Crisis Detection in Enterprises Based on AHP with Clustering

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ABSTRACT

Crisis detection can help enterprises to make full preparation to respond real crisis, so it is an important field to promote enterprises' competition and keep them develop continuously. Crisis in enterprises may be caused by many factors and most of them are very common and necessary parts in normal operating procedure. This paper takes these parts as crisis signals indicated in many managing books. Group decision-making strategy is put forward to help enterprises to analyze crisis signals based on the characteristics of the decision-making procedure. To get a meaningful and credible result, AHP is used to support the whole procedure. To exhibit the role of managers, system cluster is used to classify experts involved in decision-making procedure. An example to analyze a key engineer's dismissing is given to illustrate the decision-making procedure and to prove the efficiency of this idea and AHP method.

Keywords

Crisis pre-response, AHP, system cluster, enterprise

INTRODUCTION

Crises for enterprises are both dangerous and hopeful. Every crisis exists in ordinary matters as one event or factor of affairs. If such event doesn't emerge to show its danger and damage to enterprises, it will be only a necessary part in enterprises' process. But if sudden changes occur on such event, it will be crisis for enterprises that will bring damage and even cause enterprises ruin. So, paying attention to such events is very important. Evaluate such events that can be taken as crisis signals and take the evaluating result as a detection of crisis.

SIGNALS OF ENTERPRISES CRISES

All events or factors in an enterprise can be taken as signals of crisis including producing, management, selling, etc. Especially, there are still something evident to be a potential crisis including firing employees or employees demission, financial target lower than expectation, low morale of employees, lawsuit, media report with negative effects, damaging news, products with shortcomings or quality problems, technique faults, violence-threat behaviours by current employees with dissatisfied emotions or by formal employees, sudden death of high-level decision-maker because of job accident, loss of main customers, investigation or penalty of government, economic rejection and strike, becoming such object that will be merged and sold, etc. The above events are very popular signals of crisis. If one of the above happens, that means a potential crisis has existed.

As we can conclude that crisis can cause many negative effects, even ruin of enterprises. These negative effects may be obvious damage of reputation, credit, confidence and trust; decreasing loyalty of employees; short of profit; necessary cost of reducing loss caused by crisis; loss of time and energy; etc. So, we will try our best to respond crisis by evaluation the above signals to reduce happening opportunities of crisis.

EVALUATION OF CRISIS BASED ON AHP

For the above crisis signals, an efficient method should be taken to evaluate and to distinguish crisis. Here, group decision strategy and AHP will be proposed to solve this problem.

Group Decision Strategy

Evaluation about a crisis signal is serious-minded because the evaluation results will be significantly meaningful to an enterprise. It will be done as completely as possible. A crisis signal will contain a lot of information and knowledge, so it will be a multi-disciplinary analysis problem. As we know, one person can't have so wholly knowledge and experience, this evaluation about crisis signals should be carried out by a group of experts who have necessary knowledge and experience. Then, this evaluation is a procedure of Group Decision-making.

And Group Decision-making Strategy to solve this problem will have the following advantages:

(1) There are a lot of complex knowledge and information in a group of experts. This will bring group intelligence which individual intelligence has no compare-ability with. Expert group attending decision-making can collect most ideas and different solutions will be put forward from different aspects. This will make considering more comprehensive and identical and avoid shrivelling, losing good opportunity or deciding in a hurry when individual faces crisis and stress.

(2) Decisions are made by group and it will encourage each decision-maker has more responsibilities and confidences about the solution. This increases psychology capacity of decision makers. It will be helpful to carrying out the solution.

(3) An analysis about a crisis signal can be separated into several parts according some rules and can be dealt with by experts with different expertise background. This will be parallel and time can be saved.

(4) Most experts will be members of this enterprise or have some relationship with the enterprise. They hope this enterprise will be better and want to join its growth with their own attendance. They're willing to accept the developing results of enterprise with their own decisions.

Generally speaking, group decision-making will be better than individual's.

AHP with Clustering

This idea is put forward by Yunyan Wu (2003) to calculate for weight-values of experts in group decision-making. Here we use it to finish a procedure of group decision-making about crisis.

Classification of Experts in Group

Suppose m experts evaluate n solutions. Describe experts group as $E=\{E_1,E_2,\Lambda\ ,E_m\}$, describe solutions needed to evaluate as $S=\{S_1,S_2,\Lambda\ ,S_n\}$.

Suppose number k expert as E_k, his evaluation judgement matrix is $A^k=(a_{ij}^{(k)})_{n\times n}$, $k=1,2,\Lambda\ ,m$, $i,j=1,2,\Lambda\ ,n$. $W^{(k)}=(w_1^{(k)},w_2^{(k)},\Lambda\ ,w_n^{(k)})^T$ are weight-vectors of all elements defined by $A^{(k)}$, then:

$$w^{(k)}_i > 0, \sum_{i=1}^{n} w_i^{(k)} = 1 (i,j=1,2,\Lambda\ ,n) \quad (1)$$

Matrix $B^{(k)}=(b_{ij}^{(k)})_{n\times n}$,

$$b_{ij}^{(k)} = \frac{a_{ij}^{(k)}}{\sum_{i=1}^{n} a_{ij}^{(k)}}, i,j=1,2,\Lambda\ ,n \quad (2)$$

Obviously, $b_j^{(k)}=(b_{1j}^{(k)},b_{2j}^{(k)},\Lambda\ ,b_{nj}^{(k)},)^T$ is a normalized vector j in $A^{(k)}$. Then,

$$\overline{b}^{(k)} = (\overline{b}_i^{(k)})_{n\times 1} = \frac{1}{n}\sum_{j=1}^{n} b^{(k)}_j \quad (3)$$

Apply system cluster to classify experts. Distances between vectors are calculated by the following formula:

$$d_{ij} = \cos\theta_{ij} = \frac{\overline{b}^{(i)} \bullet \overline{b}^{j}}{\left|\overline{b}^{(i)}\right| \cdot \left|\overline{b}^{(j)}\right|} = \frac{\sum_{k=1}^{n} \overline{b}_k^{(i)} \overline{b}_k^{(j)}}{[(\sum_{k=1}^{n}(\overline{b}_k^{(i)})^2)(\sum_{k=1}^{n}(\overline{b}_k^{(j)})^2)]^{1/2}} \quad (4)$$

If value of d_{ij} is larger, expert i and expert j will be more similar. When the similarity degree reaches some value, the two experts can be classified into the same classification. According to this idea, cluster analysis about experts can be described as below:

Step 1 Suppose every expert is a classification only including himself, namely, $G_1 = \{E_1\}, G_2 = \{E_2\}, \Lambda, G_m = \{E_m\}$, there will be m classifications, at the same time, suppose $q = m$;

Step 2 According to formula (4) calculate d_{ij};

Step 3 Select the maxmum in d_{ij} as d_{xy} and combine the corresponding classifications G_x and G_y into a new classification $G_{q+1}, G_{q+1} = \{G_x, G_y\}$;

Step 4 If there is $q = 2(m-1)$, then turn to Step 7; or, turn to Step 5;

Step 5 Get rid of G_x and G_y in classification-set and add the new classification G_{q+1};

Step 6 Calculate the new d_{ij} in new classification-set, $d_{i,q+1} = \max\{d_{ix}, d_{iy}\}, i \neq x, y, i = 1,2,\Lambda, m$. At the same time, $q = q+1$, turn to Step 3 to continue to combine the rest classifications;

Step 7 Draw clustering hierarchical diagram and decide the count of classifications and the contents of classifications according to the chart.

Expert Weight-value

The m experts have been classified into l classifications ($l \leq m$). Because the classified standard is the similarity of two experts, we can say experts in the same classification have the same weight-value. For different classifications, if a classification includes more experts, namely larger containing classification, this means this classification expresses similar advices of larger count of experts more than the other classifications. So, according to the principle of larger count, the experts should have larger weight-value, while if count of experts in a classification is small, those experts in this classification will have small weight-value.

Suppose the classification in which there is expert k contains ψ_k experts, and his weight-value is a_k. According to the above principle, a_k will be positive rated with ψ_k, so

$$a_k = a \cdot \psi_k, k = 1,2,\Lambda, m \quad (5)$$

Because $\sum_{k=1}^{m} a_k = 1$, there will be:

$$a_1 : a_2 : \Lambda : a_m = \psi_1 : \psi_2 : \Lambda : \psi_m \quad (6)$$

Solve equal group formed by formula (5) and (6), formula (7) can be got to define weight-value of expert k.

$$a_k = \frac{\psi_k}{\sum_{i=1}^{m} \psi_i} \quad (7)$$

Calculation of Credit Degree of Judge

To get more reasonable judging result, consistency should be tested first. Take λ as the most similar character-root of this matrix, then:

$$\lambda = \frac{1}{n} \sum_{i=1}^{n} \frac{(A\overline{b})_{(i)}}{\overline{b}^{(i)}} \quad (8)$$

Calculate the consistent target CI according to $CI = \frac{\lambda - n}{n-1}$. When CI=0, the matrix is consistent. But it is only ideal. Most time, we will calculate another target CR (Consistent Ratio) to decide if a matrix is consistent enough. This is due to $CR = \frac{CI}{RI}$. RI is random index satisfied with the relation in Table 1.

Variable	Number										
n	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.56	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51

Table 1. The Corresponding Relation between RI and n

If CR<0.1, the matrix is consistent enough. Then the matrix needn't be adjusted. Or, the matrix need be adjusted and it will be discussed in some other papers. In this paper, we only talk about judgement matrix without adjustment.

Then, $\overline{W}^{(k)} = (\overline{w}_1^{(k)}, \overline{w}_2^{(k)}, \Lambda, \overline{w}_n^{(k)})^T$ is weight-vector, same as $\overline{b}^{(k)}$, β_k is credit degree weight-value of expert k 's judgement matrix. Take t_{ij} as the consistent degree between $A^{(i)}$ and $A^{(j)}$,which is equal to d_{ij}.

$$t_{ij} = \cos\theta_{ij} = \frac{\overline{w}^{(i)} \bullet \overline{w}^{(j)}}{\left|\overline{w}^{(i)}\right| \cdot \left|\overline{w}^{(j)}\right|} \qquad (9)$$

Average consistent degree of judgement matrix $A^{(i)}$ is t_i and it can be calculated with formula (10).

$$t_i = \frac{1}{m-1} \cdot \sum_{\substack{j=1 \\ j \neq i}}^{m} a_j \cdot t_{ij} \qquad (10)$$

Then normalize t_i to get t_i^*, corresponding consistent degree of every judgement matrix:

$$t_i^* = \beta_i = \frac{a_i \cdot t_i}{\sum_{j=1}^{m} a_j \cdot t_j} \qquad (11)$$

According to keeping order principle, weight-plus average method is used to finish combination judgement matrix and the formula is as following:

$$\overline{w}_i = \prod_{k=1}^{m} \left[\overline{w}_i^{(k)}\right]^{\beta_k}, i = 1,2,\Lambda, n \qquad (12)$$

After normalization, w_i^* is weight-value of the element i

$$w_i^* = \frac{w_i}{\sum_{j=1}^{n} w_j} \qquad (13)$$

AN EXAMPLE OF CRISIS EVALUATION

Suppose in some enterprise, a skilful engineer is dismissed because he isn't satisfied with his salary and some relation in his team from outlook. He knows about the core technology of one main product. This may be a crisis signal. How will the enterprise respond to this? Four major managers who are in charge of producing, technology development, human resource and selling in this enterprise have a meeting to discuss this problem. There are four solutions they can imagine to avoid crisis happening. These are (1) choose an alternative person to replace the dismissing engineer as soon as possible; (2) increase salary for engineers in case of more people dismiss; (3) reorganize human resource in this department to reduce conflicts among people; (4) try to persuade the dismissing engineer coming back under the condition of satisfying his demands as much as possible.

Apply the above method to help this enterprise to make a decision. The four managers are four experts facing four elements to make a decision. After their evaluation, the following four matrixes are given to reflect their opinions.

$$A^{(1)} = \begin{bmatrix} 1 & 8 & 6 & 3 \\ 1/8 & 1 & 1 & 1/3 \\ 1/6 & 1 & 1 & 1/4 \\ 1/3 & 3 & 4 & 1 \end{bmatrix}, A^{(2)} = \begin{bmatrix} 1 & 5 & 6 & 4 \\ 1/5 & 1 & 1 & 1 \\ 1/6 & 1 & 1 & 1 \\ 1/4 & 1 & 1 & 1 \end{bmatrix}, A^{(3)} = \begin{bmatrix} 1 & 3 & 7 & 4 \\ 1/3 & 1 & 2 & 2 \\ 1/7 & 1/2 & 1 & 1 \\ 1/4 & 1/2 & 1 & 1 \end{bmatrix}, A^{(4)} = \begin{bmatrix} 1 & 4 & 2 & 2 \\ 1/4 & 1 & 1/2 & 1/4 \\ 1/2 & 2 & 1 & 2 \\ 1 & 4 & 1/2 & 1 \end{bmatrix}$$

According to formula (2) and (3), the calculating results are:

$\overline{b}^{(1)} = (0.5336, 0.0895, 0.0917, 0.2853)^T$, $\overline{b}^{(2)} = (0.6204, 0.1257, 0.1205, 0.1334)^T$

$\overline{b}^{(3)} = (0.5789, 0.2062, 0.0997, 0.1152)^T$, $\overline{b}^{(4)} = (0.3656, 0.0914, 0.2711, 0.2719)^T$

Because the consistent rates (CR) of the above four matrixes are all lower than 0.1, the matrixes have good consistent-ability.

$CR_{(1)} = 0.0354$, $CR_{(2)} = 0.057$, $CR_{(3)} = 0.0116$, $CR_{(4)} = 0.0922$

They needn't be rebuilt.

At First, calculate the weight-value of experts a_i.

Cluster the experts. At the beginning, the four experts can be classified into four classifications. $G_1 = \{E_1\}$, $G_2 = \{E_2\}$, $G_3 = \{E_3\}$, $G_4 = \{E_4\}$, $q = 4$.

According to formula (4), calculate the similarity-degree of each two experts.

$d_{12} = 0.9617$, $d_{13} = 0.9434$, $d_{14} = 0.9189$, $d_{23} = 0.9899$, $d_{24} = 0.8764$, $d_{34} = 0.8477$

According to clustering principle based on max distance, we can get the following figure.

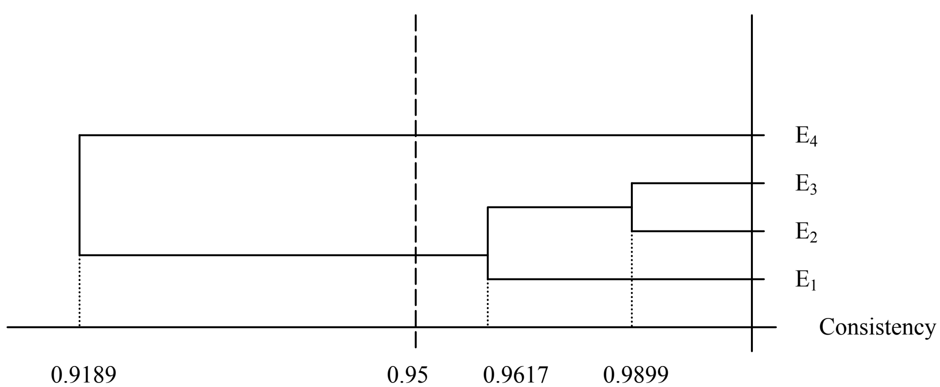

Figure 1 Clustering hierarchical diagram

We can cut once at point which consistency value is 0.95. Then the four experts have been classified into two classifications: C1={E1, E2, E3}, C2={E4}. Calculate weight-values for the four experts according to formula (7).

$$a_1 = a_2 = a_3 = \frac{3}{3+3+3+1} = 0.3, \quad a_4 = \frac{1}{3+3+3+1} = 0.1$$

Then, Credit Degree of Judgement Matrix will be calculated. Because the original matrixes are suitable, there will be $t_{ij} = d_{ij}$.

According to formula (10), $t_1 = 0.2211$, $t_2 = 0.2244$, $t_3 = 0.2216$, $t_4 = 0.2643$.

After normalization, we can get:

$\beta_1^* = 0.2927$, $\beta_2^* = 0.2971$, $\beta_3^* = 0.2934$, $\beta_4^* = 0.1166$.

According to formula (12),

$\overline{w_1^*} = 0.1722$, $\overline{w_2^*} = 0.1996$, $\overline{w_3^*} = 0.2107$, $\overline{w_4^*} = 0.2143$.

Normalize the above $\overline{w_i^*}$, we can get:

$w_1 = 0.2161$, $w_2 = 0.2505$, $w_3 = 0.2644$, $w_4 = 0.2690$.

Finally, we get the four experts' comprehensive result about the four solutions as:

$W^* = (0.2162,0.2505,0.2644,0.2690)$.

From the above result, it can be seen that the four managers think the fourth solution is the most important, then the third one, the second one, and the first one.

CONCLUSION

Crisis detection for an enterprise is very important because it is related to the existence and future of an enterprise. The fortune will be decided by a group of managers but not only one person, especially when an enterprise encounters crisis. So, studying Group Decision Support strategy has operation significance. When many solutions are given out, how to choose is the most important. AHP used here is suitable, but there are still many problems to be focused on. For example, judgement matrixes in the above example are good enough and they needn't be rebuilt. If they need to be rebuilt, what method shall we take? What is the new measurement to judge if a matrix is good enough? So, more study should be carried out in this area.

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