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Soft Computing in Financial Decision Making

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Abstract

Managing organizational resources is a complex and difficult task at the hands of the managers. Finance, being one of those many resources, is the 'lifeblood' of any organization; hence its efficient and effective management is even more important. Decisions related to financial matters conventionally involve quantitative analysis and interpretation of facts and figures. These analyses are crisp and discrete in nature, and hence may not always lead to appropriate, pragmatic conclusions. Parameters involved in decision making process are more often than not, beyond the boundaries of numeric figures. Unlike the conventional (hard) computational techniques, soft computing includes provisions for approximations, partial truth, uncertainty and imprecisions. Soft computing primarily constitutes Fuzzy Logic (FL), Neural Computing (NC), Evolutionary Computing (EC), Machine Learning (ML), and Probabilistic Learning (PL). The idea behind soft computing is to model cognitive behavior of human mind. Soft computing is well suited for real world problems where ideal models are not available. This makes application of soft computing in financial decision making even more purposeful as it involves too many parameters for consideration and hence very complex to solve using conventional statistical techniques. This paper is an effort to put forward a completely conceptual model using Fuzzy Logic Control (FLC) and the Euclidean Distance concept to assist managers in making financial decisions in particular, and other management decisions in general.

Keywords: Soft computing, fuzzy logic, financial decision making, Euclidean distance.

1. Introduction

During the early 90s, Lotfi A. Zadeh, professor of Computer Science at the University of California in Berkeley coined the term “soft computing” and defined it as: "Basically, soft computing is not a homogeneous body of concepts and techniques. Rather, it is a partnership of distinct methods that in one way or another conform to its guiding principle. At this juncture, the dominant aim of soft computing is to exploit the tolerance for imprecision and uncertainty to achieve tractability, robustness and low solutions cost. The principal constituents of soft computing are fuzzy logic, neurocomputing, and probabilistic reasoning, with the latter subsuming genetic algorithms, belief networks, chaotic systems, and parts of learning theory. In the partnership of fuzzy logic, neurocomputing, and probabilistic reasoning, fuzzy logic is mainly concerned with imprecision and approximate reasoning; neurocomputing with learning and curve-fitting; and probabilistic reasoning with uncertainty and belief propagation".

The concept of Fuzzy Logic was propounded by Zadeh in his seminal work “Fuzzy sets,” which described the mathematics of fuzzy set theory in the year 1965. In his words, “Computing, in its usual sense, is centered on manipulation of numbers and symbols. In contrast, Computing with Words (CW) is a methodology in which objects of computation are words and propositions drawn from natural language. There are two major imperatives for computing with words. First computing with words is a necessity when the available information is too imprecise to justify the use of numbers; and second, when there is tolerance for imprecision which can be exploited to achieve tractability, robustness, low solution cost and better rapport with reality”.

Fuzzy Logic (FL) basically is a multivalued logic that has provisions for values to be defined between conventional evaluations like true/false, yes/no, high/low, good/bad, beautiful/ugly, etc. So, unlike the conventional logic (also known as crisp logic or discrete logic), fuzzy logic provides greater scope for evaluation of situations which are closer to the real world. This featured potential of fuzzy logic in today’s modern era provides it a place in the areas like automobile engines& automatic gear control systems, air conditioners, automatic focus control, video enhancement in TV sets, washing machines, behaviour-based mobile robots, sorting and handling data, image processing,motion control systems, decision support, traffic control systems and many others. Its significance and applications have grown manifolds and today fuzzy logic is not restricted to only engineering and other technological fields, but also to the field of management as a decision support system.

2. Fuzzy Logic Control (FLC) in Decision Making

Any system is basically an “Input-Output” model. To evaluate the capability of the system is to analyze the efficiency (or economic worth) of the process of the input-output based on the established goals and industrial peripheral equipment. Activities such as technologies, systems and/or subsystems including Computer Integrated Manufacturing (CIM), Computer Aided Designing (CAD), Computer Aided

Manufacturing (CAM), profits, brand equity, market share, etc. are usually in the transform process. Therefore, to evaluate an integrated system is to systematically assess all these technologies, systems and/or subsystems. However, due to the difficulty in collecting data and lack of objective evaluation standards, it is very hard to quantitatively and efficiently assess these activities. Nowadays, financial tools like Capital Budgeting, Payback Period, Net Present Value, Internal Rate of Return, Benefit-Cost Ratio,etc. are being applied to analyze economic worth of the activities stated above.During the past few years, Fuzzy Logic Control (FLC) has emerged as one of the most active fields for research in the applications of fuzzy set theory. The literature in FLC has been growing rapidly in recent years, making it difficult to present a comprehensive survey of the wide variety of applications that have been made. Fuzzy logic is very much closer in spirit to human thinking and natural language than the traditional logical systems and provides an effective means of capturing the approximate, inexact nature of the complex systems. The essential part of the FLC is a set of linguistic control rules related by the dual concepts of fuzzy implication and the compositional rule of inference. In essence, then, the FLC provides an algorithm which can convert the linguistic control strategy based on expert knowledge into an automatic control strategy. These give the idea to apply FLC to support the implementation of the evaluation of integrated financial capability for industrial companies of the same kind. With the exception of projects which deal with the utilization of fuzzy control in the context of complex processes that can be controlled by a skilled human operator without the knowledge of their underlying dynamics, this paper represents the first application of FLC to the evaluation problem of financial capability in the phase of decision-making. A conceptual evaluation model is developed and demonstrated.

3. Model Development

For the sake of model development, four hypothetical companies belonging to the telecom sector are considered and out of many possible parameters of success, only four randomly selected key activities are taken in to account to evaluate the financial capability of those companies, and on them FLC will be applied.Please take a note that the values and variables taken up here are all imaginary. The sole intension behind it is to create a generic model which may later be customized and reproduced to suite real-time requirements. The following steps are involved in the development of the model:

Step 1: Let the selected key parameters involved for financial decision making are:a)Brand equityb)Profitc)Current ratio, and d)Market share. Though there can be a number of other important activities required for financial decision making, these four activities are selected on simple random basis for the model development purpose only. Likewise if needed, more activities may be added for evaluation. The only thing which will vary is the complexity of calculation.

Step 2: Let the four fictitious telecom service providers randomly chosen be:a) Airwave mobile b) Matrix Cellularc) NTC Mobile, and d) RTalk

Step 3: In this step, the key activities and the capabilities of companies need to be assigned the fuzzy linguistic variables and those variables will be assigned fuzzy values.Here, each of the four activities needs to be assigned priorities. These priorities will be assessed linguistically by selecting values of the variable X = importance.The indicators of the level of importance of the activities may be obtained by interviews of executives from the respective companies and also through the questionnaires specially designed for the purpose, and from some secondary sources of information as well. The findings of assessment of activities are shown in table:

Table 1: Fuzzy linguistic priorities for activities.

Activities xi	**Brand equity**	**Current ratio**	**Profit**	**Market share**
Fuzzy Linguistic Assessment (variable value, xi)	Very important (x2)	Not important (x4)	Very very important (x1)	Important (x3)

Now, the compatibility functions (membership values) regarding different values of "important" for different key activities can be found from study through questionnaires and secondary data. The fictitious figures are tabulated as follows:

Table 2: Compatibility function for x_i = important.

Uxi	**Brand equity**	**Current ratio**	**Profit**	**Market share**
uxi	0.8	0.2	1.0	0.5

Table 3: Compatibility function for y_i = strong.

Uyi	**Brand equity**	**Current ratio**	**Profit**	**Market share**
Uyi	0.9	0.5	1.0	0.7

Table 4: Fuzzy linguistic assessments for service capabilities of companies based on activities.

Company→ Activities↓	**Airwave mobile**	**Matrix Cellular**	**NTC Mobile**	**RTalk**
Brand equity (x1)	y1	y2	y3	y2
Current ratio (x2)	y4	y2	y1	y3
Profit (x3)	y1	y3	y4	y2
Market share (x4)	y2	y1	y3	y4

Such inferences maybe drawn from the secondary data and expert knowledge.The compatibility functions of the two primary fuzzy linguistic variables values shown may be represented as follows:

$(C_{S(important)})(u_{important}) = \{0.8, 0.2, 0.9, 0.5\}$

$C_{S(strong)}(u_{strong}) = \{ 0.9, 0.5, 1.0, 0.7\}$

The other variable values with linguistic hedges (e.g. not, very, not very, etc.) cansimilarly be calculated from the primary fuzzy linguistic variable values in Table 1 & 2.

Step 4: According to the fuzzy relation defined in the previous step and the fuzzy control rule defined, the fuzzy control rule, R^k for the companies are derived as follows:

For Airwave Mobile: if x_1 then $y_1 = R^1{}_{11}$

if x_2 then $y_4 = R^1{}_{24}$

if x_3 then $y_1 = R^1{}_{31}$

if x_4 then $y_2 = R^1{}_{42}$

Now, $R^1{}_{11} = x_1 * y_1 =$ [0.4096, 0.0016, 0.6561, 0.0625] [0.6561, 0.06251, 1.0, 0.2401]

$$R^1{}_{11} = \begin{bmatrix} 0.4096 & 0.0625 & 0.4096 & 0.2401 \\ 0.0016 & 0.0016 & 0.0016 & 0.0016 \\ 0.6561 & 0.0625 & 0.6561 & 0.2401 \\ 0.0625 & 0.0625 & 0.0625 & 0.0625 \end{bmatrix}$$

$R^1{}_{24} = x_2 * y_4 =$ [0.64, 0.04, 0.81, 0.25] [0.1, 0.5, 0.9, 0.3] $R^1{}_{24} =$

$$\begin{bmatrix} 0.1 & 0.5 & 0.64 & 0.3 \\ 0.04 & 0.04 & 0.04 & 0.04 \\ 0.1 & 0.5 & 0.81 & 0.3 \\ 0.1 & 0.25 & 0.25 & 0.25 \end{bmatrix}$$

$R^1{}_{31} = x_3 * y_1 =$ [0.8, 0.2, 0.9, 0.5] [0.6561, 0.0625, 1.0, 0.2401] $R^1{}_{31} =$

$$\begin{bmatrix} 0.6561 & 0.0625 & 0.8 & 0.2401 \\ 0.2 & 0.0625 & 0.2 & 0.2 \\ 0.6561 & 0.0625 & 0.9 & 0.2401 \\ 0.5 & 0.0625 & 0.5 & 0.2401 \end{bmatrix}$$

$R^1{}_{42} = x_4 * y_2 =$ [0.2, 0.8, 0.1, 0.5] [0.81, 0.25, 1.0, 0.49] $R^1{}_{42} =$

$$\begin{bmatrix} 0.2 & 0.2 & 0.2 & 0.2 \\ 0.8 & 0.25 & 0.8 & 0.49 \\ 0.1 & 0.1 & 0.1 & 0.1 \\ 0.5 & 0.25 & 0.5 & 0.49 \end{bmatrix}$$

Now, $R^1 = R^1{}_{11}$ □ $R^1{}_{24}$ □$R^1{}_{31}$ □$R^1{}_{42}$ $R^1 =$

$$\begin{bmatrix} 0.2 & 0.0625 & 0.2 & 0.2 \\ 0.0016 & 0.0016 & 0.0016 & 0.0016 \\ 0.1 & 0.0625 & 0.1 & 0.1 \\ 0.0625 & 0.0625 & 0.0625 & 0.0625 \end{bmatrix}$$

Similarly $R^2=\begin{bmatrix} 0.2 & 0.0625 & 0.2 & 0.2 \\ 0.0016 & 0.0016 & 0.0016 & 0.0016 \\ 0.1 & 0.0625 & 0.1 & 0.1 \\ 0.0625 & 0.0625 & 0.0625 & 0.0625 \end{bmatrix}$,

$R^3=\begin{bmatrix} 0.1 & 0.0625 & 0.2 & 0.2 \\ 0.0016 & 0.0016 & 0.0016 & 0.0016 \\ 0.1 & 0.0625 & 0.1 & 0.1 \\ 0.0625 & 0.0625 & 0.0625 & 0.0625 \end{bmatrix}$, &

$R^4=\begin{bmatrix} 0.1 & 0.2 & 0.2 & 0.2 \\ 0.0016 & 0.0016 & 0.0016 & 0.0016 \\ 0.1 & 0.1 & 0.1 & 0.1 \\ 0.0625 & 0.0625 & 0.0625 & 0.0625 \end{bmatrix}$ can be calculated.

Step 5: Now the most desirable values x* = very very important; y* = very very strong may be established and calculation may be preceded further as follows:

$Y_1^* = x^* * R^1 = [0.4096\ 0.0016\ 0.6561\ 0.0625] *$

$$\begin{bmatrix} 0.2 & 0.0625 & 0.2 & 0.2 \\ 0.0016 & 0.0016 & 0.0016 & 0.0016 \\ 0.1 & 0.0625 & 0.1 & 0.1 \\ 0.0625 & 0.0625 & 0.0625 & 0.0625 \end{bmatrix}$$

$Y_1^* = [0.1514\ 0.0705\ 0.1514\ 0.1514]$

Now, it is the time to figure out the relative "Euclidean distance". Euclidean distance determines the gap between the actual performance and the ideally most desirable performance. It is done as follows:

$Y^* = [0.6561\ 0.0625, 1.0, 0.2401]$

$Y_1^* = [0.1514\ 0.0705\ 0.1514\ 0.1514]$

$\varepsilon_1 = d(y^*, y^*_1)$

$= [1/4\ \{(0.6561 - 0.1514)^2 + (0.0625 - 0.0705)^2 + (1 - 0.1514)^2 + (0.2401 - 0.1514)^2\}]^{1/2}$

$\varepsilon_1 = 0.4956$

i.e. the Euclidean distance between the activities of Airwave mobile and the most favourable condition is 0.49567. Similarly, for Matrix cellular, $\varepsilon_2 = 0.4956$, for NTC mobile, $\varepsilon_3 = 0.5064$ and for RTalk, $\varepsilon_4 = 0.5083$.

Thus, from the fuzzy calculation done so far, it is clear that Airwave mobile and Matrix Cellular have the least relative Euclidean distance from the most favourable condition (y*= very very strong) of profit making and hence selected to have the best capability among the four companies based on evaluating the four key parameters.This evaluation is of great importance to all the companies in decision making, keeping in view, what they want to be, and where they actually are. This will also help companies to minimise the gap between the two values and also to assess competitor performance and factors responsible for their current position.

4. Conclusion

Fuzzy logic is very flexible and if required, the calculations may include ‘n’ number of key activities and ‘n’ number of companies. The calculation shown as an illustration will act as a guiding model for the decision makers of any company. This model, with slight modifications, may be used in almost every industry and every type of activity which require appropriate decision making, from manufacturing to distribution, from financing to servicing, etc.Fuzzy linguistic variables can be used in place of discrete numerical to capture the approximate and inexact nature of human thinking and natural language. The characterisation of simple relations between variables by fuzzy conditional statements which are expressed in the form of “if-then” illustrate the relationship between the importance of an activity representing the evaluation system input and the capability of the activity representing the corresponding evaluation system output. The model presented here is still in its infancy and hence leads to possibility of lots of improvements.

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