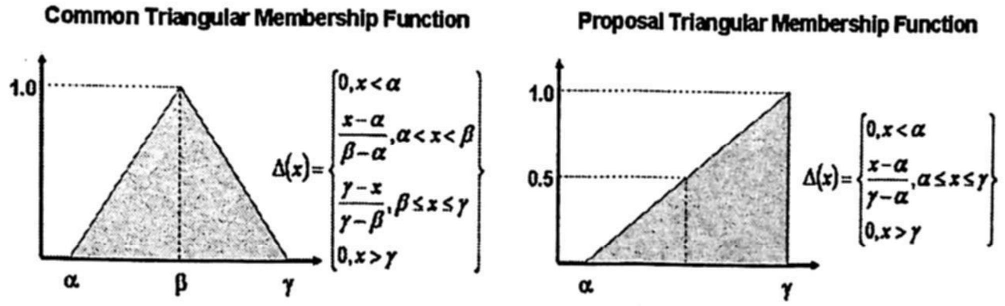
Level 4: 7 If it is partially covered, 8 It is covered completely and not have anything of next level
Level 5: 9 If it is partially covered, 10 It is covered completely.

Develop the selection of elements, which in the case of participating companies can generate a standardized model for the exchange of best practices. For this, The overall efficiency index is determined by a scale of 5 levels. If a variable of the company is closer to 1, is major source of weakness for the company, whereas the more close to 5, more clearly represent a of strength.

Table 1. *Characteristics of the semantic scale for overall efficiency index of competitiveness.*

Overall Efficiency Index	Level				
	1	2	3	4	5
	Highly Negative	Negative	Balanced	Positive	Highly Positive
OPERATIONAL BUSINESS STRATEGY	Operations strategy is not functional, It can not be competitive with the competition	Operational Strategy fails to meet the committed results	Operational Strategy can meet the targets	Operational Strategy exceed targets in a sustainable way	Operational strategy allows to drive the market
STRENGTHS AND WEAKNESSES	Companies where there is no possibility of meeting the objectives	Companies where their weaknesses limit the achievement of objectives	Companies that the balance between their strengths and weaknesses in achieving goals and face competition in a sustainable way.	Companies that allow their strengths to lead the market with predictive actions against competition in a sustainable way.	Companies where their strengths allow to innovate and market competition
ACTION PLAN	Take actions for change, under a new organizational strategy	Its priority must be to improve the level 1 components, and react to reduce their operational and transactional problems	Its priority must be to keep the weak level 3 components for a sustainable growth	Its actions to increase their strengths in a sustainable manner.	Solidify its strengths and renew its functional structure according to Generational Plan (long-term vision)
Type of Company	Companies in decline in global markets	Companies in restructuring	Average Companies	Growing Businesses	World - Class Company

The preliminary model uses a proposal of membership functions that is consistent with the definitions of each component. It creates a right triangle to the membership function, which differs from the common form of this type of triangular functions as shown in the figure below.



$$\Delta(x)=\begin{cases}0, x<\alpha\\ \dfrac{x-\alpha}{\beta-\alpha}, \alpha<x<\beta\\ \dfrac{\gamma-x}{\gamma-\beta}, \beta\le x\le\gamma\\ 0, x>\gamma\end{cases}$$

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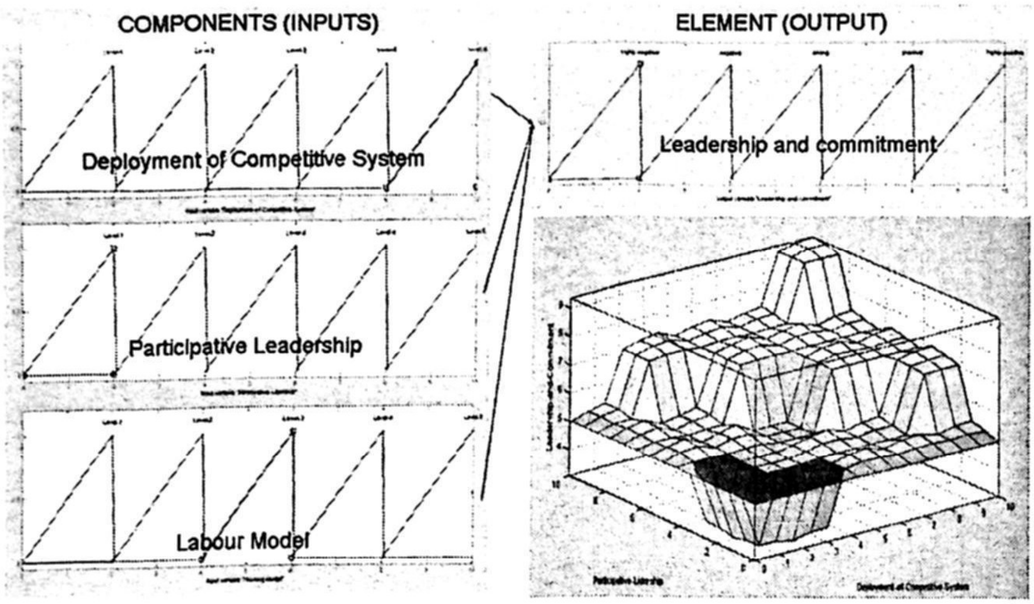


Fig. 3. Triangular Membership Function (above). Diagram of fuzzy inputs to one element (below).

The model identifies 10 elements of output, and 35 components that form the group of fuzzy inputs to the system. The interest of using this model is to generate a diagnosis that can be contrasted with the self-assessment and to define future states to address performance improvement actions on the priority elements. In Table 2 presents the list of elements and components included in the model.

In this evaluation process, the fuzzy rules are structured in the IF part and THEN part. The IF part is the relationship between the components of each element, and the THEN part is the computational result of the evaluated element. The number of rules is equal to the 5^k, where 5 is the number of level and k is the number of components of the element under investigation. Example in figure 3, the element "Leadership and commitment" has three components; the number of rules are 125.

4 Graphical Representations

The search for graphics that could be used within the model of competitiveness to ensure their understanding and application in decision making is contrasted to the group of users who make use of the information model, which has 10 components and 35 components.

The use of graphical procedure should help to avoid the complexity of the proposed fuzzy model, given the expertise of users, extracting maximum knowledge with minimum handling of information available to users. The types of graphics used, and combinations of these were:

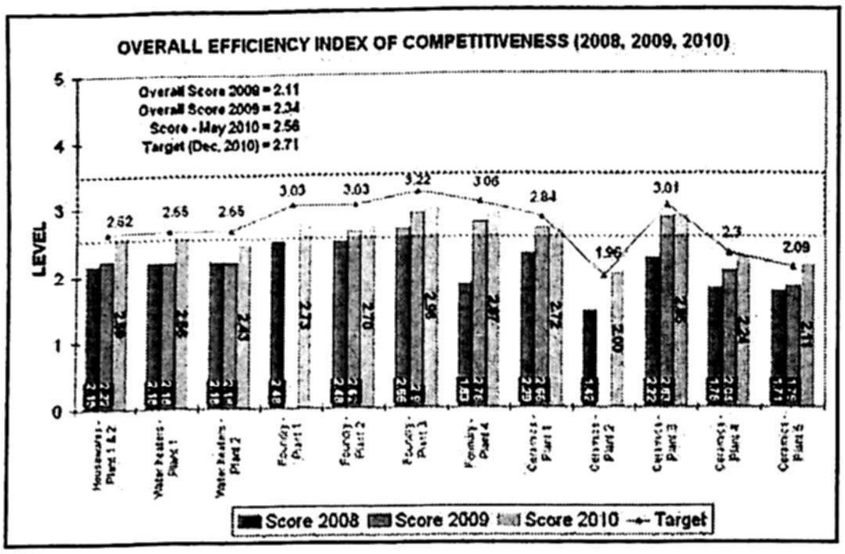
- Line graphs. To compare the behavior over time and emphasizing the changes in trends.
- Column charts. To compare the differences from one period to the next.
- Clustered Column chart. To study independently multiple data series.
- Stacked column charts. Show each data set as a percentage of the total. Allow to study how to change components of an element over time.
- Area Charts. They are a variant of the line. Keep in mind that whenever they are stacked, which facilitates the display of the totals of the series, but can be confusing for the user if the series are many peaks, there is no simple interpretation of the layers.
- Column or bar graph population pyramid. Used when there are two groups that compare. It proved to be confusing to users.
- Rings or toroidal graph, formed by concentric circles, thereby enabling the representation of various data sets. It is difficult to interpret.
- XY or scatter chart used to show the relationship between two variables. Shows the correlation positive, negative or non-existent between the two variables. Often added a line with the trend. It's sophisticated and therefore may confuse audiences unfamiliar with statistics.
- The bubble chart, as the dispersion but showing an additional data series proportional to the size of the bubble.
- The radial graph. It has a separately for each variable axis that extends from the center of the chart out. Useful for show deviations.
- Box plots. Provide complete information on how visual data is distributed. They can be very useful as a technique for exploratory data analysis.
- Chernoff Faces. It is the multidimensional representation of information by a person's face: eyes, mouth, nose, etc. mean different variables. The study characteristics are associated with different gestures in the face of a person.
- Multivariate Graphics. Multivariate techniques as factor analysis, cluster analysis, multidimensional scales and self-organized neural maps graphically summarized in a large amount of data and variables.

The proposal is based on developing a strategy that may improve the assessment of factors influencing the functional areas which may be related to the comments of stakeholders, generating a self-assessment method to recognize performance problems and causes underlying these inefficiencies.

The function of the variable base is made using a proposal of a modified triangular distributions; this would represent the categories of judgments of experts similar to the functions in figure 3.

5. Results from field data.

The development of fuzzy variables in the model will be compared with the results obtained by the self-assessments in different companies. Te graphical representations of competitiveness model, applied to 12 production plants at Northern Mexico, obtaining the following results, figure 4.



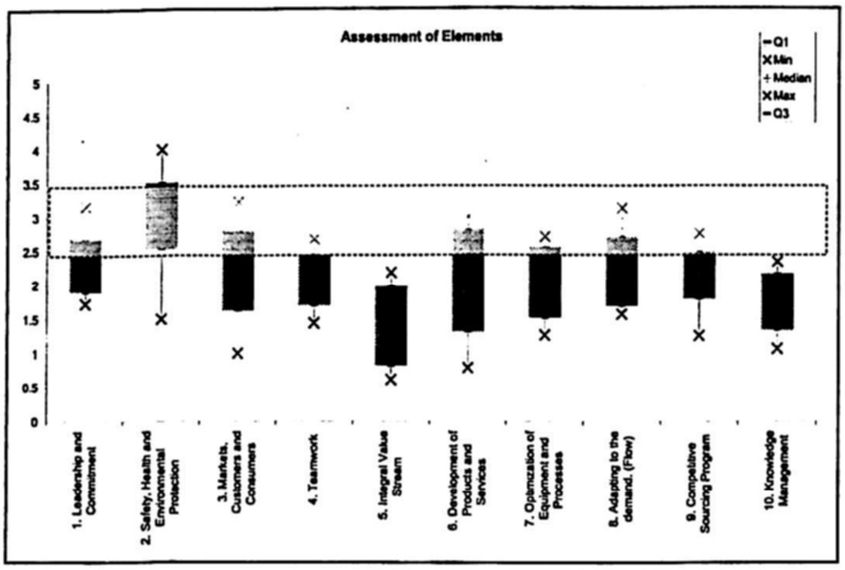


Fig. 4. Assessment of competitiveness (Selected Graph by users)

Users found that the use of the graphic above, were allowed to know the history of each assessment, the line denotes the particular objective of each plant, the interval band denotes the region in which you can identify characteristics of the element in a level balance which indicates that under conditions of at least meet its strategic objectives. At the suggestion of users, it was identified that bars use the group's consolidated performance, created confusion because the information was confused with another plant, which generates a table to add the top left corner with consolidated information.

For the results of each component, it was decided by a mix of radar graphs within a framework of graphics elements and in each corner of the figure represents one component of that element. Figure 5 presents the graphs corresponding to three elements of the Ceramic - 5th Plant.

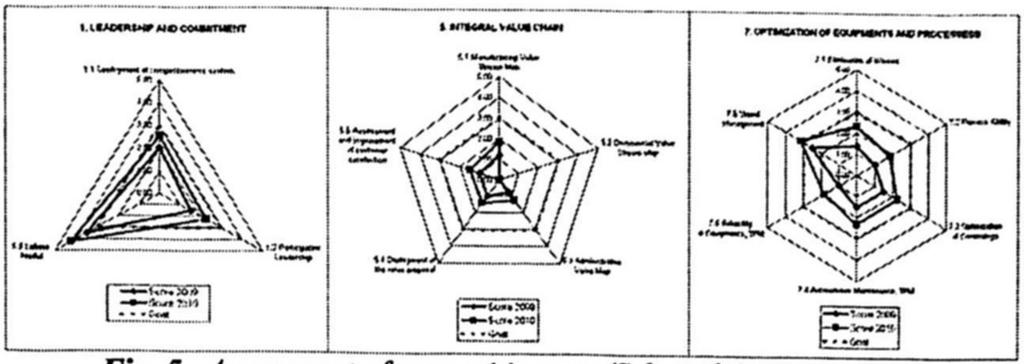
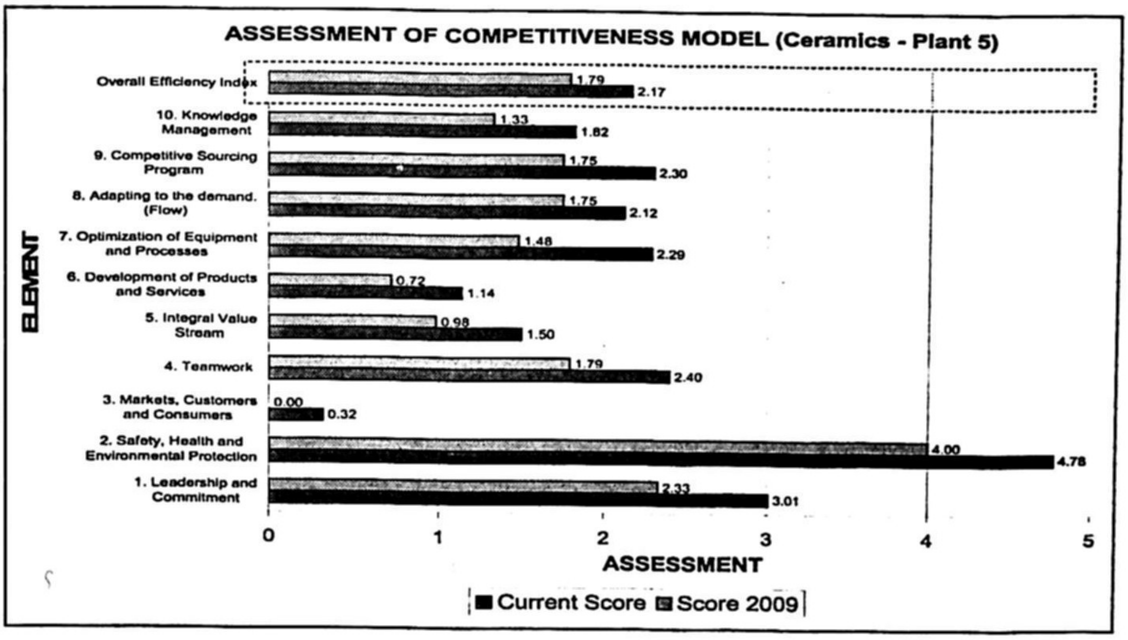


Fig. 5. *Assessment of competitiveness (Selected Graph by users)*

In the following graphs, showing the evaluation of each element in Ceramic - 5th Plant, showing the value of its overall efficiency competitiveness index.



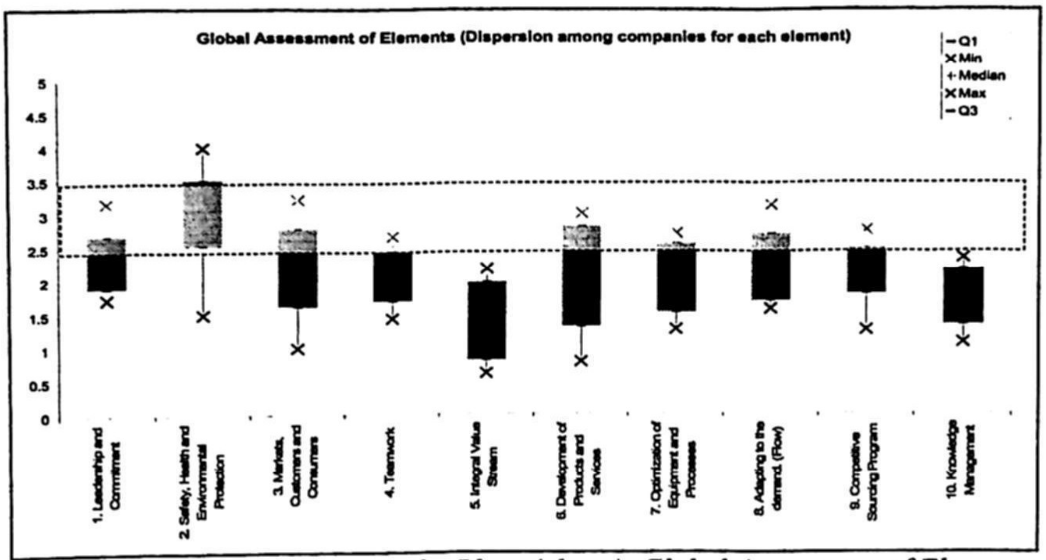


Fig. 6. Assessment of Elements by Plant (above), Global Assessment of Elements (below)

For the treatment and behavior of actions, it was decided to use cub Plots, which are used in experimental designs where each level may signify the status or level of one variable, which can be identified in a simple interaction between elements. The scheme can be followed as shown in the following figures.

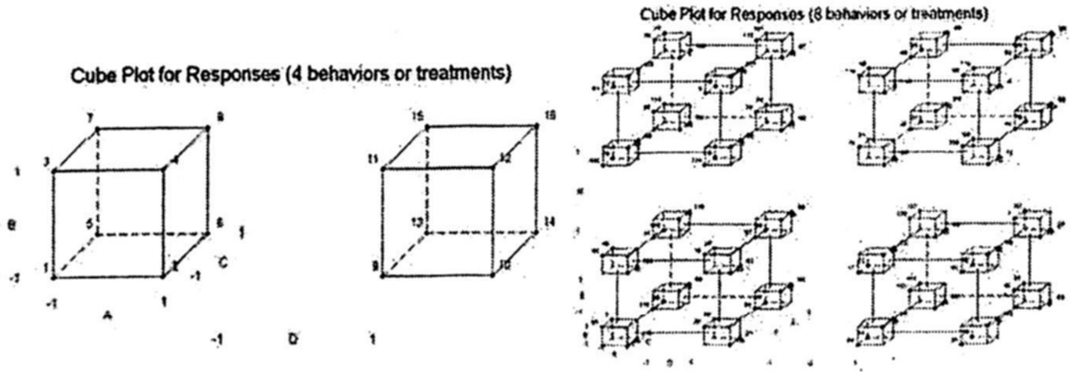


Fig. 7. Scheme of cub plots to relations between of treatments with elements and components of Competitiveness Model.

6 Conclusions and Future Researches

The study develops the selection of variables in the application of a semantic interval scale, where the measurement and evaluation processes are different levels of information on the functional areas that affect business competitiveness. The process to define fuzzy variables presented in this article is applicable to any industry and any set of variables. In that sense, there are two main areas that should be of interest to administrators with the use of graphical representations.

First, the graphical representation model can be used to demonstrate the performance and valuation the competitive elements that identify the strengths and weaknesses of companies and to define the lines of action within its strategic planning. This study provides a key focus for the selection of a group of graphics and their treatment that can replace the complexity of fuzzy graph models, giving a reasonable response rates that are used to determine the overall efficiency index of competitiveness. Generate a process of benchmarking between companies of a different nature in the objectivity and understanding of the groups of users.

Second, consciously or unconsciously it is easy to misuse of the graphics, since it must identify the level of expertise to use, so that no errors are induced in decision making. Of this depends on many models can be used consistently, especially when they differ substantially from the common processes that precede them for decision making.

The use of any univariate analysis is simple. The box plots graphically summarize the main statistical and can even become a complementary tool to support decision making. However, as all univariate analysis, is inadequate in a complex issue and therefore necessarily a multivariate analysis with ability to handle several variables simultaneously. Chernoff Parameters can help understand and display up to 10 dimensions, something beneficial with respect to a graph X, Y & Z and color that can only represent four dimensions [4]. The use of Mosaic Images [5] may be characterized more than 40 attributes, but it is important to verify that users can use these for making decisions without extensive training, which resulted in the abandonment of them. The graphics shown in this study, improved employment and use of the competitive model by 67% compared to the initial fuzzy model graphics, and other graphic. This shows the importance of the selection process of graphic representations.

In future research, the main focus of interest is the application and validation of the proposal fuzzy model, including the impact of the indicators of competitiveness in business growth and productivity, given the marginal effects of the decision variables used, considering the use of a fuzzy approach and evolution strategies for optimization and contrast with the field data.

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