FHESMM: Fuzzy Hybrid Expert System for Marketing Mix Model

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Abstract

Increasing customers' satisfaction in this developed world is the most important factor to have a successful trade and production. New marketing methods and supervising the marketing choices will have a key role to increase the profit of a company. This paper investigates an expert system through four main principles of marketing (price, product, Place and Promotion) and their composition with a logic fuzzy system and benefiting from the experiences of marketing specialists. Comparing with the other systems, this one has special properties such as investigating and extracting different fields in which affect the customers' satisfaction directly or indirectly as input parameters (26), using knowledge of experts to design inference system rule, composing the results of five fuzzy expert systems and calculating final result(customer's satisfaction) and finally creating a high function expert system on management and guiding the managers to do a successful marketing in dynamic markets.

Keywords: *marketing mix model, fuzzy decision making system, fuzzy, expert system, mamdani inference, four P's.*

1. Introduction

Philip Kotler has defined marketing management as the analysis, planning, implementation, and control of programs designed to bring about desired exchanges with target audiences for the purpose of personal or mutual gain [1]. One of the most critical marketing management decisions is that decision of setting the marketing mix values, and selecting and employing strategy that periodically changes that marketing mixes in response to changing business environment. The marketing mix problem involves setting the values of the marketing decision variables; the four P's; namely, Product, Price, Place and Promotion. Developing an effective marketing mix is important for product planners seeking to gain competitive advantage in industrial markets. The decision regarding specifying the marketing mix depends on a set of variables, the majority of which are **stochastic**, **dynamic**, **vague** or **inexact**, and **qualitative** or **intangible;** such as competitor's price, competitor's product quality, competition level, forecasted sales and others**.** These types of variables necessitate adoption of appropriate approaches that can deal with such variables' nature. These variables natures are inherent in various business sectors, specially in case of agriculture business, like agro-food companies, producers of fertilizers, and other agro-chemical products, where the existence of some stochastic variables such as climate, forecasts, demand and a varieties of qualitative variables like food safety, availability, competition, etc. The proposed model is generally applicable to any business sector or industry and specially useful and appropriate in the situation where stochastic, qualitative and vague variables are inherent in the inputs to the problem [2].

2. Literature Review

Traditionally, the problem of setting the marketing- mix has been dealt with in a partial manner, in the sense that most of the articles considered only one element of such mix at a time. For instance, in 1987 Magruth and Kenneth provided three major criteria for evaluating marketing channels [3]. In 1989, Lyrch and Hooky explored the question of possible changes in industrial advertising practice by focusing on the advertising budgeting approaches revealed in recent large-scale U.K. survey [4]. In 1995, Earl Cox described a model for new product pricing [5]. Fuzzy logic methods are very important at management and subgroups. Z. L. Yang Use of Fuzzy Evidential Reasoning in Maritime Security Assessment [14] and Enrico Zio a Fuzzy Decision Tree for Fault Classification [15], Enrico Cameron Risk Management and the Precautionary Principle: A Fuzzy Logic Model [16]. The model combines the expertise of financial, marketing, sales, and manufacturing management to develop a recommended initial pricing position for a new consumer product. This pricing model showed how fuzzy rule-based system can combine the intelligence of several experts into a single, cohesive process. Little literature attempted to deal with the stochastic, vague and qualitative nature of variables, which inherently affects such marketing decision or provide a whole method for setting the four P's and also very little ones that have considered the practical expression of product quality and integrating it with other 3 P's. However, in attempting to treat the problem from a total perspective, Bay Arinze in 1990 described a computer-based marketing decision support system to support planning strategy for marketing and as an expert system shell aid in the selection of marketing mix variables' values [6]. In 1992, Arinze and Burton developed a simulation model as the heart of a marketing decision support system (MKDSS) to model the stochastic element of the marketing mix, marketing dynamics, the interactions between marketing instruments and competitive effects, to support decision making process and developing the marketing mix [7]. In 2001, Fazlollani and Vahidov attempted to extend the effectiveness of simulation-based DSS through genetic algorithms [8]. They applied a hybrid method based on the combination of Mont Carlo Simulation and GA to the marketing mix problem to improve the process for searching and evaluating alternatives for decision support. Genetic algorithms for tourism marketing was proposed by stephen hurley[8]and Bayesian neural network learning for repeat purchase modeling in direct marketing was proposed by bart baesens[9].modeling fuzzy data in qualitative marketing research was proposed by sajeed varki[10] On optimal partially integrated production and marketing policy with variable demand under flexibility and reliability considerations via Genetic Algorithm [11]and Variable selection in clustering for marketing segmentation using genetic algorithms[12].
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3. Method

3.1 Fuzzy Marketing Method

Marketing management and Customer Relationship Management (CRM) need methods to analyze, evaluate and segment their customers according their value for the company in order to improve customer relationships, optimize customer or marketing performance and to maximize profitability. One problem of scoring methods like the RFM (Recency, Frequency, Monetary value) model, ABC and portfolio analysis is that they have always been applied in a sharp manner so far, i.e. values are assigned sharply to predefined classes. This often leads to misclassifications (under-/overvaluations) [13].

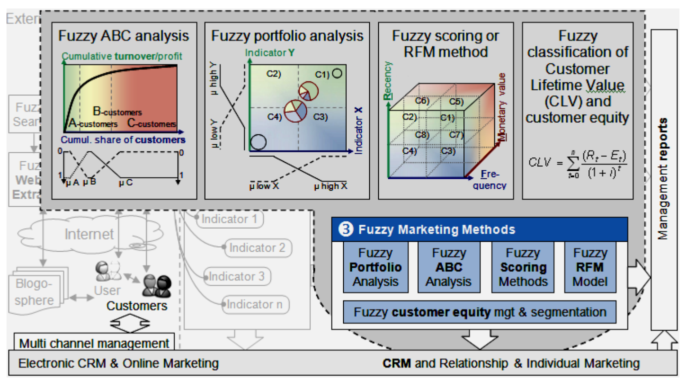

Fig. 1 Fuzzy Marketing Model.

With the fuzzy classification approach, these problems can be avoided, objects are classified exactly and resources can be allocated optimally. In a fuzzy ABC analysis, customers can partly belong to two classes, in fuzzy portfolio analysis to four and in fuzzy scoring methods to several classes at the same time. In addition, the membership degree to each class can be computed, which allows e.g. the calculation of individual, personal prices, accounts or incentives and the adoption of the marketing mix (mass customization).In addition, the fuzzy logic approach can be used also in the domain of performance measurement in order to analyze, classify, evaluate and manage different marketing relevant measures and indicators, for instance customer equity or Customer Lifetime Value (CLV) The main advantage of a fuzzy classification compared to a classical one is that an element is not limited to a single class but can be assigned to several classes. In addition, fuzzy classification and fuzzy methods support qualitative and quantitative indicators. The fuzzy classification with its query facility allows improving customer equity, launching loyalty programs, automating mass customization issues, and refining marketing campaigns.

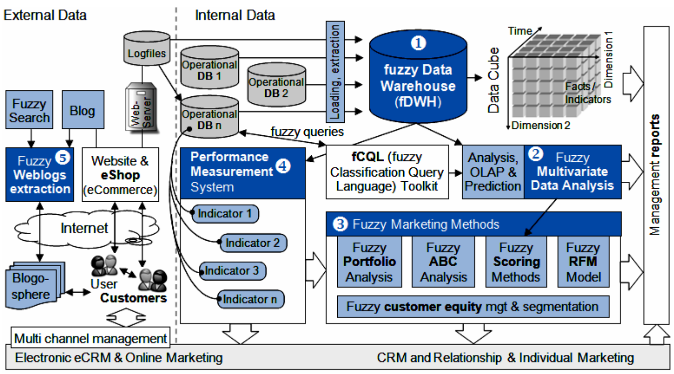

Fig. 2 The framework of fuzzy marketing methods.

3.2 The aim and new method

The marketing-mix problem is a typical problem, which involves vague and uncertain type of input variables and dynamic, non-linear relationships. The problem involves setting the values of the marketing decision variables; the four P's (Product, Price, Place - distribution expenditures and Promotion.

A fuzzy marketing mix model is used in this article this system includes four subsystems having several inputs each. The outputs of these systems are considered as input of the fifth system and final result shows the successfulness level of marketing. Other inputs and their characteristics are as follows:

Table 1: characteristics and input of place expert system

Name='marketing place'	Inputs
Type='mamdani'	1)'Export.drop.shippers'
NumInputs=6 NumOutputs=1	2)'Export.merchants'
NumRules=15	3)'ETC'
AndMethod='min' ImpMethod='min'	4)'manufacturer.export.agent'
OrMethod='max'	5)'EMC'
AggMethod='max'	6)'export.brokers'
DefuzzMethod='centroid'	

Table 2: characteristics and input of price expert system

Name='marketing price'	Inputs
Type='mamdani'	1)'request.inducement'
NumInputs=7 NumOutputs=1	2)'price.importance'
NumRules=25	3)'price.quality'
AndMethod='min' ImpMethod='min'	4)'price.adversary'
OrMethod='max'	5)'price.specific.clientele'
AggMethod='max'	6)'price.cast'
DefuzzMethod='centroid'	7)'price.without'

Table 3: characteristics and input of product expert system units.

Name='marketing product'	Inputs
Type='mamdani'	1)'quality'
NumInputs=6 NumOutputs=1	2)'features'
NumRules=20	3)'packaging'
AndMethod='min' ImpMethod='min'	4)'design'
OrMethod='max'	5)'aftersale.service'
AggMethod='max'	6)'lifetime.warranty'
DefuzzMethod='centroid'	

Table 4: characteristics and input of promotion expert system units.

Name='marketing promotion'	Inputs
Type='mamdani'	1)'personal.sale'
NumInputs=7 NumOutputs=1	2)'pictorial.sale'
NumRules=30	3)'radio.sale'
AndMethod='min' ImpMethod='min'	4)'newspaper.sale'
OrMethod='max'	5)'poster.sale'
AggMethod='max'	6)'caption.poster.sale'
DefuzzMethod='centroid'	7)'award.sale'

The relationship among targets, economic conditions, developments, and other input variables from one side and the marketing-mix setting in the other side is non-linear and difficult or cannot exactly defined unless it is expressed in forms of experts' If-Then decision rules. It is now clear and evident that one way to handle all such aspects of the marketing mix problem is the use of fuzzy logic sets, which effectively handle such vague, uncertain, subjective inputs and efficiently model nonlinear relationships between problem inputs and outputs.

3.2.1 Hybrid fuzzy expert systems designing

A fuzzy expert system is a mix of expert and logic fuzzy systems. This system includes five main sections.

1. Expert: who have specialty in a field. This specialization could be experienced or be gained through wide studies.

2. Fuzzification: The fuzzification comprises the process of transforming crisp values into grades of membership for linguistic terms of fuzzy sets. The membership function is used to associate a grade to each linguistic term... It has different types in which the triangle and trapezoid one are used.

3. Inference engine: it draws a conclusion from data and rules based on a field mamdani inference system.

4. Fuzzy rules bank: it is a complex of < If … Then> rules.

5. Defuzzification: the process of producing a quantifiable result in fuzzy logic. Typically, a fuzzy system will have a number of rules that transform a number of variables into a "fuzzy" result, that is, the result is described in terms of membership in fuzzy sets. For example, rules designed to decide how much pressure to apply might result in "Decrease Pressure (15%), Maintain Pressure (34%), and Increase Pressure (72%)". Defuzzification would transform this result into a single number indicating the change in pressure. The simplest but least useful defuzzification method is to choose the set with the highest membership, in this case, "Increase Pressure" since it has a 72% membership, and ignore the others, and convert this 72% to some number. The problem with this approach is that it loses information. The rules that called for decreasing or maintaining pressure might as well have not been there in this case. A useful defuzzification technique must first add the results of the rules together in some way. The most typical fuzzy set membership function has the graph of a triangle. Now, if this triangle were to be cut in a straight horizontal line somewhere between the top and the bottom, and the top portion were to be removed, the remaining portion forms a trapezoid. The first step of defuzzification typically "chops off" parts of the graphs to form trapezoids (or other shapes if the initial shapes were not triangles). For example, if the output has "Decrease Pressure (15%)", then this triangle will be cut 15% the way up from the bottom. In the most common technique, all of these trapezoids are then superimposed one upon another, forming a single geometric shape. Then, the centroid of this shape, called the fuzzy centroid, is calculated. The x coordinate of the centroid is the defuzzified value.

6. Knowledge engineering: KE is an engineering discipline that involves integrating knowledge into computer systems in order to solve complex problems normally requiring a high level of expertise. At present, it refers to the building, maintaining and development of knowledge-based systems. It has a great deal in common with software engineering, and is used in many computer science domains such as artificial intelligence including databases, data mining, expert systems, decision support systems and geographic information systems. Knowledge engineering is also related to mathematical logic, as well as strongly involved in cognitive science and socio-cognitive engineering where the knowledge is produced by socio-cognitive aggregates (mainly humans) and is structured according to our understanding of how human reasoning and logic works.

- Various activities of KE specific for the development of a knowledge-based system:
- Assessment of the problem
- Development of a knowledge-based system shell/structure
- Acquisition and structuring of the related information, knowledge and specific preferences (IPK model)
- Implementation of the structured knowledge into knowledge bases
- Testing and validation of the inserted knowledge
- Integration and maintenance of the system
- Revision and evaluation of the system.

Being still more art than engineering, KE is not as neat as the above list in practice. The phases overlap, the process might be iterative, and many challenges could appear. Recently, emerges meta-knowledge engineering as a new formal systemic approach to the development of a unified knowledge and intelligence theory.

7. Expert (marketing expert): An expert, more generally, is a person with extensive knowledge or ability based on research, experience, or occupation and in a particular area of study. Experts are called in for advice on their respective subject, but they do not always agree on the particulars of a field of study. An expert can be, by virtue of credential, training, education, profession, publication or experience, believed to have special knowledge of a subject beyond that of the average person, sufficient that others may officially (and legally) rely upon the individual's opinion. Historically, an expert was referred to as a sage.

8. Market or the environment that the expert acts inside it.

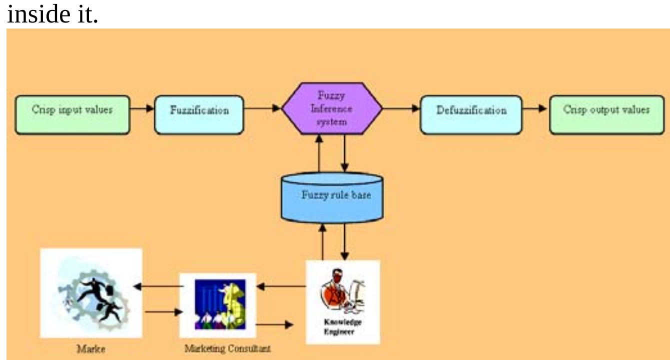

Fig. 3 shows a fuzzy expert system for marketing

This research uses five fuzzy expert systems. Figure 4 shows the system including a fuzzy expert system for each p and the whole results on another system and finally the rate of successfulness.

3.2.1.1 Defuzzification

The values of input and output variables are fuzzified Based on opinion of experts and analysts, triangular membership functions with five fuzzy sets are used. Except for the variable competition level, five fuzzy sets are used for all other variables: “Very Low” as VL, “Low” as L, “Medium” as M, “High” as H, and “Very High” as VH. The membership functions of all the marketing place fields have been defined below:

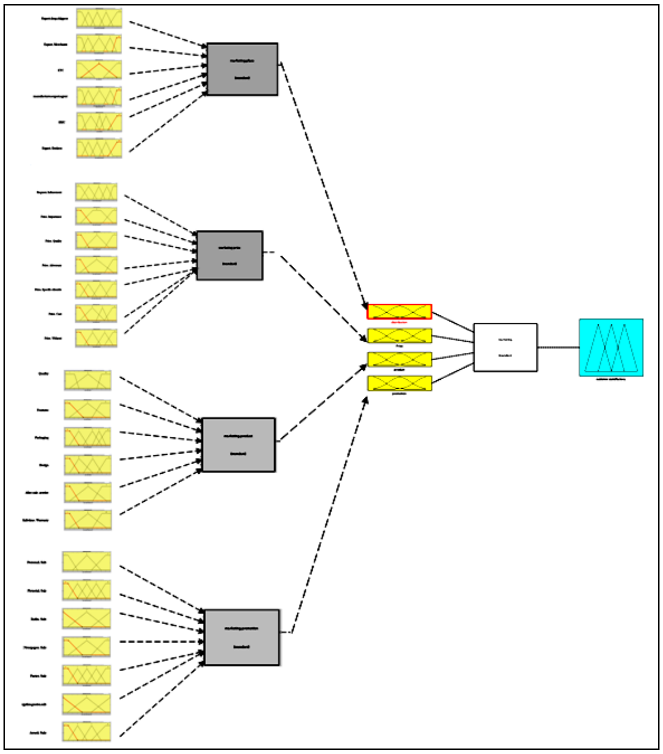

Fig 4.fuzzy hybrid expert system for marketing

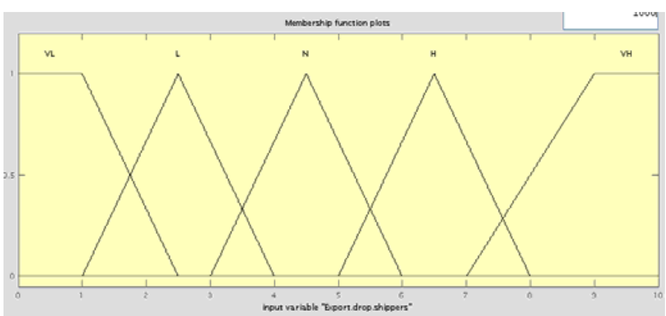

Fig 5.Fuzzification of 'Export.drop.shippers'

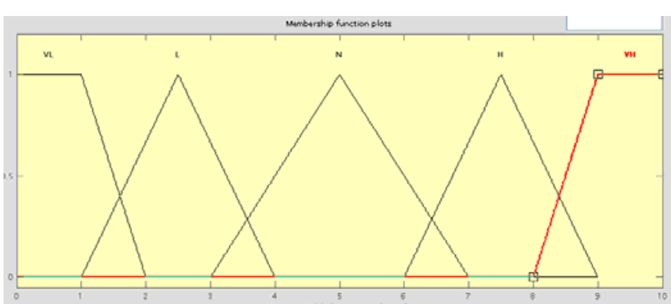

Fig 6.Fuzzification of export. Merchants

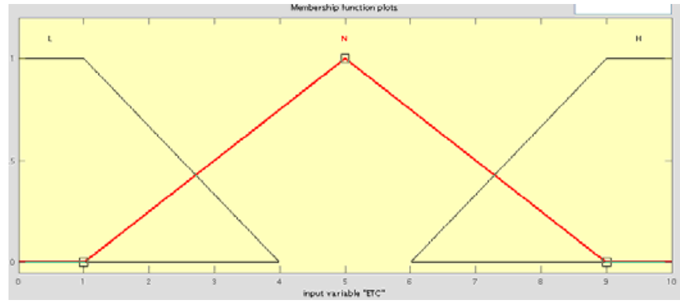

Fig 7.Fuzzification of ETC

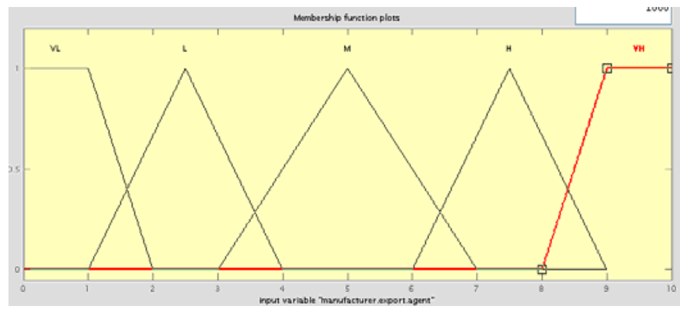

Fig 8.Fuzzification of manufacturer.export.agent

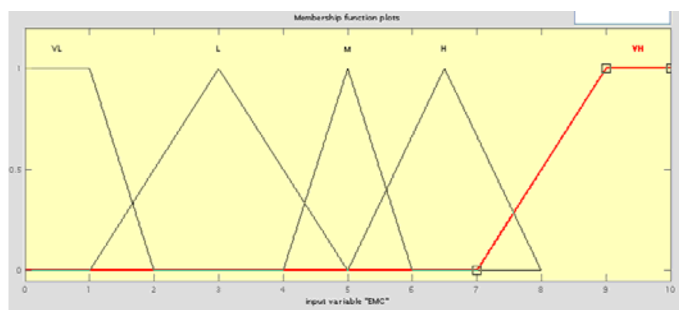

Fig 9.Fuzzification of EMC

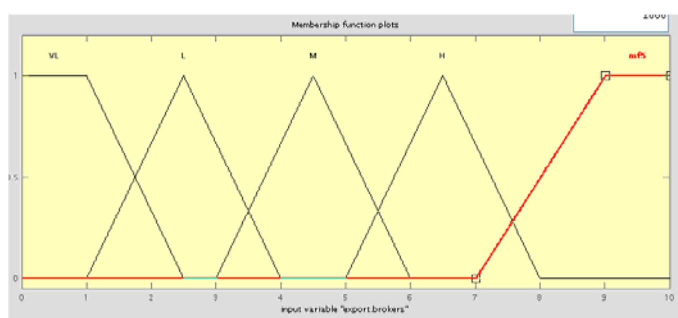

Fig 10.Fuzzification of export brokers

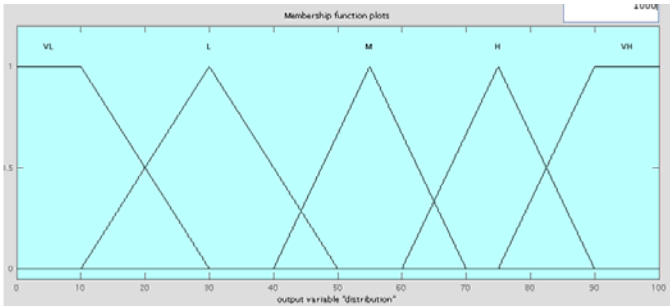

Fig 11.Fuzzification of output distribution

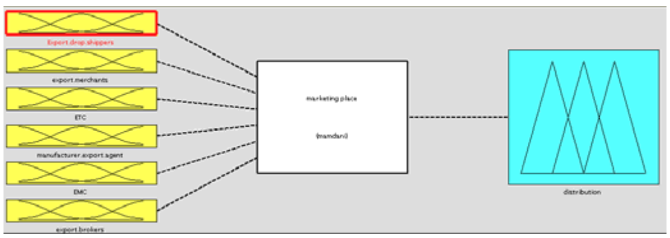

Fig 12.Outline model of place fuzzy expert system

There are several fuzzy statuses such as Very Low (VL), Low (L), Normal (N), High (H) and Very High (VH) for output of place fuzzy expert system that modifies the quality of the product. Regarding triangle fuzzification, High, Low and Very high status are as follows:

$$\mu_{low}(distribution) = \begin{cases} 0 & \alpha \le 10 \\ (\alpha - 10)/20 & 10 < \alpha \le 30 \\ (50 - \alpha)/20 & 30 < \alpha \le 50 \\ 0 & \alpha > 50 \end{cases} \quad (1$$

$$\mu_{high}(distribution) = \begin{cases} 0 & \alpha \le 60 \\ (\alpha - 60)/15 & 60 < \alpha \le 75 \\ (90 - \alpha)/15 & 75 < \alpha \le 90 \\ 0 & \alpha > 90 \end{cases} \quad (2$$

$$\mu_{veryhigh}(distribution) = \begin{cases} 0 & \alpha \le 75 \\ (\alpha - 75)/15 & 75 < \alpha \le 90 \\ 1 & 90 < \alpha \le 100 \\ 0 & \alpha > 100 \end{cases} \quad (3$$

For example, "Expert.dro.shippers" fuzzy membership function is as follows:

$$\mu_{high}(export.drop.shipper) = \begin{cases} 0 & \alpha \le 1 \\ (\alpha - 1)/4 & 1 < \alpha \le 5 \\ (9 - \alpha)/4 & 5 < \alpha \le 9 \\ 0 & \alpha > 9 \end{cases} \quad (4$$

$$\mu_{high(\text{Export.drop.shippers})} = \{\frac{0}{1} + \frac{0.25}{2} + \frac{0.5}{3} + \frac{0.75}{4} + \frac{1}{5} + \frac{0.75}{6} + \frac{0.5}{7} + \frac{0.25}{8} + \frac{0}{9}\} \quad (5$$

3.2.1.2 Rules Bank and Defuzzification

Taking into account different conditions of CS and even situations that have not yet occurred but may occur in the future, the rules have been edited. In total, there are 105 dependent rules, where each rule is a collection of variants that have occurred "AND" together and show a special situation of CS. These rules cover all the situations that the fuzzy system may face. Also, there may occasionally be an opposition be between the base rules. This problem is solved by the inference engine and defuzzification parts of the system. The Inference engine and defuzzification parts give us an optimized result by taking an average of the attained rules. Defuzzification's centre of gravity formula is used for calculating the certain output amount.

$$D^* = \frac{\int D.\mu_{middle}(D)dD}{\int \mu_{middle}(D)dD} \quad (6$$

Table 5.Collection rules of marketing place fuzzy expert system

Export.drop .shippers	Export. merchants	ETC	Manufacturer. Export. agent	EMC	Export. brokers	distribution
(VL)	L	VL	VL	L	VL	VL
VL	L	VL	VL	VL	L	VL
N	N	L	N	N	VL	N
H	N	H	H	H	N	H
....	......	......	......	......	......	......
VH	VH	N	VH	VH	H	VH

Table 6.COLLECTION RULES OF 'marketing price' FUZZY EXPERT SYSTEM

Request .inducement	Price .importance	Price. quality	Price. adversary	specific_ .clientele	Price .cast	Price .without	distribution
VL	VL	VL	L	L	VL	VL	VL
L	L	VL	N	L	VL	L	L
L	N	H	N	N	N	N	N
H	H	H	L	H	H	VH	H
....	....	....	....	....	....	....	....
VH	H	VH	VH	VH	H	H	VH

Table 7.COLLECTION RULES OF 'marketing product 'FUZZY EXPERT SYSTEM

quality	features	packaging	design	Aftersale .service	Lifetime .warranty	product
N	VL	VL	VL	L	VL	VL
VL	N	VL	VL	L	VL	VL
L	L	N	L	L	VL	L
N	L	H	N	N	N	N
VH	VL	H	H	H	H	H
......	......	......	....	....	....	....
H	VH	VH	H	VH	VH	VH

Table 8.COLLECTION RULES OF 'marketing promotion' FUZZY EXPERT SYSTEM

Personal .sale	Pictorial .sale	Radio .sale	Newspaper .sale	Poster .sale	Caption .poster.sale	Award .sale	promotion
VL	VL	VL	N	VL	L	VL	VL
L	L	VL	N	L	L	L	L
N	N	N	N	VL	H	N	N
H	H	H	VH	N	H	H	H
....	....	....	....	....	....	....	....
VH	VH	VH	H	VH	VH	H	VH

The accuracy of α rules should be clarified at this stage. Firstly, the minimum amount of each rule is recognized and then the maximum amount between them is chosen. For instance (Export.drop.shippers =2.2, export. merchants =6.6, ETC =3.5, manufacturer.export.agent =3.5, EMC =5.2. export. brokers =6) make rules 22 and 23 active.

$$\alpha_{22} = \min(VL, N, L, L, M, M)$$
$$\alpha_{22} = \min(0.2,0.2,0.17,0.34,0.8,0) = 0.17$$

$$\alpha_{23} = \min(L, H, N, N, H, H)$$
$$\alpha_{23} = \min(0.8,0.4,0.625,0.25,0.13,0.66) = 0.13$$

Using the mamdani inference (max, min), the system's membership function is:

$$\max(\alpha_{22}, \alpha_{23}) = \max(0.17,0.13) = 0.17$$

Inference rules for the variables and the output are as follows:

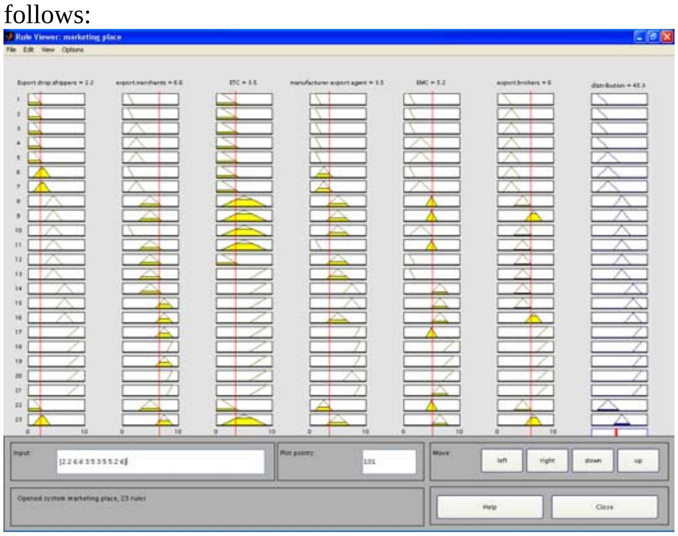

Fig 13.Rule viewer marketing place

For instance (Request. inducement =2.8, Price .importance =7.5, price. quality =5, price. adversary =7.2, specific. clientele =5, Price .cast =6.5, Price .without=1) make rules 6 and 28 active.

$$\alpha_{6} = \min(VL, M, N, N, L, M, L)$$
$$\alpha_{6} = \min(0.1,0.5,1,0.45,0,0.167,1) = 0.1$$
$$\alpha_{28} = \min(L, H, N, H, M, H, L)$$
$$\alpha_{28} = \min(0.9,0.4,1,0.1,0.5,1,1) = 0.1$$
$$\max(\alpha_{6}, \alpha_{28}) = (0.1,0.1) = 0.1$$

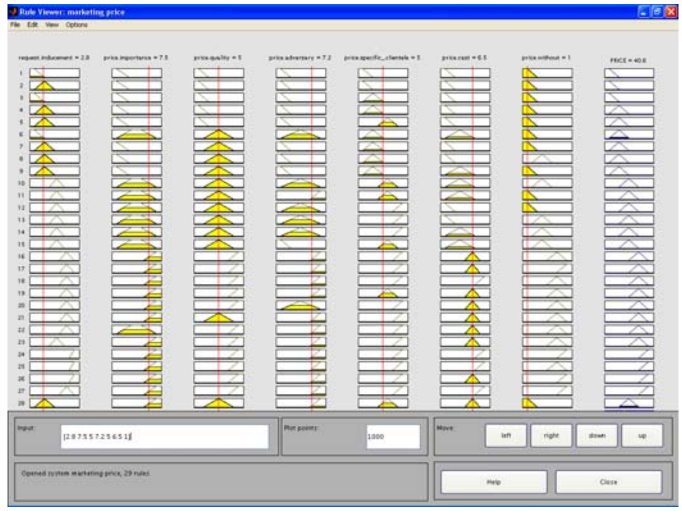

Fig 14. Rule viewer marketing price

For instance (quality =4, features =8.1, packaging =6.3, design =7.5, aftersale.service =9, Lifetime. warranty =7.5) make rules 56 and 71 active.

$$\alpha_{56} = \min(N, H, N, H, N, M)$$
$$\alpha_{56} = \min(0.75,0.225,0.85,0.5,0,0.375) = 0$$
$$\alpha_{71} = \min(N, VH, H, VH, H, H)$$
$$\alpha_{71} = \min(0.75,1,0.13,0.25,1,0.75) = 0.13$$
$$\max(\alpha_{56}, \alpha_{71}) = \max(0,0.13) = 0.13$$

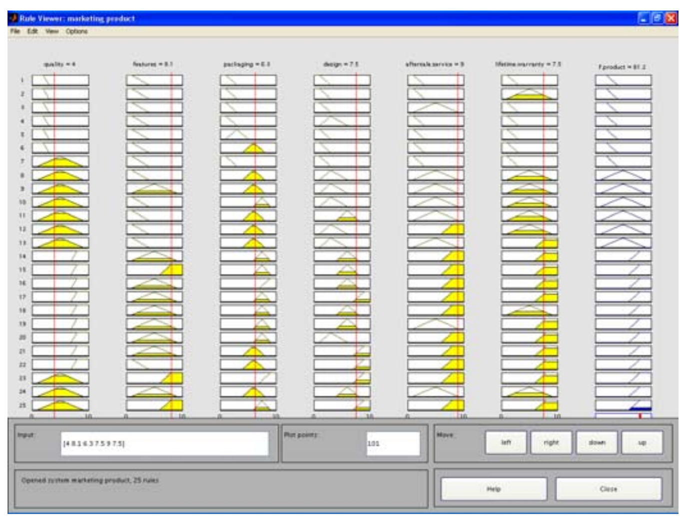

Fig 15.Rule viewer marketing product

For instance (personal. sale=7, pictorial. sale =6, radio. sale=5, newspaper. sale=4, poster. sale=6, caption.poster.sale=7, award. sale=4.5) make rules 56 and 71 active.

$$\alpha_{74} = \min(N, M, N, L, N, N, N)$$
$$\alpha_{74} = \min(0.33, 0.5, 1, 0, 0.5, 0.5, 0.25) = 0.25$$
$$\alpha_{98} = \min(H, H, N, N, H, H, H)$$
$$\alpha_{98} = \min(0.33, 0.5, 1, 0.75, 0.5, 0.25, 0.25) = 0.25$$
$$\max(\alpha_{74}, \alpha_{98}) = \max(0.25, 0.25) = 0.25$$

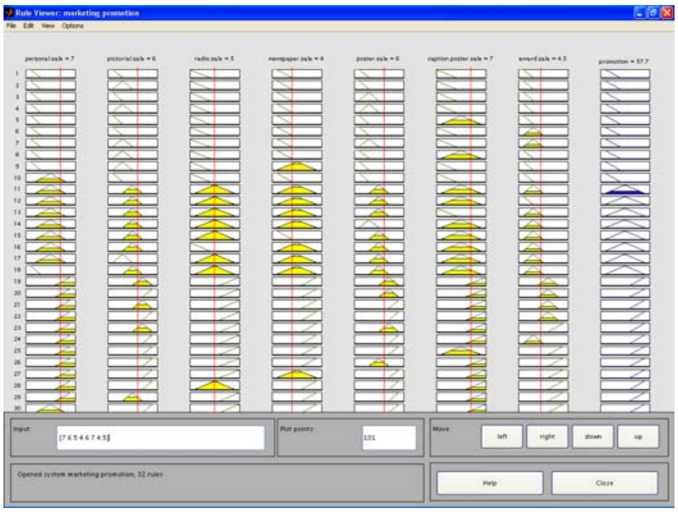

Fig 16.Rule viewer marketing promotion

The fields in final fuzzy expert system are as follows:

For instance (distribution=45.3, price=40.6, product=81.2, promotion=57.7) make rules 6,7,8,14,22 active.

$$\alpha_6 = \min(M, N, M, N)$$
$$\alpha_6 = \min(0.354, 0.53, 0.22, 0.81) = 0.22$$
$$\alpha_7 = \min(L, N, M, N)$$
$$\alpha_7 = \min(0.235, 0.53, 0.22, 0.81) = 0.22$$
$$\alpha_8 = \min(M, L, M, N)$$
$$\alpha_8 = \min(0.354, 0.47, 0.22, 0.81) = 0.22$$
$$\alpha_{14} = \min(L, L, H, N)$$
$$\alpha_{14} = \min(0.235, 0.47, 1, 0.81) = 0.235$$
$$\alpha_{22} = \min(M, N, H, N)$$
$$\alpha_{22} = \min(0.354, 0.53, 1, 0.81) = 0.354$$
$$\max(\alpha_6, \alpha_7, \alpha_8, \alpha_{14}, \alpha_{22}) =$$
$$\max(0.22, 0.22, 0.22, 0.235, 0.354) = 0.354$$

As figure ( ) shows, the rate of satisfaction is low if fields of fuzzy expert have high variables. In this system it is obvious that price and distribution filed have a very high affect.

Fig 17.Rule viewer final marketing

4. Conclusions

A mix fuzzy expert system is designed and used to determine the successfulness on marketing based on 4p principle. A fuzzy expert system is designed for each effective field for marketing. It had several inputs and outputs. The results of each four systems input a final fuzzy expert system and show a final logic result through conclusion rules. This result would be considered as an important parameter for experts in marketing that they use it. Any inconvenience on marketing and management will cause several irreparable damages in economy. Therefore, due to marketing risk and its fuzzy nature and meeting the customers having variable behaviors, using this system could be found as a very effective help to prevent the damages. This system applying knowledge and experience of marketing experts could be equipped with very strong inference rules to have very useful and careful results. Comparing the operation of the experts and simulating different situations in the market, this system showed very good result by 91.5% accuracy.

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