DIFFUSE APPLICATIONS IN THE MANAGEMENT OF SUPPLY CHAINS

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Abstract: The present work refers to the application of models of fuzzy logic on the supply chain in the market, more specifically in the use of the model proposed by Mandani to solve the cost relation in production with the final price of the product, associated to the supply chain, taking into account its most important variables, on which a possible margin representing the relationship between these departments will be determined and it will make it possible to streamline decision making in the resources provided in each one of them, with in order to optimize the processes within the chain, offering more stable values among the associated variables, so as to guarantee a better profit at the moment of finishing the production process of a certain product

Keywords: Supplychain,Mandanimodel,decisionmaking,productionprocess

APLICACIONES DIFUSAS EN LA GESTIÓN DE CADENAS DE SUMINISTRO

Resumen: El presente trabajo se refiere a la aplicación de modelos de lógica difusa en la cadena de suministro en el mercado, más específicamente en el uso del modelo propuesto por Mandani para resolver la relación de costo en producción con el precio final del producto, asociado a la cadena de suministro, teniendo en cuenta sus variables más importantes, sobre la cual se determinará un posible margen que represente la relación entre estos departamentos y permitirá racionalizar la toma de decisiones en los recursos provistos en cada uno de ellos, con el fin de optimizar los procesos dentro de la cadena, ofreciendo valores más estables entre las variables asociadas, a fin de garantizar un mejor beneficio al momento de finalizar el proceso de producción de un determinado producto.

Palabras Clave: Cadena de suministro, modelo Mandani, toma de decisiones, proceso de producción

I. INTRODUCTION

By making a global definition, it is possible to define the supply chain as a process formed by all those groups of activities directly or indirectly involved in satisfying supply needs, these sets include suppliers at all levels; places of storage of raw material, the production line, warehouses of finished products, distribution channels, wholesalers, retailers and the end customer. Within each organization there is a different supply chain depending on the item that the company manages. There are three types of companies: industrial, marketing and service. [1]. Service companies have very short supply chains. Industrial companies have supply chains with a lot of logistics depending on the raw material they use, the production lines they have and the market segments to which their products are directed. Marketers, for example, have very little use of stock, so their supply chains are less elaborate [1-3]. All the functions that participate in the supply chain are destined to the reception and fulfillment of a request of the client. These functions include, but are not limited to, the development of new products, marketing, operations, distribution, finance and customer service [3].

The development of a Mandani application of fuzzy logic in Matlab is presented, which evaluates the parameters in the process of the supply chain, whose values are diffuse, lacking precision due to its qualitative nature. The developed application allows to maximize profits based on the main variables that appear throughout the process of the supply chain; marketing expenses, expenses for purchases, operational expenses, price of the raw material, production time and finally, price of the final product. The Matlab © software was used for the design of the Mandani model, with support in triangular transfer functions that offer greater distinction in the definition of linguistic variables and the structure of the diffuse set.

The following work is distributed in sections, in

the second it shows the development in a general way, including the background, later in section III there is an explanation of the fuzzy models applied to the supply chain, as previous works that support to this investigation, in section IV it is possible to appreciate the development of the diffuse application used. Finally the results and conclusions are shown.

II. DEVELOPMENT

The supply chain could be defined as the set of companies composed of suppliers, distributors and retailers both wholesalers and retailers [2], they are organized in such a way that they coordinate their functions in a collaborative manner to address the product requirements in all stages of the process in the precise time at the lowest cost, establishing the optimal requirements to satisfy the final consumers.

The main components of the supply chain system are: the flow of materials, the flow of information and the relationships between buyers and sellers, in addition to this there are other elements such as suppliers, assemblers, manufacturers, distributors and customers. Therefore, the supplier must take good care of the way in which their products are offered in the market, as well as the materials and quality of them in order to be competitive. The time of a product in the market is usually very short, since soon similar new products of higher quality and at a lower price emerge. It is necessary that the companies maintain a thorough rigor of the product in the distributing sources, taking care of every detail of the processes in the supply chain.

The relations between buyers and sellers in one of the most important aspects in the chain, this constitutes the success of a product in the market, together with the information and communication technologies for the management of systems that give answers to the flow of materials and products in the warehouses, as well as the control of inventories and the appropriate supply of products according to the characteristics of the environment.

Verruschi et al [4] propose a computational mathematical model to address the supply chain in an oil refinery, the authors propose GAMS and its CPLEX and SNOPT resolvers, for optimization in the linear modeling process. Likewise, Arango and Serna [5] propose negotiation protocol where the elements of the supply chain are visualized as agents of a diffuse system, which are linked to coordinate the inherent activities and reach the common goals. Silva and Silva [6] suggest the use of SAP software for the treatment of the supply chain in the process of obtaining aluminum, the authors propose a business system that offers effective solutions in the handling of information and management of the supply chain.

The management of information within the chain is essential to maintain the right proportions, in addition to guaranteeing the necessary alliances to establish costs and produce new products.

The quality of companies requires a high degree of sophistication, taking into account managerial decisions, as stated by the World Economic Forum [7], promoting productivity and business growth from decisions taken in the macroeconomic environment. The management states are supported with indicators, production and productivity tables, balance sheets, indices and graphs that support the efficiency of organizations in the optimization of resources. To ensure the reliability of the companies, this requires administrative procedures with increasingly didactic and versatile tools that facilitate the processing of information without distorting it and always prevailing the conservation and reliability of it.

III. DIFFUSE MODEL IN THE SUPPLY CHAIN

Fuzzy logic is associated with the variables of human appreciation, which make up a broad structure of considerations to be taken into account in decision making. In this way it is necessary to establish the parameters according to a specific context, which contrasts with the measures associated with each variable that make up the diffuse set. In business administration, marketing and production, the associated variables in this context are of a qualitative nature, of great complexity for their characterization, and difficult to handle with traditional mathematical processes. These variables are associated with production, problem management, planning, process control [8], that is, they present an inaccuracy in their operation range and in the numerical handling of them. Therefore, each of the variables associated with the supply chain is largely determined by the validation of experts who can give an assessment of them, that is, they depend on human opinions and decisions.

Considering that fuzzy models offer important advantages, many researches have valued the diffuse application in the supply chain, Arango et al [9], it suggests examples of relevance in the field of marketing, where parameters of suppliers' plant, purchasing department, production department and sales department are evaluated, which are validated by the experts for the definition of their values. So, Oramas and Ortíz [10], propose fuzzy models for the evaluation of suppliers, and the management of inventories, promoting the rationality in imports and strengthening the purchase-sale. In addition, Cúnico and Vechiette

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[11], developed a mathematical model that minimizes the costs derived from the supply of materials, when it is not possible to model the uncertainty in the provision of raw materials from a distribution of specific failures, for each supplier. The authors suggest a diffuse model to be able to appreciate the degree of reliability of the providers based on the previous conduct carried out by them. In this way, it is possible to appreciate that the diffuse logic has been related to the supply chain in different perspectives, offering better results in the process and in the cost / benefit assessment [12].

IV. APPLICATION OF THE DIFFUSE LOGIC IN THE SUPPLY CHAIN

To establish the variables associated with the supply chain and their respective parameters, validation with the experts was necessary, since these variables lack definable values, their values are diffuse and require particular attention. The objective is to maximize profits based on these variables. The mathematical model designed by [9] was the starting point of the fuzzy set.

As input variables were considered: Marketing expenses (M), expenses for purchases (S), operational expenses (O), price of raw material (Si), production time (T). While the variable that was taken into account as output was the price of the final product (P). The model was characterized by

$$MaxZ = P - [(S_1 + S_2 + S_3 + \cdots + S_i) + S + M + O + \alpha IT] \quad (1)$$

where α represents a constant that refers to the annual interest rate, while I is the investment made in the plant.

A. Definition of the rules

Once the parameters were defined, the following rules were taken into account:

- Yes:
-- Marketing expenses M are altos,
-- The expenses for purchases S are altos,
-- Operational expenses O are altos,
-- The price of raw materials Si they are caros,
-- The production time T is alto,
- Then the price of the final product P will be alto
- Yes:
-- Marketing expenses M are bajos,
-- Expenses for purchases S are bajos,
-- Operational expenses O are bajos,
-- The price of raw materials Si they are baratos,
-- The production time T is bajo,
- Then the price of the final product P will be bajo

In this case the experts suggested values according to the previous knowledge obtained. The six rules defined for the Mandani model are shown in figure 2 and are subject to the conditions provided by the experts, which do not consider the failures in the taking of the uncertainty.

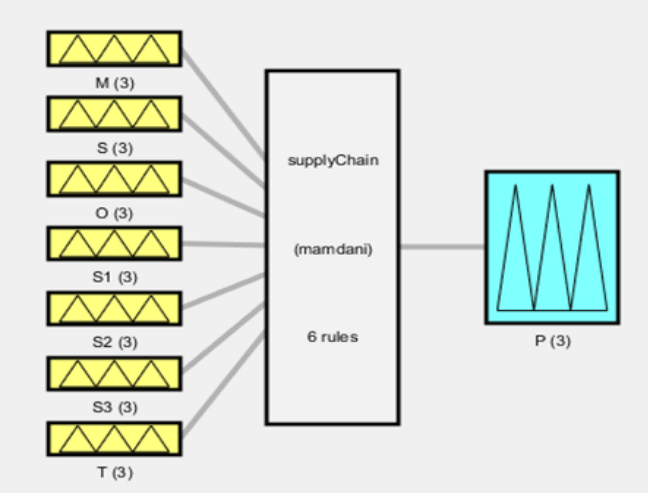

Figure 3. Rules in the Mandani model

The model in figure 3, corresponds to the mentioned entries, which are shown in table I, where the parameters of each of them have been defined according to their participation in the supply chain.

Table I. Variables of the supply chain

Variable	Rank
M	[0 1,20]
S	[0 0,60]
O	[0 0,90]
S1	[0 6,03]
S2	[0 1,20]
S3	[0 0,60]
T	[0 0,75]

While the output has been designed with the same triangular functions but in the range of values offered by experts, which ensure a final price that can vary from cheap to caro, as barato in table II.

Table II. Output variable in the supply chain

Variable	Function	Rank
'barato'	trimf'	[0 2,10 4,20]
'promedio´	trimf	[4,20 6,30 8,40]
'caro'	trimf	[8,40 10,50 12,60]

In turn, the input variables were also defined with three categories, according to the individual characteristics.

V. RESULTS

The membership functions were established in a triangular way, since they allow a better visualization of the parameters, the values offered by the experts focus on the prior knowledge, therefore it is possible that the average marketing expenses are in the order of 0.4 and 0.8 when perhaps its real value is 0.75. Figure 1 shows the diagrams of the membership functions, it shows the parameters provided by the experts, which show possible values of each of the variables according to their participation in the supply chain.

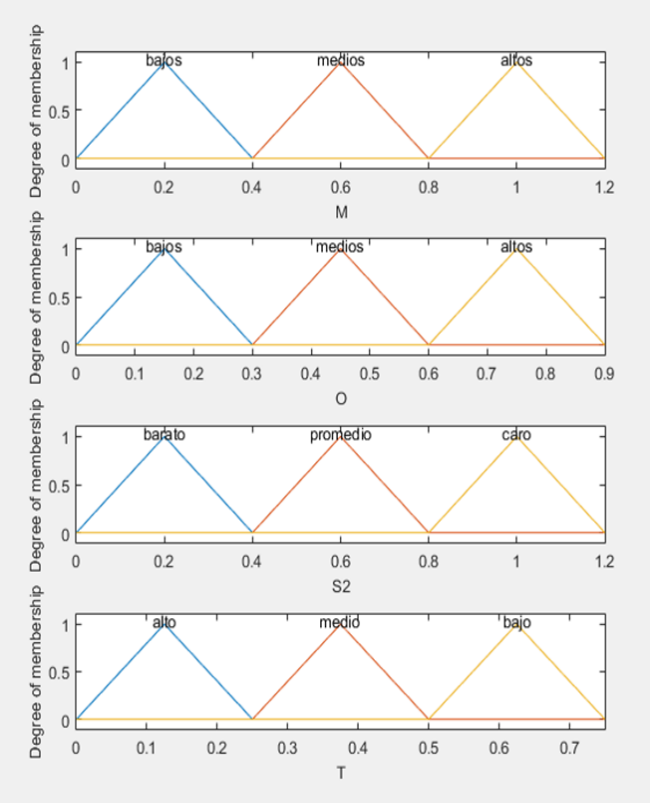

Figure 1. Membership functions for the variables M, O, S2 and T.

The company can take considerations in the results, according to the uncertainty that it wants to associate to it, being able like this to discard the solutions that it does not consider pertinent. For example, the company can take into account that what is invested in purchases provides good savings on the investment in raw material, so it would be necessary to strengthen the department. On the other hand, suppliers may have other appreciations, having to consider other associated changes.

The diffuse logic allows finding an intermediate solution, which would be subject to the decisions of the company, according to their own experiences.

For the values of the final price some parameters based on the experts have been considered, which suppose operating ranges between 0 and 4.2 for the barata diffuse variable, while the promedio variable is established as those prices that are considered accessible for all types of public. and that they guarantee some margin of associated quality, delimiting it between 4.2 and 8.4. Likewise, the caro variable is categorized between 8.4 and 12.6, leading to the three associated diffuse variables.

```
fis = addvar(fis, 'output', 'P', [0 12.6]);
fis = addmf(fis, 'output', 1, 'barato', 'trimf', [0 2.1 4.2]);
fis = addmf(fis, 'output', 1, 'promedio', 'trimf', [4.2 6.3
8.4]);
fis = addmf(fis, 'output', 1, 'caro', 'trimf', [8.4 10.5
12.6]);
```

The execution of the rules requires the combination of data that guarantees an accurate result in the values proposed by the experts, (2) reveals the matrix of rules associated with the Mandani model for its execution

```
m= [3 3 3 3 3 3 3 1 1;
  1 1 1 1 1 1 1 1 1;
  3 1 2 3 1 2 1 3 1 2;
  3 1 1 1 2 2 2 3 1 2;
  1 3 3 3 2 2 1 1 1 1;
 1 2 3 1 2 3 1 1 1 1];
```

(2)

The relationship between marketing expenses, expenses for purchases and the price of the final product, is linear, as shown in Figure 2, where each of these variables determines the decisions of the final price.

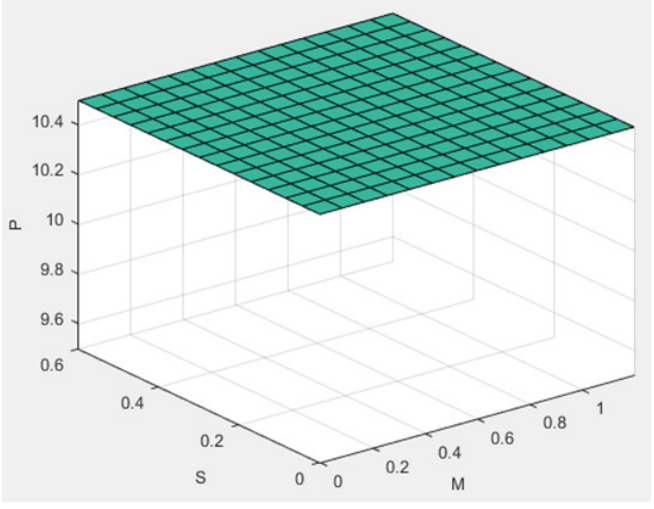

Figure 2. Linear relationship of P, M and S.

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Note that the values of marketing expenses are below the expenses for purchases, however their impact on the final price is practically the same.

VI. CONCLUSIONS

The results obtained are feasible provided that the use of resources invested outside the context represented in the model is taken into account, which indicates that it is necessary to include other variables that yield more precision in the characterization of the values provided by the experts. However, it is possible to ensure that fuzzy models offer great advantages in making decisions, speed up the processes for the validation of data of complex variables of difficult appreciation.

The variables considered in the Mandani model focus on proposed values, which may well be affected if the uncertainties associated with the supply chain process are included, which may result in greater satisfaction of the solutions, so that a value of 12 as noted, it can be reflected as an approximate value of 12, which provides a better appreciation of the real trends of the variables.

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