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Risk Analysis of non-supply of New Products: Application of Fuzzy Logic

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Introduction

The ability of a company to identify, measure and manage the risks involved in their projects and processes is considered as an indicator of efficiency and effectiveness, by adding value and represent a competitive advantage over its competitors.

The main processes in risk management, according to the PMBOK (PMI, 2004) are: hazard identification, risk quantification, risk response development and control of risk responses. All have interfaces with each other, interact with other areas of knowledge and should be performed at each stage of a project, such as: design, feasibility, development and implementation. In addition, Conrow (2003) emphasizes that the risks identified are specific characteristics of projects or processes. Therefore, it is necessary to reassess the management model that was designed, and if necessary, make changes or adjustments in accordance with the attributes and peculiarities of the project to be studied.

In the steps of identifying and quantifying the risks, many companies use historical information from previous projects. This process is to organize and manage the data and information from the past through project files and databases, so that you can incorporate the knowledge gained in the next projects. But often refers only to the knowledge of the project team, which makes the information less reliable due to the high degree of subjectivity. This is because knowledge is extremely attached to the experience of experts and professionals, creating a very strong dependence of the interpretation made by them. In addition, there are in the business environment increasingly unmeasured risk factors, known as qualitative risks, evaluation and determination which are also made in a subjective way. Another drawback found when considering only past projects, can you face new risks, with no previous experience to be analyzed and interpreted, making the mapping and analysis.

In order to propose an alternative methodology for risk management does not supply the launch of products, greater efficiency and effectiveness submitted by the PMBOK, this study was applied to a manufacturer of cosmetics. According to the characteristics of the line of business which the company operates, the constant innovation and strategic product launches are key questions to ensure competitiveness in the face of its competitors. The importance of releases due to the fact that for most products generate the first three months of 30% to 70% of revenues in its first year of sales. However, during the development cycle of new product variability occurring in nature imprecise and not measurable, which can significantly compromise the success of its launch, caused major losses to the company as a whole.

Currently, the company has a risk analysis process simple, based on the impact and likelihood, according to the methodology PMBOK (PMI, 2004). However, the procedure for performing the identification of a potential risk is very dependent on knowledge and experience of experts of the process, especially the professionals in supply chain planning. Studying this scenario, we identified the opportunity to apply an unconventional technique for analysis of the risks involved in launching new products, enabling a better assessment of these. To identify and quantify the risks, so you can monitor and minimize the critical factors that lead to a lack of products on the consumer.

After a preliminary analysis for the choice of technique to be used, the concepts of Fuzzy Logic and Fuzzy Inference Systems were considered the best alternative to assess the problem at hand. Fuzzy logic can be applied to this situation, because, according to Zadeh (1965), it aims to provide mathematical tools for the treatment of inaccurate and subjective.

Project management

To understand the concept of project management is necessary to first understand the definition of "project". The Institute of Project Management or Project Management Institute - PMI through their PMBOK (PMI, 2004), defines project as "a temporary endeavor undertaken to create a product, service or result." The Design Guide is characterized as being temporary, it has the same life cycle pre-determined start and end with very well defined. One can consider a project completed, when all goals are met successfully, or when it becomes clear that the project objectives will not or can no longer be achieved, so the need for the project no longer exists, was then finished.

According to Dinsmore (2009), the projects usually require the establishment of a differentiated organization of the normal structure of the company. They are led by a project manager, which assesses the infrastructure resources, human and financial resources unique to the project, thus implementing a planning and control tools to ensure the goals of time, cost and quality.

Kerzner (2006) says that for project management to be successful it needs a workflow and horizontal coordination, unlike the traditional management which is vertical, thus an emphasis on communication, increased effectiveness, efficiency and productivity, with particular emphasis on the role of project manager.

New product designs

According to Dinsmore (2009), the competition for competitiveness and business segments related to the product, among others, means that companies looking for ways to gain an advantage over its competitors in the conquest of markets. In this context, companies that invest in innovation launch new products or renew existing ones, seeking to ensure their survival or gain new markets.

The methodology of project management is a great option to manage this whole process, since the launch of a new product it is nonetheless a project with limited resources and time.

The product development process has several specificities compared to other business processes. Some of the main characteristics cited by Rozenfeld et al. (2006) are:

a) High degree of uncertainty and risks of the activities and results;
b) High degree of importance of decision making;
c) Essentially multidisciplinary activity;
d) The basic activities follow an iterative cycle of detailed product and process engineering: design, build, test and optimize;
e) Handling and generating high volumes of information;
f) The information and activities comes from various sources and areas of enterprise and supply chain.

One of the well-known factors on the process of product development is that the degree of uncertainty at the beginning of this process is very high, decreasing with time, but at the very beginning that selects the highest amount of constructive solutions. Decisions between alternatives early in the development cycle are responsible for 85% of the cost of the final product. The cost of change increases over the development cycle, as each change, a greater number of decisions already taken at risk of being mistaken, and that involves financial waste of time and opportunity.

So it is a great challenge to manage the uncertainties involved in the process of product development, where decisions have the greatest impact to be taken at the time there are a number of alternatives and uncertainty.

Risk management

For the UK Association for Project Management - APM - risk is associated with an uncertain event or set of circumstances, which if it occurs, will have an effect on the success of achieving the objectives. And, according to the Guide RAMP - Risk Assessment and Management Process - risk is the possibility of an event, which may affect (positively or negatively) the achievement of the objectives of an investment.

According to the PMBOK (PMI, 2004), the categories of risks can be divided as follows:

a) Technical Risk - performance, capacity, complexity of technology, quality etc;

b) Risk of project management - involves risks facing the project management, such as: project planning, scheduling, control, communication etc;

c) Organizational Risk - concerns the allocation of resources, buildings and facilities, definition of roles and responsibilities etc;

d) External risks - risks with respect to the project team does not have full command and control, such as laws, regulations, market, customer and climate etc.

According to the PMBOK (PMI, 2004), Project Risk Management process consists of mapping, analysis and responses to project risks, always seeking to maximize opportunities and minimize the impact of negative events.

There are several techniques for risk assessment, in which we can highlight:

a) Checklist: the checklist is usually based on historical information and previous experience gained by the project team members. After we made a list of possible risks, it is recommended to convert it into a checklist which will allow the identification of future risks more quickly. However, this technique is very limited and may not cover all risks (Heldman, 2002);

b) Brainstorming: according to the PMBOK (PMI, 2004) and Heldman (2002) is the most widely used technique for identifying risks. Seeks to involve experienced people, the project team and anyone who can contribute to the process, to identify any possible risk;

c) Interviews with experts: first to identify people with previous experience in similar projects. After that you must prepare a schedule and document the questions will be asked during the interview to the expert. The advantage is that you can interview experts and experiences with different profiles and add these diverse views about the risks. However, the disadvantage is the dependence of knowledge of the interviewer, who sets the questions, and the specialist, who answers them (Heldman, 2002);

d) Delphi technique: it has characteristics similar to the technique of brainstorming and interview with the expert, but experts are identified but participate anonymously. A questionnaire is assembled and sent to the experts to identify possible risks, they respond and forward it back. Subsequently, additional comments are added and finally a final list of risks is built by the facilitator. This technique is a great tool in which allows reaching a consensus quickly, with the advantage of reducing the possible deviations of the result. As a disadvantage, as well as some techniques, there is a dependency on how the questionnaire was designed by the facilitator (Dinsmore, 2009);

e) Analysis of Strengths, Weaknesses, Oportunities and Threats (SWOT) analysis that identifies the strengths, weaknesses, opportunities and threats of the project as a whole, including project management, resources, organization, etc. The advantage is that this technique helps to broaden the perspective from where to find the risks, but should be considered as an ancillary technique according to the PMBOK (PMI, 2004);

f) Technical diagrams: include techniques Ishikawa diagram, process flow chart and influence diagram. In general, these techniques help identify the causes of hazards, the inter-relationship and influence between them, cites the PMBOK (PMI, 2004).

Miller and Lessard (2001 apud BUYUKOZKAN And FEYZIOGLU, 2002) identify three main categories of risks in engineering projects:

a) "Completion risks": group of technical risks, construction and operation;

b) "Market related risks": corresponds to the risk of demand, financial and Supply Chain;

c) "Institutional risks": understands the risks of social acceptance.

As can be seen, uncertain factors are highly dependent on how the theme is focused and investigated. However, we can briefly say that all types of uncertainty can be divided into two categories: external and internal. In considering the decision points in the process of developing new products as a whole, should minimize the effects and the uncertainties described above and increase the effectiveness of decisions. For this reason, various methods have been developed to overcome the uncertainty of the problems. These methods, according Davilla (2000) and Infanger (1994 apud BUYUKOZKAN and FEYZIOGLU, 2002); Trittle et al., 2000 are:

a) Probabilistic models (Monte Carlo);

b) Scoring models and checklists;

c) Fuzzy logic;

d) Sensitivity analysis;

e) Analysis of scenario.

Supply chain

Supply chain can be defined as the concept of integrating the company with all firms in the supply chain: suppliers, customers and third party providers of logistics plans and share information needed to make the channel more efficient and competitive. The share is deepest, accurate and comprehensive than the traditional relationship and conflicting buyer/seller (SCM Council, 1990).

The supply chain can have direct effect on the ability of a corporation run their businesses, provide finished products to the market or provide services to clients. Modern supply chains are very complex, with different materials and information flows parallel to ensure that the products will be delivered in the right quantity, within negotiated and the lowest cost. Over the years, some authors suggest that the tendency to develop supply chains more efficient at the same time make them more vulnerable to "break". In addition, the supply chain is characterized by being dynamic and involves a high degree of uncertainty, mainly due to characteristics of the markets in which firms are present, where the uncertainties of activities extend from suppliers to consumers, thus making the supply inaccurate chain as a whole.

The current scenario is characterized by turbulence and uncertainty, and these characteristics tend to increase due to factors such as: the volatility of demand is at its highest in nearly all lines of business, the life cycles of products and technology have significantly decreased and the importance of ensuring competitiveness by launching new products further complicates the prediction of demand. According to Christopher et al. (2002), supply chain management in the competitive environment it is extremely challenging.

One of the main challenges encountered in launching new products is linked to the difficulty of predicting demand even when it is introduced. For demand to be extremely unstable, and when dealing with risk in the supply chain, its uncertainty is a major risk factor because it has high probability and high impact throughout the chain.

You can see that there are many variables, both measurable and non-measurable, that are present in the process of developing new products that may impair the release of a product, for example, qualifications and location of suppliers, sales volume estimated, manufacturing strategy, etc. With pressure from companies to adjust and dynamic adaptation of the supply chain according to the market situation, and product life cycles getting shorter, faced with a difficult problem. Therefore it is necessary to be wary of strategies that will be defined.

Due to the complexity of managing it becomes increasingly important to develop new methods that can assist in case management in order to eliminate, minimize or at least predict the occurrence of undesirable factors. Therefore, fuzzy systems can be an alternative method to deal with the uncertainties of supply chain processes and developing new products.

Fuzzy model

"When the complexity increases, precise statements lose meaning and meaningful lose precision" (Zadeh, 1965).

According Tanscheit (2007), humans have the ability to handle very complex processes, based on inaccurate information, uncertain or approximate. In the industrial environment, for example, often the strategies adopted by human operators are likely inaccurate, and generally able to be expressed in linguistic variables. Within this context, the fuzzy sets theory was conceived by Zadeh in 1965, with the book Fuzzy Sets - Information and Control, in order to provide mathematical tools for processing information of vagueness or vague. Thus, the theory can be used to translate in mathematical terms the inaccurate information expressed by a set of linguistic rules. In practice, this means that in a given case, a human operator is able to translate their strategies and decision-making in a set of rules of the form "if ... then", you can implement such information through algorithms in a computer. The result is a system based on rules of inference, in which the fuzzy sets theory and fuzzy logic provides mathematical tools to interpret such linguistic rules.

Hime et al. (2007), argue that the logic is the science that aims to study the laws of reasoning. Fuzzy logic aims to study the formal principles of approximate reasoning. That is, the great advantage of the fuzzy model is the ability to model and manipulate mathematically vague and imprecise information, the natural human language and, therefore, provided by specialists (not mathematical) to analyze the processes in which they have the knowledge. Therefore, the techniques of fuzzy set theory has been applied in several areas, one of the main techniques is to Fuzzy control, which enables you to automate tasks from domestic (consumer goods) to sophisticated industrial processes. The first applications were successful in the control area, based on the work of Zadeh (1965). At the time the application was directed to control steam engines, which enabled the mathematical modeling of the decisions of the operators (experts) on the machines, automating tasks, in order to "mimic" the human ability to make rational decisions in an environment of uncertainty and imprecision. Today, one can find applications of fuzzy logic in various processes, and consumer products such as washing machines, televisions, video cameras. In the automotive industry: air conditioning, ABS brakes and electronic fuel injection. Furthermore, Fuzzy logic is also present in various industries, robotics, games of uncertainty, support systems for decision-making, medicine, financial market, control systems and industrial processes etc.

Subsequently, the range of applications has grown considerably, especially when the fuzzy inference systems have also become capable of dealing with the objective knowledge - expressed in numeric data, for example. An important step was the evolution of the concept of Computational Intelligence which comprises several areas of knowledge, in particular Fuzzy logic, artificial neural networks and various hybrid systems. At the beginning, like all revolutionary design, Computational Intelligence (in particular, Fuzzy logic) has faced resistance from more conservative scholars. However, the global industry figures show the effectiveness and efficiency of "intelligent" products, yet it is noteworthy that the set of techniques and models mentioned above is not the solution to all problems, nor is it did not detract from any areas considered as sedimented. It is simply a powerful tool that, combined with results from other areas (such as Operations Research, for example), we obtain workable solutions to intractable problems through conventional techniques. As for software to assist in the design and implementation of Fuzzy logic is the Fuzzy Toolbox of Matlab, and others like NEFCON the NEFCLASS and NEFPROX.

Fuzzy sets: fundamentals

According to Tsoukalas (2003) the mathematical foundation of Fuzzy logic is based on fuzzy set theory, which can be interpreted as the generalization of the classical theory of sets, which are ambivalent and defined as a collection of distinct elements (numbers, symbols, objects, etc.). The fact is that the elements of a set or belong to (1) or do not belong (0) to a set A, cannot take intermediate values {0,1}. That is, the classical theory of sets there is a restriction related to relevance. Below is the function that characterizes this situation:

$$\mu_A(x) = \begin{cases} 1 \; se \; x \in A \\ 0 \; se \; x \notin A \end{cases}$$

In 1965, Zadeh introduced fuzzy sets, which proposed a broader characterization, generalizing the characteristic function. Fuzzy sets in various degrees of relevance are allowed, i.e., the degree of membership of a set is indicated by a number between 0 and 1 (interval [0, 1]). Expanding the set value will change the nature of the characteristic function, now called the membership function μ_A, and determined by, in addition, due to the interval [0, 1] contain an infinite number; infinite degrees of membership are possible. The function below characterizes the fuzzy sets:

$$\mu_{\mathbf{A}} : U \rightarrow [0,1]$$

Hime et al. (2007) further complement to say that a fuzzy set A is characterized by the pair (x, μ_A (x)), where x is a variable, continuous or discrete, in a study of the universe, and is an μ_A function whose image is contained in [0,1].

Linguistic variables

According to Tsoukalas (2003), the linguistic variable is the variable in which the arguments are fuzzy numbers and words usually represented by fuzzy sets. Tanscheit (2007) goes on to say that the linguistic variable is a variable whose values are names of fuzzy sets. For example, the temperature of a given process can be a linguistic variable taking values low, medium and high. In general, the values of a linguistic variable can be expressed in different language-specific, built from:

a) Primary Terms: high, low, small, medium, large, zero, are some examples;

b) Logical connectives: negation (not) and connective (and/or);

c) Modifiers: very, somewhat, slightly, extremely;

d) Delimiters, such as parentheses.

These values are described by fuzzy sets represented by membership functions, so any temperature value has a single degree of membership for each fuzzy value of temperature (low, medium or high), as shown in figure 1:

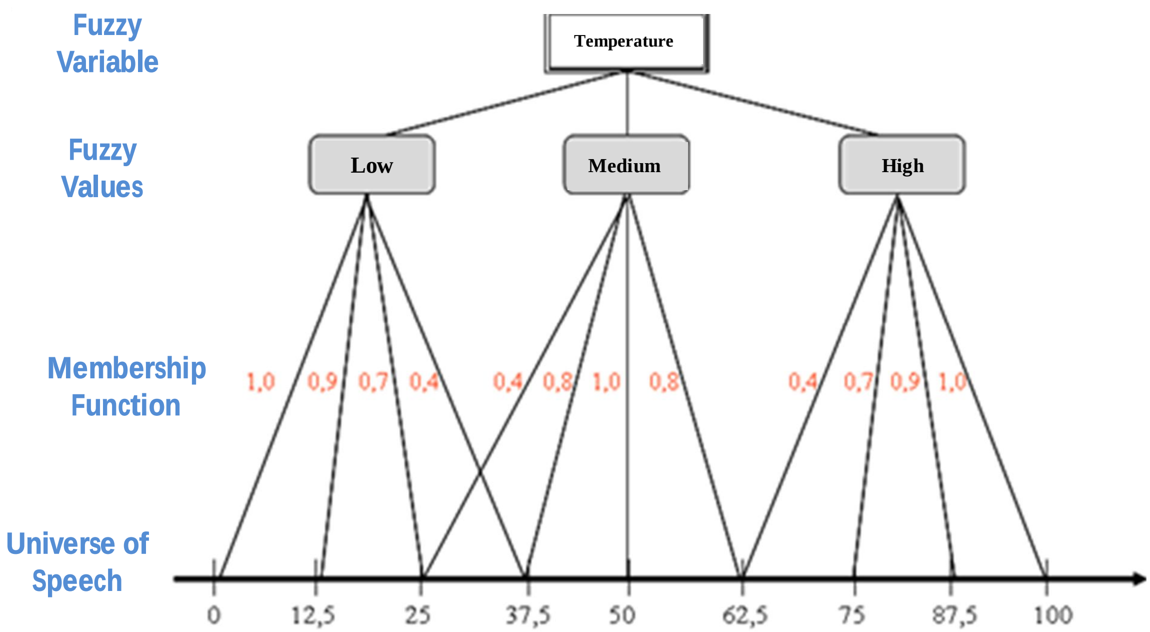

Figure 1 – A variable set of linguistic values and fuzzy
Source: Authors' adapted from Tsoukalas, 2003.

Tsoukalas (2003) highlights the existence of four different levels in the definition of a linguistic variable, as shown in Figure 1. The first level contains the variable name (e.g. temperature), below the level that you have the labels of fuzzy values (low, medium and high), and the third level refers to the membership functions and, finally, the universe of speech. All four levels are essential in the definition of a variable. It is important to note that linguistic variables have "dual nature", i.e. the two highest levels have symbolic language, since the two levels below the quantitative data are characterized by well defined. This double identity is a key feature of fuzzy language. Tanscheit (2007) complements to say that the main function of linguistic variables is to provide a more structured methodology to treat complete or ill-defined phenomena. Using the kind of description language used by humans, not only quantified variables, allows the treatment of complex systems by means of conventional mathematical terms.

Membership functions

Tanscheit and Hime et al. (2007), highlights an issue often raised by those who are starting the study on fuzzy sets and membership functions as are set. The step of defining the membership function is one of the most complexes to apply fuzzy logic, because the functions may take different forms, depending on the concept to be shown and the context in which they are used. Different people may have different notions about a linguistic variable, in addition, the environment in which people are inserted can also modify the shape and characteristics of the membership function.

Tanscheit (2007) also points out that the membership functions can be defined from the experience and the user's perspective, but usually it is common to use the membership functions defined in the standard, triangular, trapezoidal and Gaussian.

The triangular membership functions are characterized by a tender (a, b, c) where a and c determine the interval in which the function has nonzero values, and b is the point where the membership function is maximum - see Figure 2.

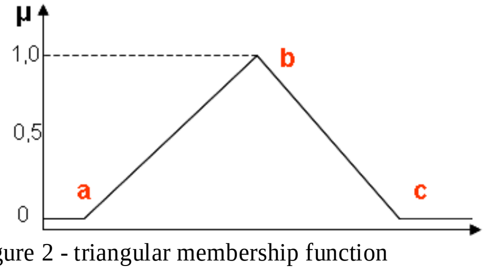

Figure 2 - triangular membership function

Source: Authors' adapted from Machado, 2007.

The Gaussian membership functions are characterized by their mean (μ) and standard deviation (σ). This type of membership function has a smooth variation and has nonzero values for the entire domain of the variable studied. By using this function must be defined to mean and standard deviation of the curve - see Figure 3.

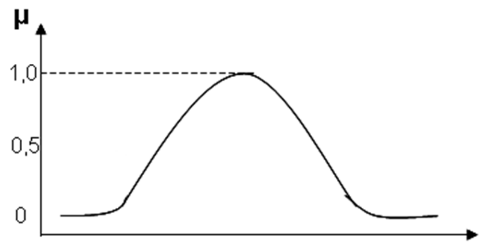

Figure 3 - Gaussian membership function
Source: Authors' adapted from Machado, 2007.

The trapezoidal membership functions are characterized by a set of four values of a, b, c and d, a and d determine the range within which the membership function takes nonzero values, a b and c determine the interval in which the membership function takes the value equal to one - see Figure 4.

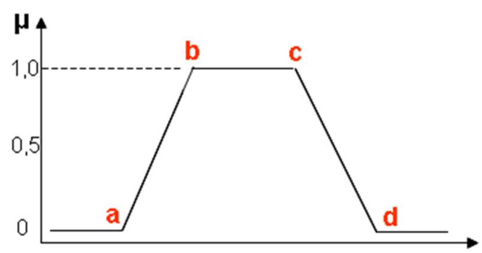

Figure 4 - trapezoidal membership function
Source: Authors' adapted from Machado, 2007.

Base Rules

Tsoukalas (2003) and Zadeh (1965), argue that fuzzy descriptive language (often called Fuzzy systems) are formal representations of a system made by fuzzy rules "if ... then". This type of rule provides an alternative, and often, language supplement to conventional methods (analytical) for modeling systems. The informal descriptive language used by humans in their day-to-day, as well as the performance of their decisions, through their skills and knowledge are usually the starting point for the development of fuzzy descriptive language. Although this language is formulated based on human language, it has a rigorous mathematical foundation, involving fuzzy sets and relations between them.

Tsoukalas (2003) states that the step of defining the rules is crucial in the performance of a fuzzy inference system. Experts of the process being studied can provide the rules in linguistic form of sentences, for example, a fuzzy controller will only perform well if the rules were defined for the system are consistent. However, to extract rules from experts in the form of sentences like "if ... then" cannot be an easy task, because despite having the knowledge, their decisions are at a level "unconscious," making it impossible for them to translate their strategies structured. Thus, an alternative way to get the definition of rules, and methods of rule extraction of numerical data. These methods are particularly useful when dealing with problems of classification and time series forecasting.

Every rule has an antecedent and a consequent. For a rule of classical logic, an example would be: "If the sky is blue (antecedent), then it will not rain" (consequent).

As for a fuzzy rule, we can proceed as follows: "If the sky is slightly overcast (antecedent), then it can rain a little" (consequent).

Note that in the first instance, or is not raining, which makes the statement true or false (similarly, zero or one, true or false ...). The second example, it is fuzzy assertions; there is some degree of uncertainty so the statement can take degrees of truth (a little cloudy, raining little consequence, cloudy, raining result so far).

Inference Systems

Hime et al. (2007) point out that the basic idea is to model the fuzzy control actions based on expert knowledge, rather than necessarily the modeling process itself. This leads to an approach different from conventional methods of process control, where they are developed through mathematical modeling of processes in order to derive the control actions as a function of the process status. The motivation for this new approach came from cases where the expert knowledge of control was available, either by operators or designers, and the mathematical models involved were too expensive or too complicated to be developed. The fuzzy inference system is shown in Figure 5, where the functions are identified for each block.

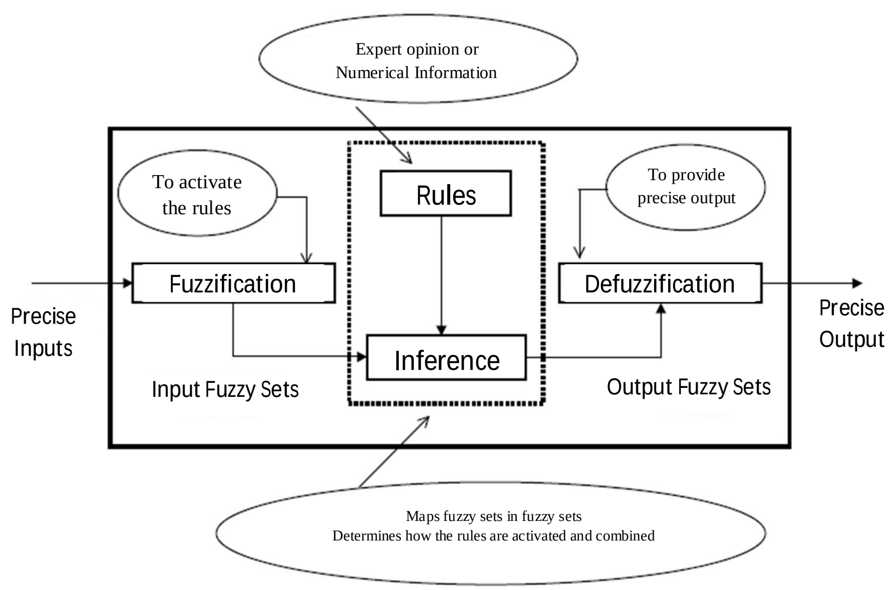

Figure 5 - Inference System

Source: Tanscheit, 2007.

Tanscheit (2007) explains that this fuzzy inference system inputs are considered to be fuzzy or precise - resulting from measurements or observations (data set, for example). In the fuzzification stage is necessary to make an accurate mapping of these data for the preparation of fuzzy sets (input), moreover, must be activated with the relevant rules for each situation.

In general, fuzzy systems are used for inference based on rules like "if ... then" and have the following phases:

a) Fuzzification of the definition of inputs and outputs;

b) Development of fuzzy rules;

c) Calculation of connective whose antecedents may be, for example, "and" or "or";

d) Calculation of the implications of each of the operators whose rules can be, for example, "minimum" or "product";

e) Aggregation of consequent whose operators may be, for example, "maximum" or "limited amount";

f) Output defuzzification.

Data Collection

This study area was a company that for reasons of compliance and internal rules did not allow his name to be disclosed, so we used the fictitious name of COSMETIC S/A.

The case study of the work in question was conducted in a business unit of a company of cosmetics and personal hygiene U.S. publicly traded, founded over 100 years, based in New York (USA) and in Brazil for more than 50 years. The company has 42,000 employees and is currently present in 145 countries worldwide, on every continent, and the main markets are: USA, Brazil, Poland and Japan Global has 5.4 million dealerships and 1.2 million dealerships only in Brazil.

In Brazil, the company has plants in Ceara, Bahia and Sao Paulo, where it has two distribution centers, one of which is currently the largest distribution center company in the world, and a factory in which it is allocated to the administrative of Brazil. Moreover, it has opened an office three years ago, where employees are responsible for allocated (Latin America), which is focused primarily for planning and monitoring the launch of new products in countries like Chile, Argentina, Bolivia, Mexico, Colombia and especially Brazil.

In Latin America, the company launched around 600 products per year, from the simple exchange of a package until the release of major innovations. In Brazil, the products it sells roughly 20 million Brazilians who buy new products every 19 days. The huge sales force is represented by more than 1 million independent dealers that give the company a gross revenue of R $ 4 billion, making Brazil one of the main markets affected by the company, being one of the priorities of senior management for investment .

The cosmetics industry is a sector of the economy has been growing in recent years, mainly in Latin America. We can observe this growth with the following data in Latin America: 15.3% market share worldwide in 2010 with a value of about USD $ 54 billion, of which Brazil had 52.9% participation, Mexico 14%, Venezuela 10%, Colombia 6%, 5% in Argentina, Chile and Peru from 3% each, and Ecuador and the Dominican Republic about 1% each. The sector's revenues in Brazil in 2010 was USD $ 16.8 billion (source: CASIC - Chamber of Cosmetics Industry in Latin America).

Since the arrival of COSMETIC S/A to Brazil for 45 years, the direct sale of cosmetics has evolved over the years, being increased by the actions of several companies, both national and multinational companies, who have been exploiting their full potential, positioning Brazil among the ten largest and best markets for direct sales in the world, recording an average growth of around 15% per year.

Data collection was conducted in the area of Supply Chain Planning (Latin America) COSMETIC S/A, by means of two questionnaires consisting of closed questions, which consists of questions in which the interviewee has limited options for answers regarding the research topic applied during the month of April 2011.

The first questionnaire was aimed at obtaining the expert opinion of the process on the probability of occurrence of the levels of each variable. The second, aimed to collect, according to the combination of variables, the risk (high, medium or high) that experts judged as the result of each situation presented.

The questionnaires were answered by five people in the area, a senior analyst, two supervisors and two managers. On average, candidates who answered the questionnaire, have seven years' experience in the supply chain.

Researchers are constantly faced with the need to "quantify the qualitative data" found in nominal variables. Correspondence analysis differs from other forms of interdependence in their ability to accommodate both non-parametric data as nonlinear relationships.

Therefore, to evaluate the homogeneity of the responses of five experts consulted, we used correspondence analysis as a multivariate non-parametric technique using the software SPAD 3.5. According to Hair et al. (2005), correspondence analysis is a recently developed technique of interdependence, which facilitates both the dimensional reduction of the classification of objects (products, people, etc.). In a set of attributes such as perceptual mapping of objects related to these attributes.

As a second step, the toolbox of Matlab ® Fuzzy R2010a was selected to perform the processing. The first questionnaire responses (probability of levels of each variable) were necessary to demonstrate the dependence of the analysis of experts and lack of homogeneity of their opinions. Since the results of the second questionnaire (risk) according to the combinations in the opinion of experts served as a reference to introduce the inference rules of the system in Matlab ®.

Analysis of results

After receiving the answers to the questionnaires sent by the experts, the data were consolidated into an Excel spreadsheet for analysis. Through the program SPAD 3.5 outputs were obtained from Figures 6 and 7, where it is suggested to divide the responses of experts in three different clusters. This classification is done based on certain values of interval scales that some of the research variables and assume that confer certain similarity between close individuals, discriminating them and joining them in a cluster or class.

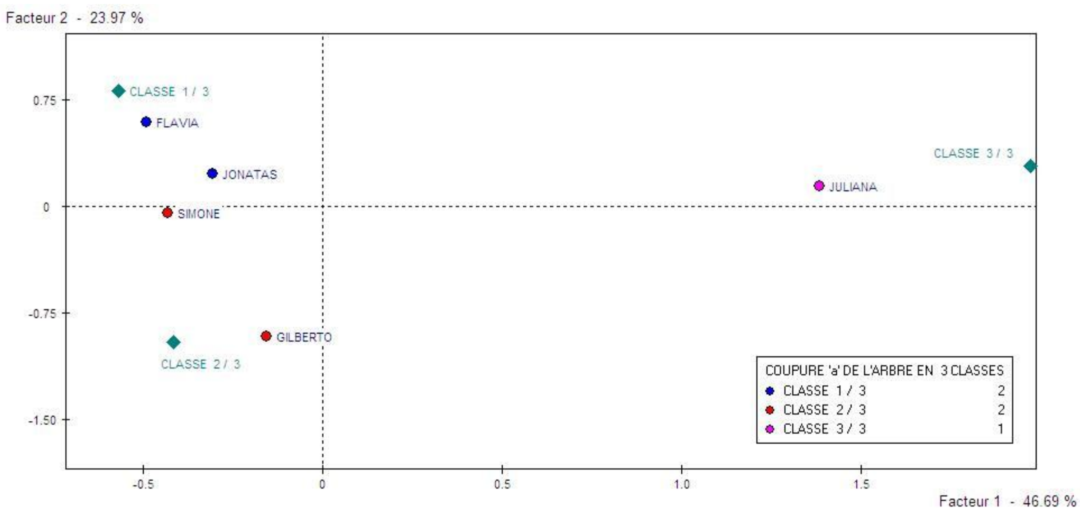

Figure 6 - Multivariate analysis of correspondence (questionnaire 1)
Source: Authors ("printscreen" SPAD 3.5).

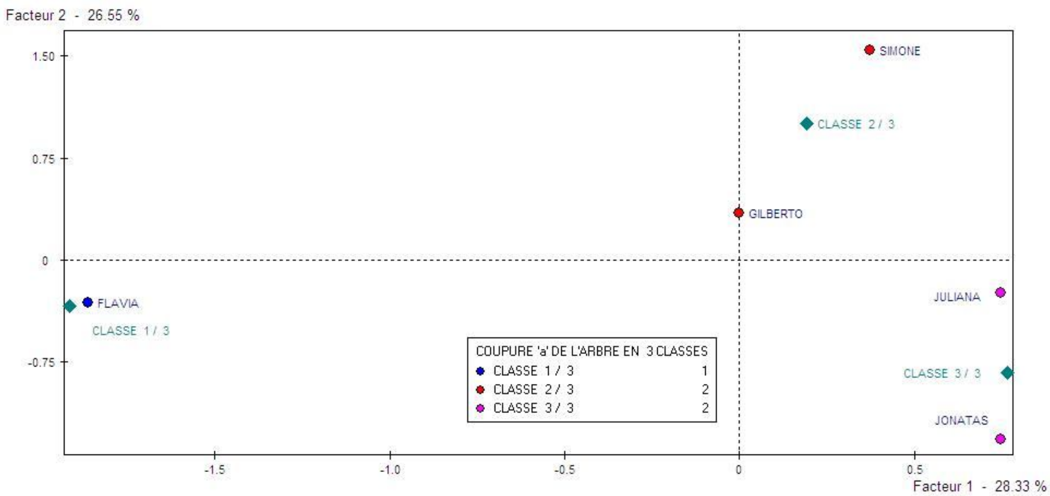

Figure 7 - Multivariate analysis of correspondence (questionnaire 2)
Source: Authors ("printscreen" SPAD 3.5).

With the results of the correlation shown in Figures 6 and 7, one can observe that the opinions of employees COSMETIC S/A are well dispersed, which shows the differences of opinion among experts, which justifies the use of logic Fuzzy in this scenario. From the study of graphical output and the consolidation of answers to the questionnaires it was possible to identify classes of answers to the inclusion of rules in Matlab ®.

Input and output variables

According to the methodology of fuzzy logic, the first step is the fuzzification, i.e., defines the input and output variables of the fuzzy system and their respective levels and membership functions. To conduct the case study was necessary to restrict the number of input variables that may affect the release of a product. Therefore, based on analysis of existing literature on the subject, reports and presentations in the area of supply chain and the characteristics of the business COSMETIC S/A, defined three input variables and their levels. Since the output variable is the risk of failing in your product launch (shortage). That is, the risk of failing to meet the amount requested in the application of the first dealership sales campaign.

Input Variable: Incentive Marketing (Table 1)

A COSMETIC S/A uses the direct sales channel, i.e., have a million dealerships across the country, responsible for liaison between the company and end customers. The sales tools used by dealers are: the printed booklet, the booklet and digital samples.

The brochures are small magazines, in A5 format (210mm x 148mm) with 185 printed pages which are the products of cosmetics and toiletries COSMETIC S/A. It is divided into segments of products, and product placement, layout and design are first designed by a company's marketing sector. In addition, there are positions that are in the brochure and highlight exposure, which typically are stamped innovative product launches. These positions are: cover, back cover and "center." Therefore, the printed products in these positions are characterized by high investment marketing, often with the presence of highly successful public figures (actors and singers) to advertise the product, both in the printed brochure as in digital media.

There are also promotional products that often adorn regular pages of the brochure, but they call attention due to the fact that a "kit" of products for special dates (Valentines, Mother's Day and Christmas) and short time of presence in the brochures. This release contains type of incentive marketing medium; it attracts the attention of customers for innovation to be a "kit" containing 2-5 products comes with a decorative box, ready to give away. But that mostly does not require investments in digital media with advertisements or disclosure.

As low incentive marketing product launches are regular (new core) of the various product categories, and also releases the exchange of a product line, in which the design or packaging, for example, were modified. Are characterized by low or medium attraction of retailers and consumers.

Variable	Level	Description
1. Incentive Marketing	High	Major exhibition in the sales brochure: cover or back cover
	Medium	Promotional Product
	Low	Portfolio regular product or line exchange

Table 1 - Levels of the input variable (Incentive Marketing)

Source: Authors.

Input Variable: Change in demand forecast (Table 2)

A major difficulty of the industries of consumer goods is effectively able to predict the demand for a product to be launched in the market. In COSMETIC S/A is no different for the next year the company aims to improve the demand forecast in order to: increase the level of service while reducing inventory levels. The lack of product in the release is considered more critical by the company as it will directly affect one of the most important indicators: "order fill rate" (the indicator that measures the level of service the company). Too much inventory of finished product, it is not desirable, but is not as critical as the first situation, because a company can opt for a strategy of consuming excess inventory throughout the life cycle of the product.

In COSMETIC S/A are made several versions of the sales forecast. However, the main predictions are:

a) Demand Forecasting in the early phase of "implementation" (one year before the launch) - this version of the forecast amount of sale is the basis for planning and negotiating with suppliers, held by the areas of sourcing, supply chain planning and planning materials;

b) Demand Forecasting at the end of phase "implementation" (six months before release) - this time the production orders and purchases should already be loaded into the system. This version of the sales forecast is prior to brochure printing, i.e. it is the final date for changes or deletion of the product in the sales brochure, besides being an important landmark of attention, if necessary to make decisions or strategies, such as: additional orders load the operating system.

Thus, to determine the levels of this variable was based only on the increase in quantity of sales forecasts of these versions: one year before the launch and six months before release, as illustrated in Figure 9. It is noteworthy that up to 40%, however it seems to be a considerable difference was determined to be low. That's because the company currently has been working with what he calls the "upside potential" in which adds 40% of the total amount of the planned sale (1 year before the launch), considering the planning and negotiation, the possible increase in demand through 40%.

Variable	Level	Description
2. Changes in demand forecasting	High	Increase in demand forecast > 60%
	Medium	Increase in demand forecast between 40% and 60%
	Low	Increase in demand forecast < 40%

Table 2 - Levels of the input variable (Changes in demand forecasting)
Source: Authors.

Input Variable: Capacity constraints of the mold (Table 3)

The vast majority of products COSMETICS S/A has a plastic casing, characterized as the main component of the products. The production of packaging is outsourced to companies working with plastic injection machine, and the mold is owned by the company. Thus, only the filling and packaging processes are carried out in the company's factory.

The molds required are extremely expensive, with investments that are around R $ 250.000,00 to R $ 1,500,000.00 and take months to be manufactured. Therefore, in order to lower product cost, profit optimization and return on investment, the company uses the strategy of sharing the mold. That is, some products share certain mold: they have the same shape of the packaging, but with different art. As an example, the case of packaging has "global templates", used for products with high added value, in which the molds produce the quantities of packaging according to global sales of the product.

In developing a new product, one of the main attributes for the decision of the development and purchase of a new mold is production capacity. Based on sales volumes, if certain mold to be used is idle capacity, will most likely not a critical situation. But if it is overloaded is necessary to conduct a study to purchasing a new mold, the restriction of capacity an important variable. If the strategy is to use a mold that is available with low capacity and there is an increase of sales forecast just months before the launch, the production of primary packaging component may not meet the new quantity desired, and can compromise the product's launch.

Variable	Level	Description
3. Restriction of template capacity	High	Capacity occupied the main component of the mold > 90%
	Medium	Capacity occupied the main component of the mold between 70% and 90%
	Low	Capacity occupied the main component of the mold < 70%

Table 3 - Levels of the input variable (Restriction of template capacity)

Source: Authors.

Variable Output: Risk of non-supply of the product at launch (Table 4)

A major concern of manufacturers of consumer goods is to lose a sale by not having the product at the time of purchase, or cannot meet the quantity of the items requested in the application. A COSMETIC S/A to be a company that works with direct selling receives requests from retailers, processes the request and is responsible for delivering products of the house dealer. Thus, a dealer who makes a claim that the product will be released next sales campaign; you will only notice the lack of the product while being the delivery of your order.

The level of service in COSMETIC S/A is measured by the indicators "order fill rate" and "fill rate piece." These indicators are global and controlled weekly, are extremely important for the company, being one of the multipliers in the formula for profit sharing for employees. Therefore the company seeks ways to foresee situations that may compromise the launch of a product in order to have enough time to make decisions that can reduce the impact of these indicators.

Based on this scenario was defined as the output variable risk of failing product launch (shortage) and the levels are indirectly linked with the probability of failing to meet the request of retailers. Therefore, low risk is characterized by low or zero probability of missing product at launch. Average risk represents the average probability (between 20% and 50%) of failing to meet the desired amount of product. And the high risk would be the most critical situation in which the probability of missing the product is high (greater than 50%).

Variable	Level	Description
Shortage	High	Risk > 70% - high probability (> 50%) of failing to meet the request of the dealer
	Medium	40% < Risk < 70% - medium probability (between 20% and 50%) of failing to meet the request of the dealer
	Low	Risk < 40% - low probability (< 20%) of failing to meet the request of the dealer

Table 4 - Levels of the output variable (risk of non-supply)

Source: Authors.

Relevance of Functions

The choice of the proper format of the membership function is not an obvious step, which may be beyond the expert's knowledge. Fuzzy systems in the simplest choice of triangular and trapezoidal functions is more common because the idea of defining regions of relevance total, average, and none is more intuitive than the specification of the modal value and dispersion, concepts related to Gaussian functions.

Considering the context of the company and according to the characteristics of the variable for the input variable: marketing incentives were established three membership functions with triangular (trimf). Since, for each level, only one point represents the maximum value of the function (equal to 1), as shown in Figure 8. For the other input variables and output variable defined three membership functions with trapezoidal (trapmf). Since, for each level there is an interval in which the function takes nonzero values and the other determines the range within which the membership function is maximum and equal to 1, as Figures 8, 9, 10 and 11.

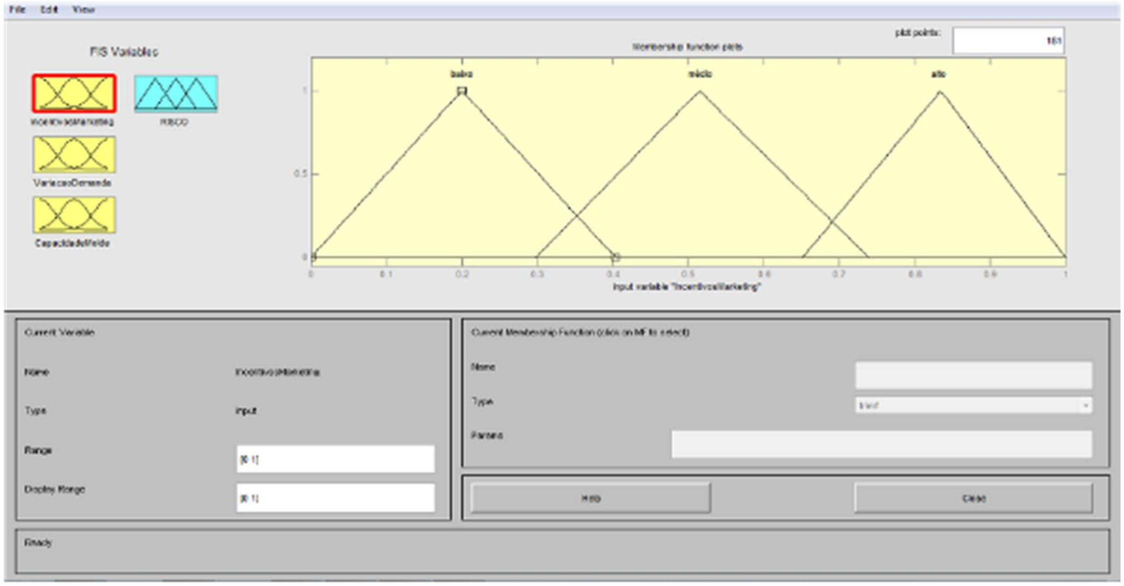

Figure 8 - Function of relevance - Incentive Marketing

Source: Authors ("printscreen" Matlab ®).

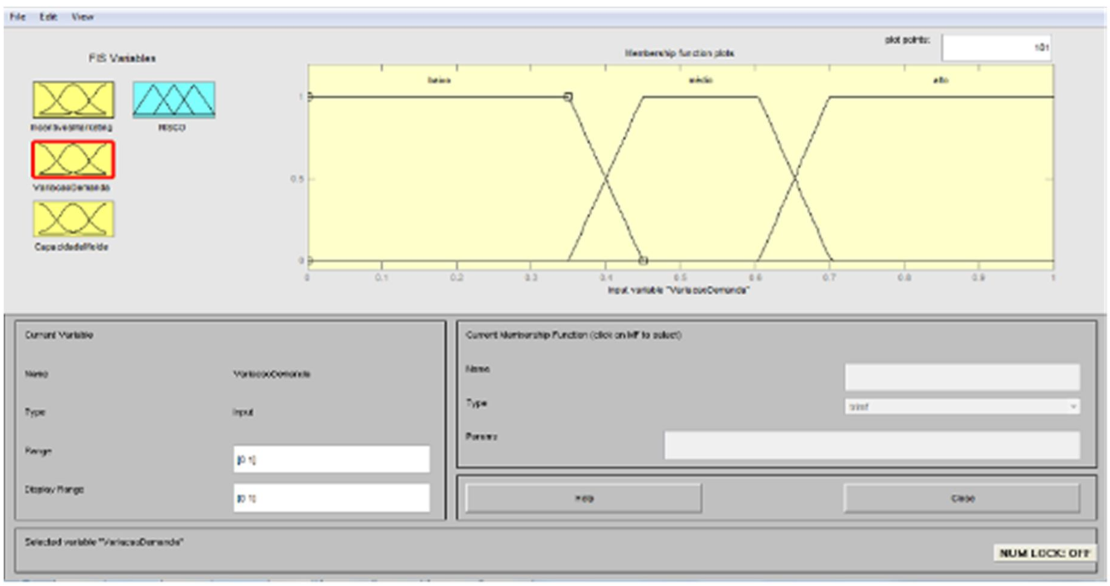

Figure 9 - Function of relevance - Change in Demand Forecasting

Source: Authors ("printscreen" Matlab ®).

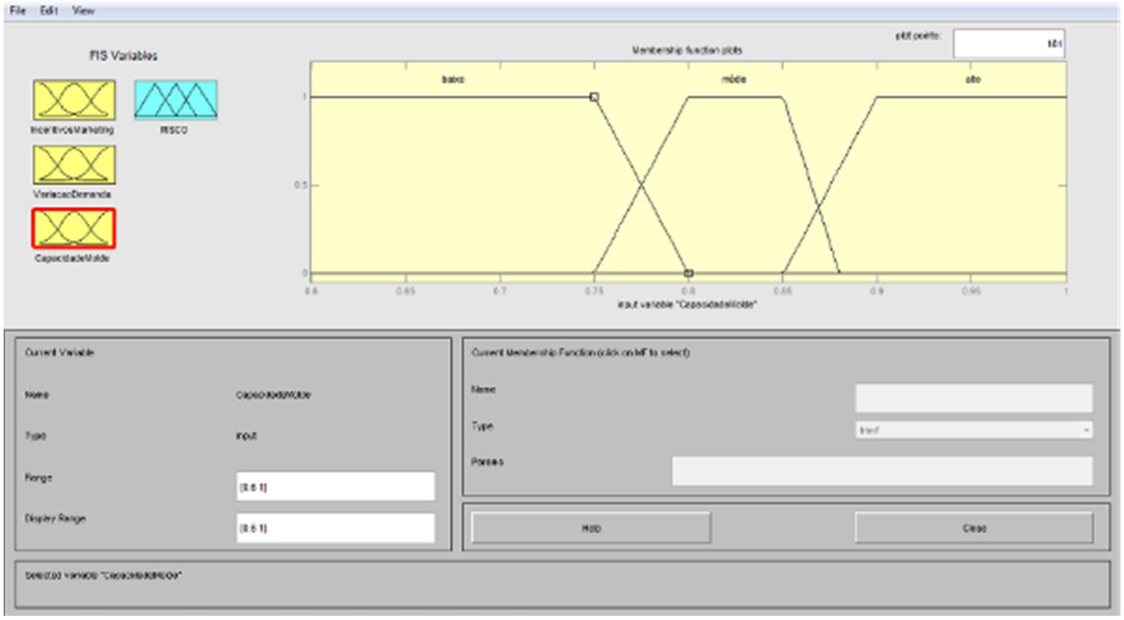

Figure 10 - Function of relevance - Mold Capacity Constraint

Source: Authors ("printscreen" Matlab ®).

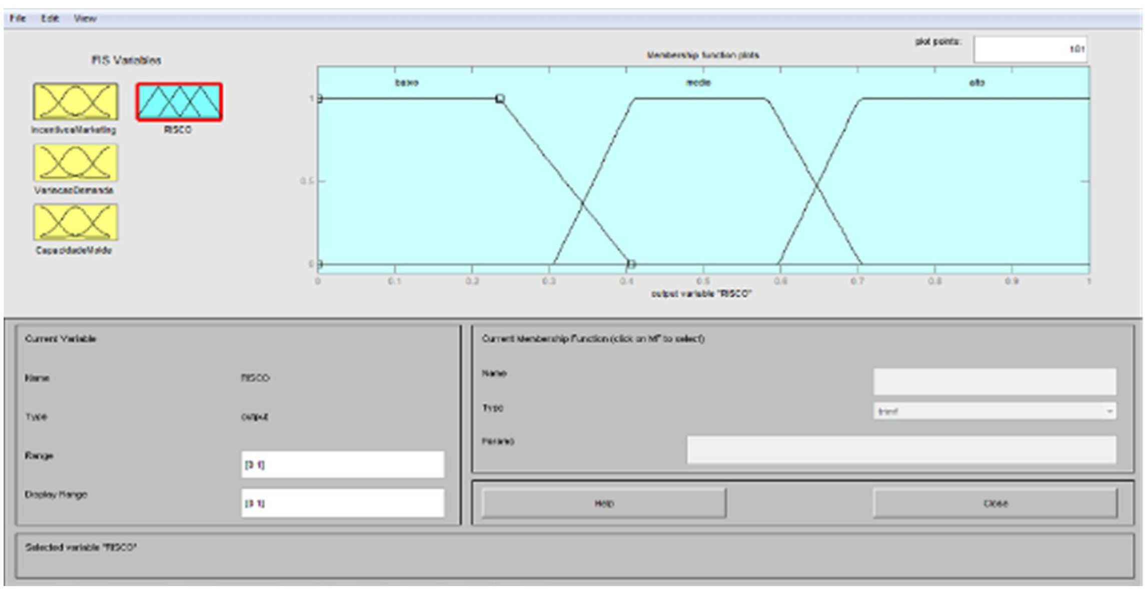

Figure 11 - Function of relevance - Risk of non-supply

Source: Authors ("printscreen" Matlab ®).

Rule base

According to the survey responses were used 2 connectives "AND" and 27 were defined inference rules for the fuzzy system in question, shown below are some of the fuzzy rules:

a) If Incentive Marketing is “Low” and the demand variation is “Low” and Restriction of template capacity is “Low”, so the level of risk is “Low”;

b) If Incentive Marketing is “High” and the demand variation is “Low” and Restriction of template capacity is “High”, then the level of risk is “Medium”;

c) If Incentive Marketing is “Low” and Change in Demand is “High” and the Restriction of template capacity is “High”, then the level of risk is “High”.

In Figure 12 you can see the representation of rules in Matlab ®.

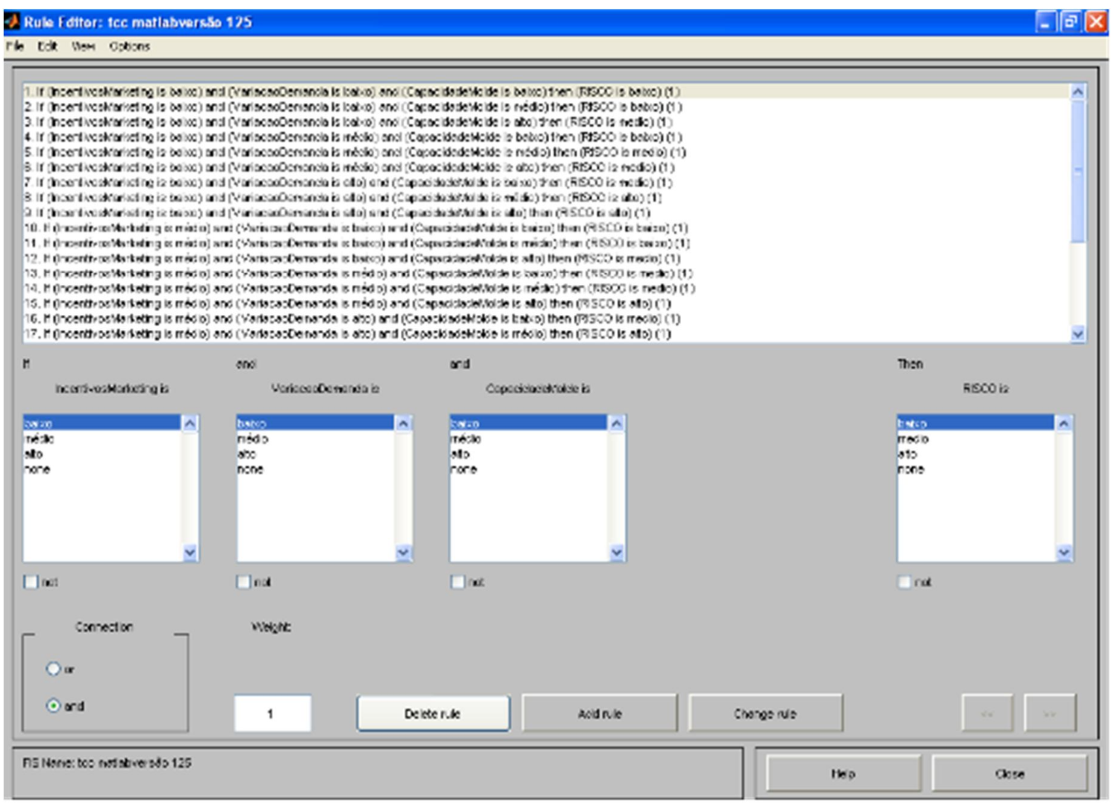

Figure 12 - Rules of Inference

Source: Authors ("printscreen" Matlab ®).

Fuzzy Control System: Scenarios

Figure 13 shows the surface of the system obtained by the Matlab ® software:

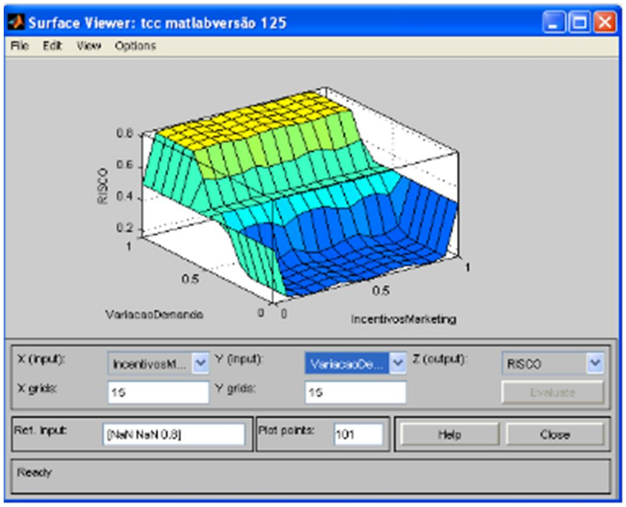

Figure 13 - Surface response

Source: Authors ("printscreen" Matlab ®).

Comparison of methodologies

The purpose of this section is through an example of a product which was launched in December 2010, comparing the outcome of the risk that COSMETIC S/A obtained when analyzing the product with the risk that the result was obtained in the fuzzy system which was developed in the case study.

In COSMETIC S/A the area of Supply Chain Planning is very involved in all stages of product launches, mainly in the development and implementation. In the Implementation phase, the area performs an analysis called "Risk Quadrant," which consists of a method of risk analysis of projects for new products that will be released in the coming months. The process was developed by managers and supervisors based on the methodology of qualitative analysis of the PMBOK (PMI): the matrix Probability/Impact.

The product, with the fictitious name of "Smell Nice," belongs to the segment of personal care toward the children. It was considered a major release for the company in this niche market (child) aimed at the Christmas festive season. The following are the characteristics of "Smell Nice" (data were provided by the company, but not to work with real data for units and a multiplier value was used):

a) Release date: 1st November 2010 campaign;

b) Country: Brazil;

c) Segment: personal hygiene;

d) Market: child audience;

e) Investment in marketing: product sales brochure cover and high investment for the licensing of Disney ® characters on the packaging;

f) Demand Forecasting (one year before the campaign launch): 196,000 units, USD $ 465,000.00;

g) Demand Forecasting (six months before the campaign launch): 340,000 units, USD $ 805,000.00, equal to an increase of 73.4% over the forecast quoted above;

h) Restriction of the capacity of the mold: Mold principal component (150ml plastic bag) with a capacity of 87% occupied.

In risk analysis (Risk Quadrant) of the product "Smell Nice" held in May 2010 by the Planning Supply Chain in COSMETIC S/A, the result of the risk was equal to 42%. Introducing the same parameters in the fuzzy system developed in Matlab ® (Figure 14), we obtained the value of the risk of the product equal to 81.1%, i.e., high probability of missing the product on the retailer's request.

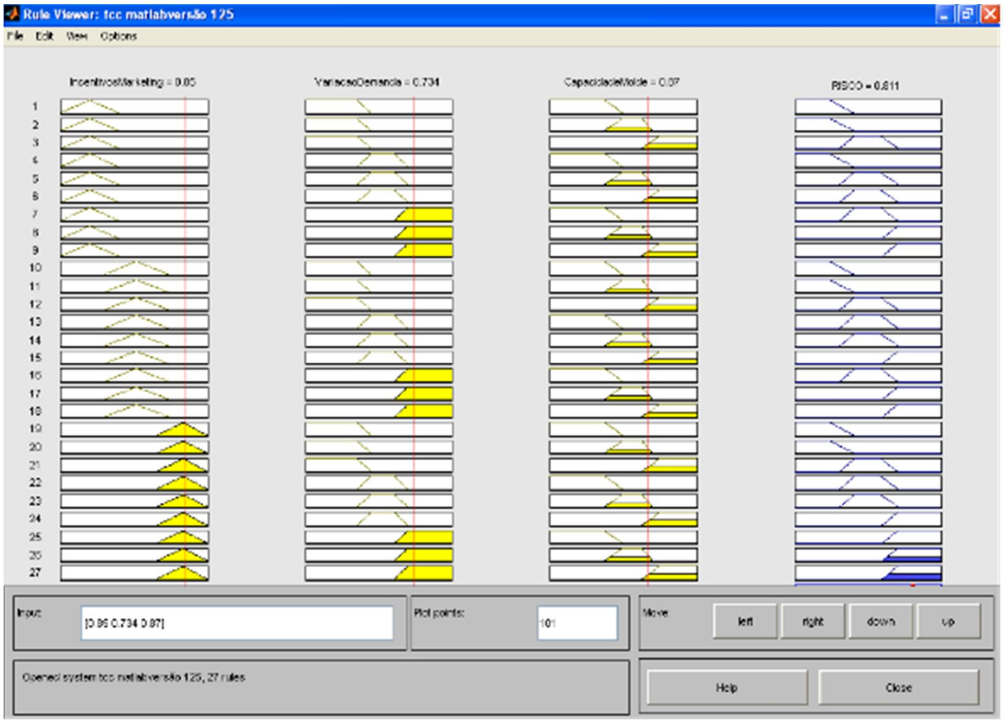

Figure 14 - Rule Viewer - product "Smell Nice"

Source: Authors ("printscreen" Matlab ®).

In December 2010 saw the release of "Smell Nice" and the actual sale was superior to all sales forecasts, hundreds of dealers complained about the lack of product due to high demand. In Brazil, the lack of product (shortage) was 24,500 units representing a value of $ 58,000.00.

Thus, one can see that according to the analysis "Risk Quadrant" the risk of supply was not mid-level (equal to 42%), i.e., average probability (20% to 50%) of missing product, but using the methodology of the fuzzy system obtained a value of high-level risk (81.1%), or high probability (greater than 50%) of missing the product. Therefore, one can consider that in this example the product "Smell Nice" risk analysis not supply the launch of new products by means of fuzzy logic, obtained a value of risk more accurate, efficient and closer to reality.

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