Research on Models of Decision-making Problem Recognition

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Abstract: - Firstly, this paper introduces the concept of problem identification that is an early stage of decision-making process. The paper proposes that, as a subjective process, problem identification is mainly influenced by people's cognition capability. Actually, the identification process is an evaluation process whose final aim is to evaluate the gap between the reality and the expected condition. Then, according to this feature, the paper establishes a gray incidence degree model and a satisfaction degree model based on response value. Further, the paper validates the models through an example.

Key-Words: - Problem identification, Gray incidence degree model, Satisfaction degree model

1 Introduction

Mintsberg, a well-known expert in artificial intelligence (AI), divides a decision-making process into three stages: problem identification, problem research and making choices. Among them, the stage of problem identification indicates that the decision-makers are worried about or pays attention to the current condition of the system, which means that the deviation of the current system condition from the expected one is no longer bearable for the decision-makers or the organization. This is the most important stage for the whole decision-making process because it directly determines the complexity and success norm of the following two steps (i.e. subsequent problem disposition and plan generation). Nevertheless, most previous relevant research has focused on studying technological and theoretical support to the proposed problems. There is a lack of research studying how to put forward a decision-making problem and what kind of decision-making problem should be put forward [1]. From this perspective, this paper utilizes two models (i.e. gray incidence degree model and satisfaction degree model) to study the identification of decision-making problems.

2 Concept of Decision-making Problem Identification

2.1 Definition of decision-making problems

According to Agre's research in cognition psychology, a problem is a situation that is not expected to appear and attracts wide attention [2]. Although it brings about difficulties, people or an organization can solve it. Accordingly, there are no problems when there are no difficulties. Many researchers take the degree of difficulty as a major basis for judging if there is a problem in current situation. In this research, a problem is a conceptual entity and an abstract of the observed situation. From the perspective of cognitive psychology, a problem is an attention distributor, namely, a problem distributes people's attention to some unsatisfactory situations in reality. If a certain system condition appears to be troublesome, then much more time and attention will be spent on eliminating the unexpected condition.

Furthermore, from the perspective of control theory, a problem is defined as the deviations of the real condition from the expected condition [3]. The deviations include not only those in objective reality, but those in knowledge and experience. Moreover, this kind of deviation must be so great (i.e. it bears enough importance) as to exceed the threshold value, consequently influence the systematic operation, and require elimination. On the contrary, if the deviation lies in the threshold value range, it is not considered as a problem.

2.2 What is decision-making problem identification?

Problem identification (or problem discovery) aims at special decision-makers and their objectives in a special decision-making environment. It is an evaluation of the likely deviation of the present system condition from the expected one and is a process that an individual, a group, or an organization realizes the unsatisfactory condition they are in. Meanwhile, problem identification is obviously unstructured as it is a subjective process involving people's cognition of objective reality and determination of the deviations of the reality from their expectation. Thus, the process includes personal preference of decision-makers.

There are many deviations because there are innate defects in human being's information disposition. Cognitive deviations might appear in any of the four stages of information obtainment, disposition, output, and feedback. This result is not only caused by knowledge structure of decision-makers but also decided by the qualities of a problem. Generally, a structured problem is easier to be identified than an unstructured one since the latter requires decision-makers make more efforts on problem cognition.

Problem identification is remarkably important in a decision-making process [4]. Generally speaking, a decision process comprises two parts that are problem formation and problem solution [5]. The former comprises three stages of problem identification, problem definition, and problem diagnosis; the latter comprises two stages of problem structuring and scheme generating. Accordingly, problem identification is the first step of the whole decision-making process and also the most important step. It determines the subsequent problem solving procedures.

Additionally, as a subjective evaluation process, problem identification requires the comprehensive involvement of decision-makers [6]. The cognition capability of decision-makers is a critical factor for the success of problem identification, whereas the identification process has the features of vagueness and uncertainty. The two features should be considered at the same time in the process of evaluation [7]. The two models of gray incidence degree model and satisfaction degree model established in this paper combine the two features. In the following section, the two models are utilized in decision-making problem identification.

3 Methods of Decision-making Problem Identification

3.1 Satisfaction degree model for decision-making problem identification

In the satisfaction degree model, decision-makers utilize satisfaction degree to evaluate subjectively the deviation of the key variables (that depict the cause and effect relations in a system) from the expected values, and then finish the problem identification process with the heuristic strategy. This model focuses on determining the conditions in which the decision-makers take the deviations as acceptable ones, i.e. the dissatisfaction degree of decision-makers towards the deviations.

The mechanism on problem identification discussed in Section 2 indicates that the decision-makers play an important role in comparing the key variable values of the current systematic condition and the expected ones and making judgment on the acceptability of the variable deviations. Consequently, problem identification is essentially the measurement of the decision-makers' satisfaction degree.

According to the research by Bailey et. al., satisfaction is related to the scenario in a special space at a special moment [8]. It is a synthetic feeling for a series of factors affecting the scenario. These factors can be identified one by one by means of critical incident interview technique. Then, the standard degree method is utilized to generate response values of each factor after the depiction of the factor from three different perspectives. For instance, the sales revenue can be studied from three aspects: syntheticness, fluctuations, and controllability. The response values are among the following seven standard degree values, as shown in Fig.1.

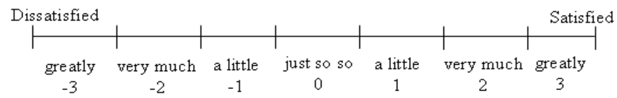

Fig.1. **Seven Standard Degree Values**

If the importance of different factors is considered simultaneously, the factors can be ranked at first and then assigned different weights [9]. The value range of weight is from 0.10 to 1.00, and increases with a step length of 0.15. Otherwise, the weights can be obtained by means of analytic hierarchy process (AHP). Then, the mathematic formula of satisfaction degree S is given by

$$S = \sum_{i=1}^{n} R_i W_i \tag{1}$$

$$R_i = \frac{1}{3}\sum_{j=1}^{3} I_{i,j} \tag{2}$$

where R_i =synthetic satisfaction degree of factor i;

W_i =weight assigned to factor i;

$I_{i,j}$ = response value when factor i depicts the problem at perspective j;

n = number of factors.

Usually, satisfaction degree S is normalized, namely

$$S' = \frac{S-(-0.3n)}{3n-(-0.3n)} = \frac{S+0.3n}{3.3n} \tag{3}$$

Then the dissatisfaction degree U_p is

$$U_p = 1 - S' \tag{4}$$

Generally, when $U_p \geq 0.5$, the current situation is considered to be in trouble and requires decision-makers deal with the problem. Vice versa, the system is considered to be normal and does not need people's involvement.

Dissatisfaction degree is a measurement of the problems existing in the present condition and the basis for problem identification of decision-makers. Moreover, during this process, decision-makers have to make use of the successful experience in the past decision-making processes as the satisfaction degree model itself is a combination of qualitative analysis and quantitative computation. This is also determined by the quality of problem identification.

3.2 Gray incidence degree model for decision-making problem identification

Although problem identification can be achieved quickly by means of satisfaction degree model, the model is designed to simple problems. Satisfaction degree model play a very limited role when utilized in many comparatively complex and giant systems. Moreover, when the systematic condition is being evaluated, time is an important factor for consideration, namely, the system bear different features when observed at different moments. Therefore, the construction of a model involving both the factor of time and the systematic behavioral features is required in the research on problem identification. With this model, different values of the behavior variables at different moments are observed, so that the normality of the system operation is determined.

The two preceding conditions are met by the gray incidence degree model established in this paper. Following is the basic idea of the model.

Firstly, according to the major factors affecting the system operation, a group of key variables that depict the behavior of the system at different moments are defined. Secondly, based on the incidence degree of the time series, whether the deviation of the present system operation condition have exceeded the predetermined threshold value is determined. That is the result of the decision-making problem identification.

Following is the construction of the gray incidence degree model for decision-making problem identification.

Suppose $X_i = (x_i(1), x_i(2), \cdots, x_i(n))$ is the time series of condition variable i that reflects system behavior. $x_i(j)$ is the value of variable i at moment j, where $i = 1,2,\cdots,m$ and $j = 1,2,\cdots,n$. And suppose $G_i = (g(1), g(2), \cdots, g(n))$ is the time series of system objectives. Then, the gray incidence ρ_{gi} of system objectives and behavior variables is described by the equation

$$\rho_{gi} = \theta\gamma_{gi} + (1-\theta) r_{gi} \tag{5}$$

where γ_{gi} = absolute incidence of G and X_i, and r_{gi} = relative incidence of G and X_i.

With X_i and G at the initial zero point, i.e. $X_i^0 = (X_i^0(1), X_i^0(2), \cdots, X_i^0(n))$ and $G^0 = (g^0(1), g^0(2), \cdots, g^0(n))$, γ_{gi} is obtained using the equations

$$\gamma_{gi} = \frac{1+|S_g|+|S_i|}{1+|S_g|+|S_i|+|S_i - S_g|} \tag{6}$$

$$|S_g| = \left|\sum_{k=2}^{n-1} g^0(k) + \frac{1}{2} g^0(n)\right| \tag{7}$$

$$|S_i| = \left|\sum_{k=2}^{n-1} x_i^0(k) + \frac{1}{2} x_i^0(n)\right| \tag{8}$$

$$|S_i - S_g| = \left|\sum_{k=2}^{n-1} (x_i^0(k) - g^0(k)) + \frac{1}{2}(x_i^0(n) - g^0(n))\right| \tag{9}$$

In detail, after changing initial zero-point images of X_i and G into their initial value images X_i' and G', and then computing the initial zero-point images with the preceding images using the equations (6) ~ (9), γ_{gi} is obtained. Finally, the gray incidence of the system ρ_{gi} is computed through equation (5), where $\theta \in [0,1]$ is assigned 0.7 according to the qualities of problem identification.

Having the value of ρ_{gi}, U_g, the deviation degree of system objectives and behavior variables, is determined by the equation

$$U_g = \sqrt{\sum_{i=1}^{m}(1-\rho_{gi})^2 \Big/ m} \quad (10)$$

The value of U_g reflects the operation condition of a system. The bigger its value is, the more obvious the degree of the deviation from system objectives. Usually, when $U_g \le 0.3$, the system is within the normal range; when $U_g > 0.3$, there are problems in the system.

3.3 Research results

From the result of the computation with satisfaction model, the key to problem identification is ascertaining the factors and satisfaction degree. For the former, many evaluation methods and diagnosis systems have already been developed. But for the latter, it depends on the subjective evaluation process of decision-makers to a great extent and is highly sensitive to decision-making environment, which brings about great difficulty for the identification process. Therefore, the gray incidence model posited in this paper focuses on the research on the factors related to the dependence and sensitivity. And further, the model substitutes subjective judgment with as much objective information as possible so as to decrease the dependence and sensitivity.

The advantages of the gray incident model are (1) reflecting the system condition in a completely dynamic way, (2) identifying problems in condition of inexplicit system tendency, which reduces the sensitivity to and dependence on decision-making environment, and (3) considering the relationship between absolute quantity and changing rate during the identification process, which complies with thinking patterns of decision-makers in reality.

4 An Example

An enterprise group is planning to explore the overseas market. The satisfaction degree model and gray incidence model are used to evaluate the future of the enterprise group so as to discover problems on time. According to the preceding procedure, the mapping quantity of enterprise future should be determined firstly. In this case, the revenue G is selected as the mapping quantity. Then, the key factors influencing G should be found out. The following seven major factors related to G are picked out: sales income X_1, total capital X_2, total cost X_3, price of leading product X_4, product market share X_5, technical added value X_6, and number of R&D employees X_7. From 2000 to 2005, the value of G is then given by

$$G = (g(1), g(2), g(3), g(4), g(5), g(6))$$
$$= (13277, 55097, 17088, 24534, 20156, 34134)$$

The corresponding values of $X_i(j)(i = 1,2,\cdots,7;\ j = 2000,2001,\cdots,2005)$ are given in Table 1.

Given the preceding conditions, problem identification utilizing satisfaction degree model comes next. According to the judgment by decision-makers, the response values and weights of the seven factors are given in Table 2.

Table 1 The Corresponding Values of $X_i(j)$

j \ i	1 (10 thou-Sand RMB)	2 (10 thou-sand RMB)	3 (10 thou-sand RMB)	4 (10 thou-sand RMB)	5 (%)	6 (10 thou-sand RMB)	7 (person)
2000	720580	1068996	707303	1.2	20	0.42	927
2001	1034188	1000014	979091	1.2	20	0.42	1003
2002	1161827	1599404	1144739	1.2	28	0.42	1020
2003	1294114	1315186	1269580	1.18	33	0.48	1016
2004	1141592	1141802	1121436	1.18	27	0.48	1033
2005	1206909	1019374	1172775	1.18	27	0.48	1033

Table 2 The Response Values and Weights of Seven Factors

Factors	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Response Value R_i	8/3	5/3	2	4/3	7/3	5/3	-1/3
Weight W_i	1.00	0.85	0.70	0.55	0.40	0.25	0.10
Satisfaction Degree	8/3	4.25/3	1.4	2.2/3	2.8/3	1.25/3	-0.1/3

With the satisfaction degree of each factor, the synthetic satisfaction degree of decision-makers is calculated by

$$S = \sum_{i=1}^{7} R_i W_i = 7.53$$

As the result of normalization, $S' = 0.417$. The corresponding dissatisfaction degree $U_p = 1 - S' = 0.583 > 0.5$. It indicates that the future of the enterprise group is not optimistic and that there must be some problems in its business operation. This requires further investigation of the decision-makers.

The calculation result of gray incidence model comes next. Firstly, the absolute incidence is calculated. With the initial zero-point image value of G

$$G^0 = (g(1)-g(1), g(2)-g(1), g(3)-g(1), g(4)-g(1), g(5)-g(1), g(6)-g(1)) = (0,41820,3811,11257,6879,20857)$$

$|S_g|$ is computed using Equation (7): $|S_g| = 74195.5$.

Then, according to the expression of initial zero-point image of X_i

$$X_i^0 = (x_i(1)-x_i(1), x_i(2)-x_i(1), x_i(3)-x_i(1), x_i(4)-x_i(1), x_i(5)-x_i(1), x_i(6)-x_i(1))$$

and Equations (6) ~ (9), the absolute incidence is calculated (see Table 3).

Secondly, the relative incidence is calculated. The initial image of G

$$G' = (\frac{g(1)}{g(1)}, \frac{g(2)}{g(1)}, \frac{g(3)}{g(1)}, \frac{g(4)}{g(1)}, \frac{g(5)}{g(1)}, \frac{g(6)}{g(1)}) = (1,4.145,1.287,1.848,1.518,2.571)$$

are introduced into Equation (7), and $|S_g'| = 5.584$. Then, the initial value image expression of X_i

$$X_i' = (\frac{x_i(1)}{x_i(1)}, \frac{x_i(2)}{x_i(1)}, \frac{x_i(3)}{x_i(1)}, \frac{x_i(4)}{x_i(1)}, \frac{x_i(5)}{x_i(1)}, \frac{x_i(6)}{x_i(1)})$$

and Equations (6) ~ (9) are used to calculate the relative incidence.

Thirdly, the gray incidence degree of the system is calculated through combining the absolute incidence and the relative incidence. The result of the calculation is shown in Table 4.

Table 3 The Calculated Absolute Incidence

value \ i	1	2	3	4	5	6	7
X_1^0	0	313608	127639	132287	-152522	65317	
X_2^0	0	-68982	599390	-284218	-173384	-122428	
X_3^0	0	271788	165648	124841	-148144	51339	
X_4^0	0	0	0	-0.02	0	0	
X_5^0	0	0	8	5	-6	0	
X_6^0	0	0	0	0.06	0	0	
X_7^0	0	76	17	-4	0	17	
$\lvert S_i \rvert$	453670.5	11592	439802.5	0.02	7	0.06	97.5
$\lvert S_i - S_g \rvert$	379475	62603.5	365607	74195.5	74188.5	74195.4	74098
γ_{gi}	0.582	0.578	0.584	0.500	0.500	0.500	0.501

Table 4 The Result of the Calculation on Gray Incidence Degree

value \ i	1	2	3	4	5	6	7
X'_1	1	1.435	1.612	1.796	1.584	1.675	
X'_2	1	0.934	1.496	1.230	1.068	0.954	
X'_3	1	1.384	1.618	1.795	1.586	1.658	
X'_4	1	1	1	0.983	0.983	0.983	
X'_5	1	1	1.4	1.65	1.35	1.35	
X'_6	1	1	1	1.143	1.143	1.143	
X'_7	1	1.082	1.100	1.096	1.096	1.114	
G'^0	0	3.145	0.287	0.848	0.518	1.571	
X'^0_1	0	0.435	0.612	0.796	0.584	0.675	
X'^0_2	0	-0.066	0.496	0.23	0.068	-0.046	
X'^0_3	0	0.384	0.618	0.795	0.586	0.658	
X'^0_4	0	0	0	-0.017	-0.017	-0.017	
X'^0_5	0	0	0.4	0.65	0.35	0.35	
X'^0_6	0	0	0	0.143	0.143	0.143	
X'^0_7	0	0.082	0.1	0.096	0.096	0.114	
$\lvert S'_i \rvert$	2.765	0.705	2.712	0.043	1.575	0.358	0.431
$\lvert S'_i - S'_g \rvert$	2.819	4.879	2.872	5.627	4.009	5.226	5.153
r'_{gi}	0.768	0.599	0.764	0.541	0.671	0.571	0.577
ρ_{gi}	0.634	0.584	0.638	0.512	0.551	0.521	0.524

Finally, the gray incidence degrees in Table 4 are introduced into Equation (10), and the deviation degree of system objectives and behavior variables is

$$U_g = \sqrt{\sum_{i=1}^{m} (1-\rho_{gi})^2 \big/ m} = 0.437$$

As $0.437 > 0.3$, the value indicates that the present business operation level of the enterprise group can not provide enough support to its future development. This result complies with that of satisfaction degree model. The problem identification process ends here.

5 Conclusion

The greatest difficulty of decision-making problem identification is that, as a subjective evaluation process, the reliability of an identification process depends on further development of the research on cognition psychology to a great extent. The quantification of the identification process is subject to the research on reliability on and sensitivity to environment since the influence of environment on problem identification is determinant. This paper attempts to provide two problem identification methods. Future research should be conducted to study environment-based control model for problem identification.

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