DIAGNOSING AND CURING BUSINESS PROBLEMS : A FUZZY DECISION SUPPORT MODEL

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ABSTRACT: In this paper, a decision support model is developed in order to diagnose and find out the most appropriate strategy for solving the problem that undermines the business performance. This model is based on fuzzy sets theory. This proposed fuzzy decision support model(FDSM) consists of two sub-models: *a) a model for diagnosing the business problems-the Diagnostic Sub-Model(DSM);* and *b) finding out the most appropriate strategies for overcoming these problems- the Curing Sub-Model(CSM).*

KEYWORDS: Fuzzy sets theory, diagnosing business problems, decision support system, problem solving.

INTRODUCTION

Nowadays almost every manager of business enterprises, no matter in which country or sector they exist, has tremendous problems which are dynamic and complex in nature. To solve these problems efficiently and effectively, first of all, managers have to determine the real reasons that cause the problems. Secondly, they should also decide which technique or strategy is to be the best solution for the problems under consideration . In practice, to make a sound decision on this issue, managers unfortunately must either relay on their past experiences or their consultants experiences.

Therefore, to deal with these problems effectively, managers have to get right information (symptoms) and use them effectively in their decision-making process. But the information provided by the business information systems is usually so complex and ambiguous that in most cases managers have great difficulties in distinguishing the relevant information from irrelevant one. Then, as the complexity of the systems increases, the efficiency of using conventional techniques decreases. Figure 1 which provides a useful insight into this idea. For systems with little complexity, hence little uncertainty, closed-form mathematical expressions provides precise descriptions of the systems. For systems that are a little more complex, but for which significant data exist, model-free methods, such as artificial neural networks, provide a powerful and robust means to reduce some uncertainty through learning, based on patterns in the available data. Finally, for the most complex systems, such as diagnosing business problems where few numerical data exist and where only ambiguous or imprecise information may be available, fuzzy relations provides a way to understand system behavior by allowing us to interpret the relationship between observed symptoms and causes.

In this study, a decision support model is developed in order to diagnose the business problems and find out the most appropriate strategy for solving the problems that undermines the business performance. This model is based on fuzzy sets theory which was developed by Zadeh(1965). It offers a linguistic approach that represents an excellent approximation to vague business information(symptoms).

This study consists of four chapters. In the following chapter, Chapter 2, the structure of the proposed fuzzy decision support model(FDSM) is explained. An illustrative example of the model and conclusion and final remarks are explained in Chapter 3 and Chapter 4, respectively.

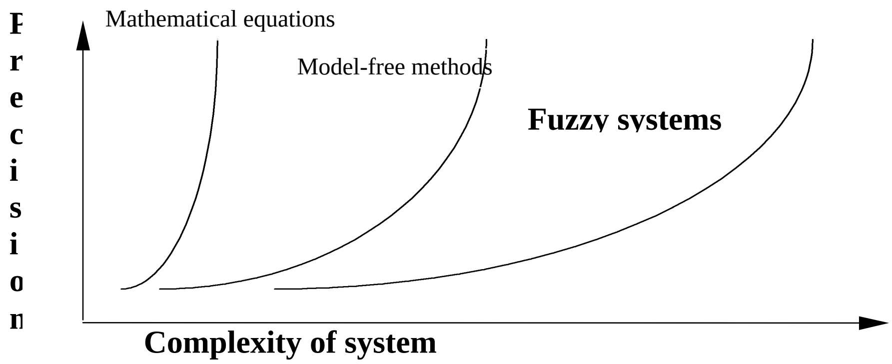

Figure 1: Complexity of a system versus precision in the model of the system[Ross, 1995].

STRUCTURE OF THE MODEL

The methodology used in this study is a modified version of the methodology used by Sanches(1979). This proposed fuzzy decision support model(FDSM) consists of two sub-models: *a) a model for diagnosing the business problems-the Diagnostic Sub-Model(DSM);* and *b) finding out the most appropriate strategies for overcoming these problems- the Curing Sub-Model(CSM).*

DIAGNOSTIC SUB-MODEL

Diagnostic sub-model -DSM is based on development of fuzzy symptom-problem relation matrix, $\tilde{R}$. Fuzzy relation matrix can be established in light of the management consultants' experiences via using Saaty(1980)'s well known Analytic Hierarchy Process method - mainly based on pairwise comparisons of symptoms which are likely to belong the specific business problem. By this matrix, business consultants' knowledge is represented as a fuzzy relation between symptoms and business problems. Thus, given the fuzzy symptoms matrix, $\tilde{D}$, observed in the selected business enterprises and the fuzzy relation matrix, $\tilde{R}$, representing the management knowledge that relates the symptoms sets to the business problems sets, then the fuzzy sets of potential problems matrix of the enterprise, $\tilde{K}$, can be determined by using compositional rule.

$$\tilde{K} = \tilde{D} \circ \tilde{R};$$

$$Z \times X \supset \tilde{D} = \tilde{I} \times \tilde{B}; \qquad X \times Y \supset \tilde{R} = \tilde{B} \times \tilde{S}$$

$$\mu_{\tilde{K}}(z,y) = \max_{x \in X}\left[\min(\mu_{\tilde{D}}(z,x), \mu_{\tilde{R}}(x,y))\right] \qquad (2.1)$$

$\tilde{D}$ denotes fuzzy sub sets of $Z \times X$ Cartesian space; and Z , X stand for crisp universal sets of all businesses and symptoms of business problems respectively. In the literature Equation 2.1 is called as Zadeh's *extension principle.*

$\tilde{R}$ (problem-symptom) and $\tilde{D}$ (company-problem), relation matrixes consist of fuzzy membership values which vary from 0 to 1. Each value in $\tilde{R}$ and $\tilde{D}$ conveys, respectively, the degree of possibility of the presence of relation between problem - symptom pair and company - symptom. These fuzzy membership values can be obtained by using experts experiences, correlation coefficients, neural networks, or genetic algorithm [Ross(1995)].

CURING SUB-MODEL

Setting *the Curing Sub-Mode(CSM)* is more complex then the *DSM* in nature. The core of this model is to establish a fuzzy relation matrix between the set of business problems and solution techniques matrix, $\tilde{J}$. This fuzzy relation matrix could be generated by using both management knowledge and consultants experiences via Saaty's AHP based pairwise comparisons method. Then, the fuzzy relation matrix of the set of the most appropriate solution technique, $\tilde{F}$, would be determined by using compositional rule between vector of problems, $\tilde{K}$,which is output of first stage-*diagnostic sub-model*, and problem-solution matrix, $\tilde{J}$.

$$\tilde{F} = \tilde{K} \circ \tilde{J} \;;$$
$$Z \times Q \supset \tilde{F} = \tilde{I} \times \tilde{P} \;; \quad Y \times Q \supset \tilde{J} = \tilde{S} \times \tilde{P}$$

$$\mu_{\tilde{F}}(z,q) = \max_{y \in Y} \left[\min(\mu_{\tilde{K}}(z,y), \mu_{\tilde{J}}(y,q) \right] \qquad (2.2)$$

AN ILLUSTRATIVE EXAMPLE

To illustrate the model more clearly, we applied the model on a very simple example. Illustrative example, consists only three companies, $z_i \in Z$, and two problems , $y_j \in Y$. And there are two sets of symptoms related to the business problems, $x_k \in X$,and curing strategies, $q_l \in Q$.

$Z=\{z_1, z_2, z_3\}$; $Y=\{y_1, y_2\}$; $X=\{x_1, x_2, x_3\}$; $Q=\{q_1, q_2, q_3\}$;

Problems:y_1 stands for problem experienced in requiring raw materials, and y_2, denotes problems related to managing human resources.
Symptoms:x_1 , x_2 , represent decrease in profit margin and market share, respectively. :x_3 ,denotes the increase in the time period of consumption of raw material inventories.
Strategies: q_1 represent a strategy investing to new technologies; q_2, defines a backward integration with a company engaged in producing raw materials of the company. q_3 , is to direct to new markets.

In the first step, we must find out the fuzzy relations among symptoms and problems, $\tilde{R}$. To this end AHP technique could be used in order for deciding on the relative importance of each pair of symptoms to each problem.

$$X \times Y \supset \tilde{R} = \begin{array}{c} \\ x_1 \\ x_2 \\ x_3 \end{array} \begin{array}{c} \begin{array}{cc} y_1 & y_2 \end{array} \\ \begin{bmatrix} 0.8 & 0.25 \\ 0.5 & 0.10 \\ 0.9 & 0.05 \end{bmatrix} \end{array} ; \; Z \times X \supset \tilde{D} = \begin{array}{c} \\ z_1 \\ z_2 \\ z_3 \end{array} \begin{array}{c} \begin{array}{ccc} x_1 & x_2 & x_3 \end{array} \\ \begin{bmatrix} 0.2 & 0.5 & 0.85 \\ 0.7 & 0.9 & 0 \\ 0.9 & 0 & 0.5 \end{bmatrix} \end{array} ; Y \times Q \supset \tilde{J} = \begin{array}{c} \\ y_1 \\ y_2 \end{array} \begin{array}{c} \begin{array}{ccc} q_1 & q_2 & q_3 \end{array} \\ \begin{bmatrix} 0.5 & 0.9 & 0 \\ 0.5 & 0.5 & 0.5 \end{bmatrix} \end{array}$$

In the second step, by using the same method, the problem-solution matrix, $\tilde{J}$, must be obtained.
Then, by using Eq. 2.1, the fuzzy problems of the three companies, $\tilde{K}$, are determined.
For example:

$$\mu_{\tilde{K}}(z_1, y_1) = \max[\min(0.2,0.8), \min(0.5,0.5), \min(0.85,0.9)] = 0.85$$

$$\tilde{K} = \tilde{D} \circ \tilde{R} = \tilde{K} = \begin{array}{c} \\ z_1 \\ z_2 \\ z_3 \end{array} \begin{array}{c} \begin{array}{ccc} x_1 & x_2 & x_3 \end{array} \\ \begin{bmatrix} 0.2 & 0.5 & 0.85 \\ 0.7 & 0.9 & 0 \\ 0.9 & 0 & 0.5 \end{bmatrix} \end{array} \circ \begin{array}{c} \\ x_1 \\ x_2 \\ x_3 \end{array} \begin{array}{c} \begin{array}{cc} y_1 & y_2 \end{array} \\ \begin{bmatrix} 0.8 & 0.25 \\ 0.5 & 0.10 \\ 0.9 & 0.05 \end{bmatrix} \end{array} = \begin{array}{c} \\ z_1 \\ z_2 \\ z_3 \end{array} \begin{array}{c} \begin{array}{cc} y_1 & y_2 \end{array} \\ \begin{bmatrix} 0.85 & 0.2 \\ 0.7 & 0.25 \\ 0.8 & 0.25 \end{bmatrix} \end{array} = \tilde{K}$$

By using Eq. 2.2, the fuzzy solution for problems of the three companies, $\tilde{F}$, are determined.
For example:
$$\mu_{\tilde{F}}(z_1, q_1) = \max[\min(0.85,0.5), \min(0.2,0.5)] = 0.5$$

$$\tilde{F} = \tilde{K} \circ \tilde{J} = \begin{matrix} & y_1 & y_2 \\ z_1 & 0.85 & 0.2 \\ z_2 & 0.7 & 0.25 \\ z_3 & 0.8 & 0.25 \end{matrix} \circ \begin{matrix} & q_1 & q_2 & q_3 \\ y_1 & 0.5 & 0.9 & 0 \\ y_2 & 0.5 & 0.5 & 0.5 \end{matrix} = \begin{matrix} & q_1 & q_2 & q_3 \\ z_1 & 0.5 & 0.85 & 0.2 \\ z_2 & 0.5 & 0.7 & 0.25 \\ z_3 & 0.5 & 0.8 & 0.25 \end{matrix} = \tilde{F}$$

The next step is to defuzzification of the $\tilde{F}$. In this stage, we can use any defuzzification method which available in the literature[1].
In this example, $\tilde{F}$ is defuzzified by using max-membership rule:

$$\mu_{\tilde{F}}(z^*, q^*) \geq \mu_{\tilde{F}}(z, q))$$

$$F = \begin{matrix} & q_1 & q_2 & q_3 \\ z_1 & 0 & 1 & 0 \\ z_2 & 0 & 1 & 0. \\ z_3 & 0 & 1 & 0 \end{matrix}$$

In accordance with this result, all companies must use the q_2 strategy-i.e. backward integration strategy. Namely, establishing a backward integration with a company engaged in producing raw materials for the company.

CONCLUSION AND FINAL REMARKS

The scope of this study is to propose a fuzzy decision support model(FDSM),which is a new approach in order to solve very complex problems of managers in problem solving, decision making and strategic management issues. And open a discussion platform in academic platform and get feedback on this issue may also be another objective.

To build a sound FDSM depends on several crucial factors: a)establishing a non-complex and relevant relation matrix which is based on both management knowledge, and expert knowledge and experience; b) an appropriate fuzzification and defuzzification method; c)the quality and quantity of information used in the model; d)clearly distinguishing symptoms from problems and e) capacity and time limitation of researchers.

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[1]See Adlassnig(1982),Hallendoorn and Thomas(1993), Ross(1995), Sugeno(1985), Lee(1990).