MODELING A DECISION SUPPORT TOOL: A PREFERRED CLIENT APPROACH

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Abstract

Finance encompasses all types of quantifications of risk under conditions of uncertainty for the purpose of finding new business partners/customers in banking sector. Traditional banking methodologies have been build upon certain information type models, and are often driven by stringent rules and regulations of the banking business. Deregulation and global/local competition of the last two couple of decades, the banking sector has also engaged to modern business in addition to their traditional duties. This has created a complex environment and new challenges and has opened for new methodologies. The fuzzy logic is one of the modern techniques that can be applied to study the uncertainty behavior. Here, the fuzzy techniques for classification of customers based on risk are discussed using a simple example. This paper is organized in the following order. First, introductory remarks of finance and banking are briefed, the basic definitions of fuzzy logic are presented, and applied to provide a flexible definition of "a preferred client" in banking sector. Next, the fuzzy decision making criteria is presented based on preferred client approach. Finally, concluding remarks are presented. The purpose of the proposed model/technique is to evaluate and rank the business partner/customer and to establish decision making index for competitive business.

1.0 Introduction

Originate of the word finance; there is evidence that it is old as human life on earth. It was originally a French word and it was adapted by English communities to mean "the management of money". Today, finance is not merely a word else has emerged into an academic and professional discipline of greater significance. In modern world, Finance is an art of managing various available resources like money, assets, investments, securities, etc. Finance is a prerequisite for obtaining physical resources, which are needed to perform productive activities and carrying business operations such as sales, pay compensations, reserve for contingencies (unascertained liabilities) and so on. Hence, Finance has now become an organic function and inseparable part of our day-to-day lives. Today, it has become a word which we often encounter on our daily basis.

Prospectors of Finance in different views provide us great diversity of the field of finance.Prospectors of Finance in different views provide us great diversity of the field of finance.

- **General** sense, "Finance is the management of money and other valuables, which can be easily converted into cash."
- **Experts**, "Finance is a simple task of providing the necessary funds (money) required by the business entities like companies, firms, individuals and others on the terms that are most favorable to achieve their economic objectives."
- **Entrepreneurs**, "Finance is concerned with cash. It is so, since, every business transaction involves cash directly or indirectly."
- **Academicians**, "Finance is the procurement (to get, obtain) of funds and effective (properly planned) utilization of funds. It also deals with profits that adequately compensate for the cost and risks borne by the business."

Finance is the life blood of trade, commerce, and industry. Modern days banking sector acts as the backbone of modern business. The development of any country mainly depends upon the banking system.

The term bank is either derived from old Italian word *banca* or from French word *banque* both mean a bench of money exchange table. In early days, European money lenders or changers used to display (show) coins of different countries in big heaps on benches or tables for the purpose of lending or exchanging.

2.0 Motivation

Today, in competitive market, bank is a major body to take main decision to run economical activities. Bank acts as main decision maker/taker. Decision-making is an essential aspect of modern finance and banking sector. Financial decisions are important as they determine both individuals and institutional/countries actions. A decision may be defined as "a course of action which is consciously chosen from among a set of alternatives to achieve a desired result." It represents a well-balanced judgment and a commitment to action. Financial decision-making is an indispensable component of the banking sector and bankers point of views.

In the modern world, bankers are professionals who identify new business strategies, design new financial products and engage in decision making process via client/customer/partner agreements in uncertain environment. One part of the work of a banker is the evaluation of the customers/partners to

- issue credit card and to finalize credit limit,
- issue business loan and to finalize loan amount and duration.
- finalize current account credit limit,
- engage to joint business project, and etc.

In all these activities, the banker should act as the decision maker. Through, this decision making process a banker automatically connects to financial market. Which means a banker faces uncertainty due to unpredictability of various economical/financial factors influencing his decision. Markets are dynamic and there are many complex factors and complicated relationships that influence indexes, currencies and commodities make decision process complicated and risky. Since, the banking sector business is mainly based on customers, understanding the client and being able to predict what will happen in near future are the key skills that every successful banking professional has to have. This paper uses a simple model with a few variables that provides the simple technique to evaluate and rank the clients and to construct preferred client index which can be used as a valuable decision making support tool.

3.0 Fuzzy Logic

In 1965, Zadeh published a paper entitled "Fuzzy Sets" in a journal known as Information and Control, introducing for the first time sets of objects whose boundaries are not sharply defined. This paper enhanced an enormous interest among researchers, and initiated the fulgurant growth of a new & discipline of mathematics, fuzzy set theory. In an early stage, the electronic engineers used fuzzy concept for their field. Today, applications of fuzzy logic that are to be found in linguistics, risk analysis, artificial intelligence (approximate reasoning, expert systems), pattern analysis and classification (pattern recognition, clustering, image processing, computer vision), reformation processing, and decision making processing in the field of medicine, finance, actuarial, insurance and etc. In this paper, we explore possible application of fuzzy set theory to banking sector by taking one example,

3.1 Fuzzy vs. Non Fuzzy

In traditional logic, an element is either contained or not contained in a given set. The transition from membership to non-membership is abrupt. Fuzzy sets, on the other hand, describe sets of elements or variables whose limits are ill-defined or imprecise. The transition between membership and non-membership is gradual: an element can "more or less" belong to a set. Consider to answer question like "How was the yesterday dinner?" If you were given only two choices (like in traditional logic, IN or OUT) "GOOD" and "BAD" to select it may be lead to over value or devalue the nature of dinner. Taking decision based on these collected data with information lost would increase the strength of the uncertainty. Instead of this IN/OUT criteria, fuzzy logic provides more flexibility environment to reduce the information lost. In this particular example nature of the dinner can be defined as VERY GOOD, GOOD, SATIESFACTORY, BAD and VERY BAD. Defending of the problems, more information can be included and by assigning numerical values to each component, the value can be computed numerically.

3.1.1 Tipping Example

Consider another example which is known as tipping problem. What is the right amount to tip your waitperson? Simple non-fuzzy approaches is assign a number between 0 and 10 that represents the quality of service at a restaurant (where 10 is excellent) and compute the tip based on quality. We consider the following different cases to compute the tip.

- The tip is always equals to 15% of the total bill (see Fig 1).
  This relationship does not take into account the quality of the service, so we need to modify this. Because service is rated on a scale of 0 to 10, we might have the tip go linearly from 5% if the service is bad to 25% if the service is excellent.

- **TIP= 0.20/10*SERVICE+0.05** (see Fig 1)
  The formula does what we want it to do, and is straightforward. However, we may want the tip to reflect the quality of the food as well. This extension of the problem is defined as follows.

Assign numbers between 0 and 10 (where 10 is excellent) that respectively represent the quality of the service and the quality of the food at a restaurant and compute the tip based on quality of service as well as food.

- **TIP = 0.20/20*(SERVICE + FOOD)+0.05** (see Fig 1)
  In this case, the results look satisfactory, but when we look at them closely, they do not seem quite right. Suppose we want the service to be a more important factor than the food quality. Specify that service accounts for 80% of the overall tipping grade and the food makes up the other 20%.

- Weight=0.8;
  TIP=Weight*(0.20/10*SERVICE+0.05) + (1-Weight)*(0.20/10*FOOD+0.05) (see Fig 2)
  The response is still somehow too uniformly linear.

All the above approaches, we are too far from reality. In reality, we may take decision based on combine effect of service and food factors. Therefore, we need to capture the essentials of this problem, leaving aside all the factors that could be arbitrary. If we make a list of what really matters in this problem, we might end up with the following rule descriptions.

- **Service Factor**
  - If service is poor, then tip is cheap
  - If service is good, then tip is average
  - If service is excellent, then tip is generous

- **Food Factor**
  - If food is rancid, then tip is cheap
  - If food is delicious, then tip is generous

Now we can combine the two different lists of rules into one tight list of three rules like so.

- **Both Service and Food Factors**
  - If service is poor or the food is rancid, then tip is cheap
  - If service is good, then tip is average
  - If service is excellent or food is delicious, then tip is generous

These three rules are the core of our solution (see Fig 2). Of course, we can define more rules depending on our choices. This means decision maker has flexibility to capture real phenomena up to certain extend. Coincidentally, we have just defined the rules for a fuzzy logic system in discrete version.

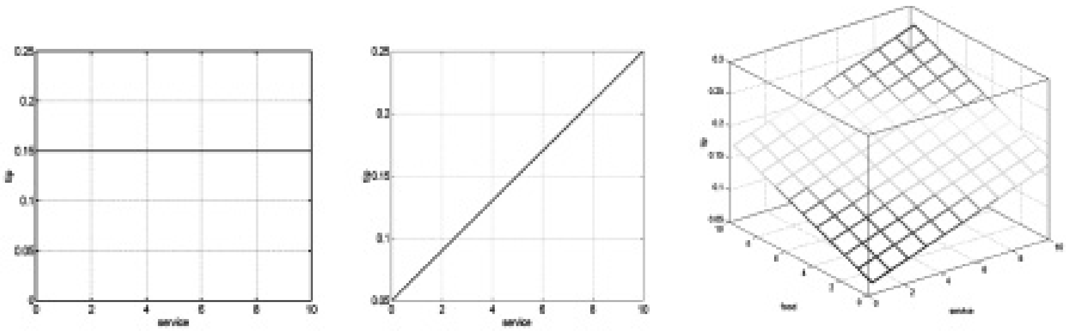

Fig 1: Tip=15% (left), Tip= 0.20/10*SERVICE+0.05 (middle), Tip=0.20/20*(SERVICE + FOOD)+0.05 (right).

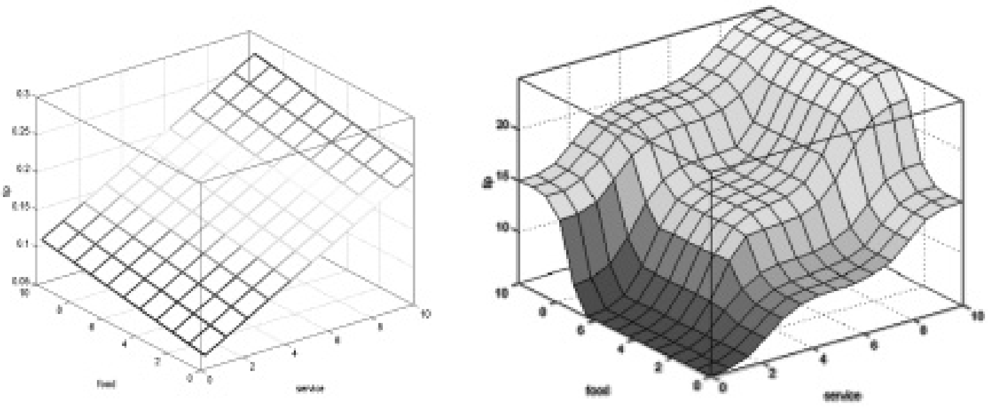

Fig 2: TIP=Weight*(0.20/10*SERVICE+0.05) + (1-Weight)*(0.20/10*FOOD+0.05) (left), Fuzzy approach (right).

3.1.2 Linguistic Variable "age"

Consider for instance a set of "young". We know age is one of the important parameter in finance and insurance sector. For example, in life insurance and automobile insurance premiums may depend on age. In traditional logic, it is assumed that any individual either belongs or does not belong to the set of young. This implies that the individual will move from the category of "young" to the complementary set of "not young" overnight. Fuzzy set theory allows for grades of membership. Depending on the specific application, one might for instance decide that individuals under 24 are definitely young, that individuals over 32 are definitely not young, and that a 20-year-old individual is "more or less" young, or is young with a grade membership of 0.7, on a scale from 0 to 1. Unlike, traditional logic, fuzzy techniques allow us to take reliable decision. Here "young" is the one of fuzzy set of the linguistic variable "age". The other possible fuzzy sets are "child", "teenage", "mid age", "old" etc. The following way the other sets can be defined.

- Child (0, 8, 12)
- Teen age (10, 16, 20)
- Young (16, 24, 32)
- Mid age (30, 40, 50)
- Old (48, 60, 70)
- Oldest (60, 80, 110)

Fig 3: shows membership functions of variable age. It is clear understood, these functions are reliable in terms of biologically too. For example, at age 10 some are still in childhood but some are in teen age. This uncertainty can be captured using fuzzy techniques.

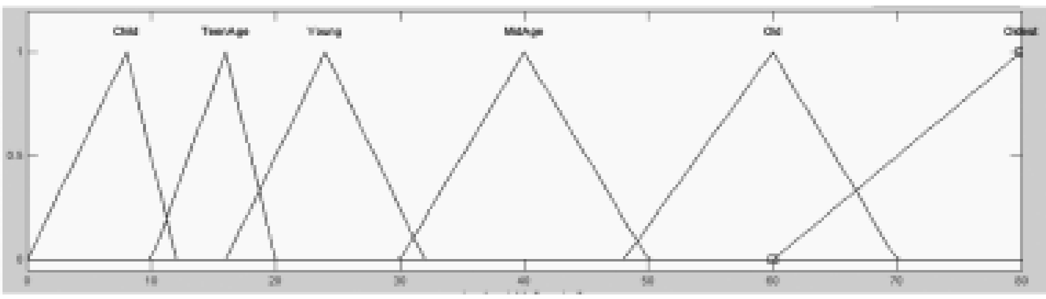

Fig 3: Membership functions of variable "age".

3.2 Fuzzy vs. Probability

A clear distinction has to be made between fuzzy sets and probability theory. Uncertainty should not be confused with imprecision Probabilities are primarily intended to represent a degree of knowledge about real entities, while the degrees of membership defining the strength of participation of an entity in class are the representation of the degree by which a proposition is partial true. Probability concepts are derived from considerations about the uncertainty of propositions about the real world. Fuzzy concepts are closely related to the multivalued logic treatments of issues of imprecision in the definition of entities. Hence, fuzzy set theory provides a better framework than probability theory for modeling problems that have some inherent imprecision.

4.0 Definition of Preferred Client

Heavy competition in USA and Europe finance/banking sector resulted a greater subdivision of customers/clients to award substantial discounts/facilities/credit limit to various professionals. Based on these, basic concept of preferred client was begun. Depending on decision makers purpose once can define preferred client who has

- asset not less than certain millions,
- annual income/profit not less than certain millions,
- debt ratio within specific limit,
- good loan recovery records during last 10 years,
- good credit card recovery records during last 10 years.
- Of course, decision maker can include many more factors according his/her choices/ requirements.

4.1 Modeling Preferred Client

For simplicity, consider the problem to identify (rank) a suitable business partner (among many clients). This can be considered as to start joint project or to issue business loan. We define X be a set of prospective client, $x = x(t_1, t_2, t_3, t_4)$. For simplicity, assume that the requirements for the status of "preferred client" will be based on the values taken by four factors:

- t_1 : total asset in millions
- t_2 : annual income/profit in millions
- t_3 : the ratio (in %) of the effective debt ratio to the recommended debt ratio
- t_4 : number of bad records in last five years.

Unlike classical approach, in fuzzy logic approach, the membership functions have to define for all criteria.

4.1.1 Membership Functions

Considering past data/experiences and/or gathering expertise knowledge/experiences the membership functions can be defined. Fuzzy techniques allow estimating the parameters utilizing expertise ideas, knowledge and experiences. Modeling the behavioral patterns is highly risky and challengeable task due to uncertainty. Utilizing of expertise knowledge and the experiences is a simple way to mitigate the risk due to uncertainty in such kind of problems. We could utilize expertise knowledge and experiences to define the membership functions. For simplicity, here we use the following membership functions.

The fuzzy set A of the individuals with a level of assets can then be defined by the membership function $\mu_A(x, t_1)$.

$$\mu_A(x,t_1) = \begin{cases} 0 & t_1 \leq 200 \\ 2\left(\frac{t_1 - 200}{40}\right)^2 & 200 < t_1 \leq 220 \\ 1 - 2\left(\frac{t_1 - 240}{40}\right)^2 & 220 < t_1 \leq 240 \\ 1 & 240 < t_1 \end{cases}$$

The fuzzy set B of the individuals with a level of profits can then be defined by the membership function $\mu_B(x, t_2)$.

The fuzzy set C of the individuals with a level of debt ratio can then be defined by the membership function $\mu_C(x, t_3)$. Over debt and under debt individuals have to consider as low preference levels. This reflected in the asymmetric membership function.

Remark: These membership functions should be defined after consultation of expertise experiences and/or decision makers' choices. Here, we use arbitrary values to construct membership functions.

$$\mu_B(x,t_2) = \begin{cases} 0 & t_2 \leq 130 \\ 2\left(\frac{t_2 - 130}{40}\right)^2 & 130 < t_2 \leq 150 \\ 1 - 2\left(\frac{t_2 - 170}{40}\right)^2 & 150 < t_1 \leq 170 \\ 1 & 170 < t_1 \end{cases}$$

$$\mu_C(x,t_3) = \begin{cases} 0 & t_3 \leq 60 \\ 2\left(\frac{t_3 - 60}{25}\right)^2 & 60 < t_2 \leq 72.5 \\ 1 - 2\left(\frac{t_3 - 85}{25}\right)^2 & 72.5 < t_1 \leq 85 \\ 1 & 85 < t_3 \leq 110 \\ 1 - 2\left(\frac{t_3 - 110}{25}\right)^2 & 110 < t_1 \leq 120 \\ 2\left(\frac{t_3 - 110}{25}\right)^2 & 120 < t_1 \leq 130 \\ 0 & 130 < t_3 \end{cases}$$

Not necessarily consider all factors as fuzzy. Sometimes, we can use in/out concept if necessary. For example, if one bad record is sufficient to consider individual as not preferred client it can be considered as traditional in/out set.

The non fuzzy set D of the individuals with no bad records can then be defined by the membership function $\mu_D(x, t_4)$.

$$\mu_D(x, t_4) = \begin{cases} 1 & t_4 = 0 \\ 0 & t_4 > 0 \end{cases}$$

The four selected membership functions are represented in Fig 4.

5.0 Combine Effect

The fuzzy set E of the good records individuals with high assets, acceptable annual income and adequate debt ratio is the intersection of the 3 fuzzy sets A, B, C, and the non fuzzy set D. Its membership function is given by:

$$\mu_E(x, t_1, t_2, t_3, t_4) = \min(\mu_A(x, t_1), \mu_B(x, t_2), \mu_C(x, t_3), \mu_D(x, t_4)).$$

It is very clear any individual gets full membership if he has no bad records and has assets, annual income and debt ratio at acceptable range. Of course, interesting problem is how we can find the degree of membership when individual does not have full membership. Consider the individual without bad records, with an asset 230 million, an annual income 155 million and who is having over debt by 12% ($x = x(230,155,112,0)$).

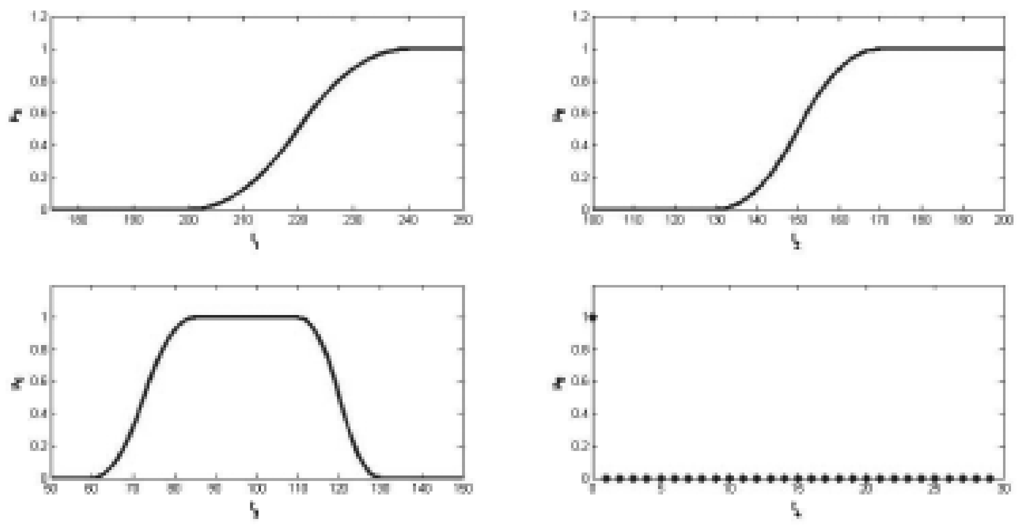

Fig 4: Membership functions for preferred client.

The degree of membership of the individual is

$$\mu_E(x, 230,155,112,0) = \min(0.875,0.71875,0.98,1) = 0.71875.$$

In other words, the combine operation assigns a degree of membership that corresponds to the most severe of the infringements to "perfection", in this case annual income. Cumulative effects and interactions between the criteria are ignored, which is not realistic. Cumulative effect is so much important it will decrease the rank of the client in terms of preferred. Also, since only the most severe condition is considered, it is impossible to introduce compensations or trade-offs in decision rules.

5.1 Defining Realistic Model

The minimum operator that characterizes the intersection corresponds to the "logical and". Other definitions of the intersection have been suggested, they correspond to "softer", more flexible interpretations of the connective "and ". They all amount to exactly the same in the conventional case of degrees of membership restricted to 0 and 1. The selection of a specific operator will depend on its possibilities to allow for cumulative effects, interactions, and compensations between the criteria. We wish the following requirements to be satisfied.

Requirement I : (cumulative effects): Two infringements are worse than one. i.e. $\mu_{A\cap B}(x) < \min\ (\mu_A(x), \mu_B(x))$

Requirement II : (interactions between criteria): Assume $\mu_A(x) < \mu_B(x)$. Then the effect of a decrease of $\mu_A(x)$ on $\mu_{A\cap B}(x)$ may depend on $\mu_B(x)$.

Requirement III : (compensations between criteria): The effect of a decrease $\mu_A(x)$ on $\mu_{A\cap B}(x)$ can be erased by an increase of. $\mu_B(x)$.

5.1.1 New Operations

Now, we consider the following four operations.

- The **algebraic product** *F* of *A* and *B* is denoted *AB* and is defined by

$$\mu_{AB}(x) = \mu_A(x)\mu_B(x).$$

- The **bounded difference** *G* of *A* and *B* is denoted $A \ominus B$ and is defined by

$$A \ominus B = \max\,(0, \mu_A(x) + \mu_B(x) - 1).$$

- The **Hamacher operator** *H* defines the intersection of two fuzzy sets *A* and *B* by

$$\mu_H^p(x) = \frac{\mu_A(x)\mu_B(x)}{p + (1-p)(\mu_A(x) + \mu_B(x) - \mu_A(x)\mu_B(x))}, \qquad 0 \le p \le 1.$$

- The **Yager operator** *Y* defines the intersection of two fuzzy sets *A* and *B* by

$$\mu_Y^p(x) = 1 - \min\left(1, \left((1-\mu_A(x))^p + (1-\mu_B(x))^p\right)^{\frac{1}{p}}\right), \qquad p \ge 1.$$

The generalized operators provide a more realistic way of modeling this specific problem because they explicitly allow for compensations and interactions between the selected criteria. First consider algebraic product:

$$\mu_F(x, 230,155,112,0) = \quad (0.875)(0.71875)(0.98)(1) = 0.6163.$$

The effect of low assets is here amplified by the presence of over debt ratio and a low annual income. This operator satisfies all three properties.

Consider bounded difference:

$$\mu_G(x, 230,155,112,0) = \quad \max(\,0, 0.875 + 0.71875 + 0.98 + 1 - 3) = 0.57375.$$

5.1.2 Decision Makers Choice

The minimum and algebraic product operators model two extreme situations. The minimum operator does not satisfy any property. Due to that compensations and interactions cannot be introduced. The algebraic product allows for compensation and maximum interaction, since the effect of one criterion fully impacts the others. The Hamacher and Yager operators model intermediate situations, with flexibility provided by the parameter *p*.

The Hamacher operator reduces to the algebraic product when $p = 1$. For $p < 1$, the denominator is less than 1 hence Hamacher provides higher membership degree than algebraic product. The product operator is "softened"; this operator models weaker interactions. It reduces the effect of combined infringements. The reduction effect is greater for severe infringements. Also, the lower the selected *p*, the greater the reduction effect. Hence this operator can be used if it is considered that the combined effect of two factors is somewhat less than multiplicative. Fig 5: shows the variation of the degree of membership with respect to parameter *p*. This model is very interesting because this provides some sort of flexibility to decision maker to change the degree of membership by choosing suitable *p*.

The Yager operator reduces to the bounded difference operator when $p = 1$, and to the minimum operator when $p \to \infty . \mu_Y^p(x)$ is an increasing function of *p*. Hence, all intermediate situations can be modeled, from the strongest to the weakest. Fig 6: shows the variation of the degree of membership with respect to parameter *p*. This model is also very interesting because this too provides some sort of flexibility to decision maker to change the degree of membership by choosing suitable *p*.

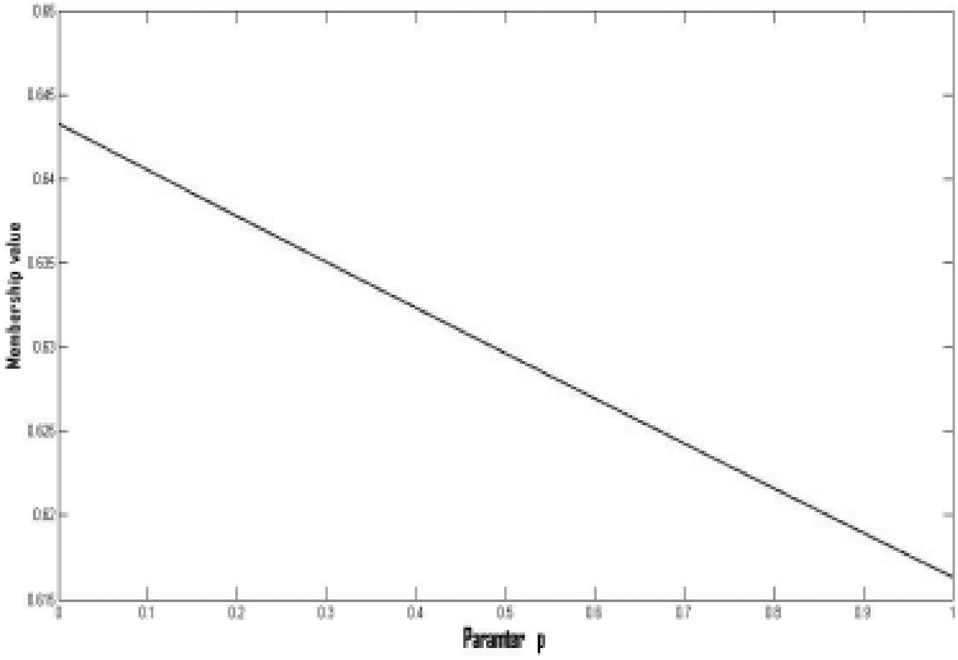

Fig 5: The variation of the degree of membership with respect to parameter *p* (Hamacher Operator).

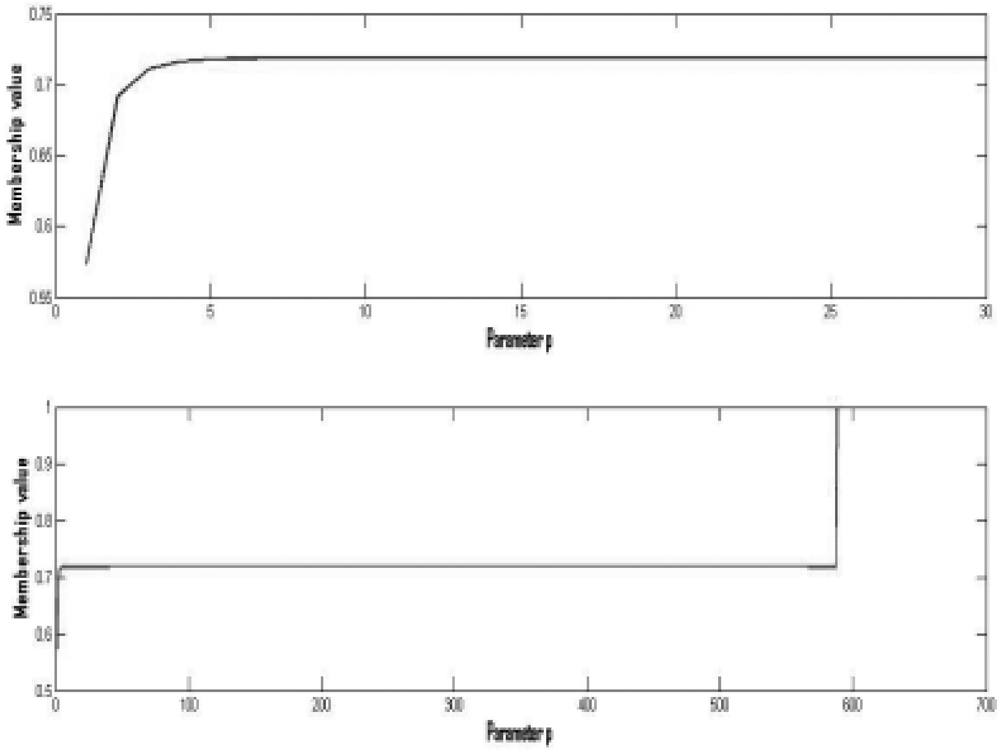

Fig 6: The variation of the degree of membership with respect to parameter *p* (Yager Operator)

6.0 Conclusions

Fuzzy logic techniques can be used to model uncertain behavior. Unlike, complex models/ formulas, fuzzy logic allow to gather the expertise experiences/ideas which is essential in the field of finance and banking. The proposed model is just an example to show the power of fuzzy logic and it can be updated based on professionals' experiences/knowledge. Hamacher and Yager models provide more flexibility so that the decision maker can take different strategies just playing with parameter "*p*".

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