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Risk Evaluation for Virtual Enterprise

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ABSTRACT

Virtual Enterprise is the potential mode of enterprise in the future. The risk management for virtual enterprise is the new research area recently. In virtual enterprise, the enterprise operation is always organized by project mode and there is always less historical data and there are many uncertain factors. Hence, in this paper, the fuzzy synthetic evaluation model for the risk evaluation of virtual enterprise is established focus on the project mode and uncertain characteristics of virtual enterprise. In the 5 levels model, the goal and sub-goal of the enterprise, the process of the project, as well as the risk event and risk factors are considered. The case study suggests that the method is useful.

Keywords: virtual enterprise, risk evaluation, fuzzy synthetic evaluation

1. INTRODUCTION

Risk Evaluation, a significant stage in risk management, is defined as a process in which the acceptance level of integrated enterprise risk is determined based on single-risk evaluation. Common evaluating methods include balance-point method, sensitive analysis and probability analysis, etc. [1-4], in which the simple relation between one kind of profit and its relevant parameter is discovered from a standpoint of profit then described mathematically or probabilistically. However, since an enterprise, especially a virtual enterprise is a complicated system consisting of a number of functional elements, its risks should be analyzed and evaluated from a systematic point of view so that the general objective of the system and functions of all parts can be managed and the relations in-between acknowledged. Only when the operating regularity of each kind of risk is studied can the integrated risk level be determined. Besides, since a virtual enterprise is a dynamic alliance [5-7] which exists temporally with the aims of grasping some new opportunity in the market, two main features of it is considered in this research. First, the operation of VE is always organized by project mode, so the integrated risk level is obtained based on the evaluation of each sub-procedure risk level in the analysis. Second, there is neither basic data nor objective probabilistic distribution for reference but personal experiences and subjective judgment, which is of great fuzziness. As a result, fuzzy method is proposed in our research. In this research, a risk evaluation model for virtual enterprises is established based on fuzzy mathematic theory from a systematic point of view and case study provided to prove its effectiveness.

2. FUZZY SYNTHETIC EVALUATION THEORYF

Comparison is often needed for judging in productive operation, scientific researches and daily life. To evaluate is easy if there is only one factor to be considered. However, it is always necessary to judge synthetically because there are always a number of attributive factors reflecting different characteristics, especially when dealing with complicated systems. If fuzzy features are also involved, it becomes a fuzzy synthetic evaluation problem[8-11].

2.1 Single-level Fuzzy Synthetic Evaluation

The single-level synthetic evaluation is used when the factor to be considered is not too much. Four factors need to be considered in this process:

1) Factor set of all factors to consider in the synthetic evaluation, denoted by the set

$$U = \{u_1, u_2, ..., u_m\} \tag{1}$$

2) Fuzzy subsets indicating importance levels of factors in the synthetic evaluation, denoted by

$$A = \frac{a_1}{u_1} + \frac{a_2}{u_2} + ... + \frac{a_m}{u_m} \tag{2}$$

among which $a_1, a_2, ..., a_m$ represents importance levels of the corresponding factors.

3) Comment set of evaluation result, denoted by

$$V = \{v_1, v_2, ..., v_m\} \tag{3}$$

4) Evaluating matrix of fuzzy relation between factor domain and comment domain, denoted by :

$$R = \begin{Bmatrix} R_1 \\ R_2 \\ \vdots \\ R_m \end{Bmatrix} = \begin{Bmatrix} r_{11} & r_{12} & ... & r_{1n} \\ r_{21} & r_{22} & ... & r_{2n} \\ & \cdots & \cdots & \\ r_{m1} & r_{m2} & ... & r_{mn} \end{Bmatrix} \tag{4}$$

where r_{ij} represents membership degree of object to be v_j from the standpoint of u_i. R_i represents the mono-factor evaluation to u_i. It is a fuzzy subset of V.

The fuzzy matrix being compound-calculated, then:

$$A \circ R = B \quad (5)$$

or

$$(a_1, a_2, ..., a_m) \circ \begin{Bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ & \cdots & \cdots & \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{Bmatrix} = (b_1, b_2, ..., b_n) \quad (6)$$

Let

$$B = (b_1, b_2, ..., b_n) \quad (7)$$

B is a fuzzy subset of comment domain V, indicating the membership degree of evaluated results to comment set, which is usually determined according to maximum membership degree principle.

A number of methods can be applied to compound calculation in fuzzy matrix, of which the two most commonly-used types are:

1) Main-factor-determining type

$$b_j = \max[\min(a_1, r_{1j}), \min(a_2, r_{2j}), ..., \min(a_n, r_{nj})] \quad (8)$$

It is best applied to the situation of which the optimum is determined by one optimal single factor.

2) Weighted-mean-determining type

$$b_j = \sum_{i=1}^{m} a_i \bullet r_{ij} \quad (9)$$

It takes function of every factor in general evaluation into account, giving attention to the influence of each, which makes it the most suitable for situations that require integrated evaluative index.

The second type is used in our analysis.

2.2 Multi-level Fuzzy Synthetic Evaluation (MFSE)

A lot of factors should be considered in complicated problems and systems. These factors might belong to different categories and hierarchies, which are in need of a multi-level evaluation: firstly they are primarily and synthetically evaluated within lowest hierarchy; then a higher hierarchy synthetic evaluation is given based on the results of its prior step in lower hierarchy; and so on, till the evaluation of top hierarchy is gotten. This method can specify the status and functions of all factors in the general evaluation and adopt all information derived from the factors.

Let L be the level number of the MFSE model, l be the counter of level. The integrated level is on the level 0, the sub-goal is on the level 1, and so on. Let K_l be the factor number of level l, k be the counter of factor number, $a_k = (a_{k1}, a_{k2}, ..., a_{kM})$ be the weight vector of factors under factor k on level l, M be the factor number under factor k on level l, m be factor counter under factor k on level l, $V = (v_1, v_2, ..., v_n)$ be the set of evaluation, b_k be the fuzzy evaluation of factor k on level l, R_k be the fuzzy evaluation matrix composed of fuzzy evaluation of each factor under factor k on level l.

The steps of MFSE are as follows.

Step 1: $l = L - 2$; k from 1 to K_l, determine R_k according to V, then:

$$b_k = a_k \circ R_k = (b_{k1}, b_{k2}, ..., b_{kn}) \; (k = 1, 2, ..., K_l) \quad (10)$$

The synthetic evaluation of level l is finished and turns to step 2.

Step 2: If $l = 0$, stop. Otherwise, let $l = l - 1$ and turn to step 3.

Step 3: Let k from 1 to K_l, according to $b_m = (b_{m1}, b_{m2}, ..., b_{mn}) \; (m = 1, 2, ..., M)$, R_k is given as follows:

$$R_k = \begin{Bmatrix} B_1 \\ B_2 \\ \vdots \\ B_M \end{Bmatrix} = \begin{Bmatrix} b_{11} & b_{12} & \cdots & b_{1n} \\ b_{21} & b_{22} & \cdots & b_{2n} \\ & \cdots & \cdots & \\ b_{M1} & b_{M2} & \cdots & b_{Mn} \end{Bmatrix} \quad (11)$$

Then, according to equation (10) the synthetic evaluation of level l is finished, and turns to step 2.

3. FUZZY SYNTHETIC EVALUATION MODEL OF RISK FOR VIRTUAL ENTERPRISE

Risk evaluation is performed based on risk identification and risk estimation. Such information can be acquired in risk identification as:

a) General Objective and sub-objectives, the contents of which do not overlap;

b) Components or operation procedures of the enterprise, the contents of which do not overlap;

c) Whether the procedures and the objectives are relevant;

d) Every possible risk;

While risk estimation provides:

a) Significance of each sub-objective and its weight;

b) Importance of relevant procedures or components to the sub-objectives and their weights;

c) Risk allocation, e.g., which procedure or component the risks affect, to which objective they are related;

d) Significance of each risk and its weight;

e) Factor-factor relations within risks and the weights of factors;

f) Fuzzy description of risk factors.

Two factors are determining the significance of a risk: risk probability and risk lost. Criterion of assessment [3] is listed as follows for analyzing the two factors (see Table 1 and 2, from which a fuzzy description of risk factors can be derived.

Based on risk identification and estimation, considering the project organization mode and the uncertain characteristics of VE, the fuzzy synthetic evaluation hierarchical model (FSEHM) of risk evaluation is given in Figure 1. In this FSEHM model, each process of the VE project is considered, as well as the fuzzy description of each risk factor.

In the FSEHM model, there are 5 levels from level 0 (top) to level 4 (bottom). The level 0 is the general object of VE to minimize risk. Table 3 provides the criterion for evaluating general objective. The level 1 is the sub-objectives the VE pursued, which are different for a special VE. The level 2 is the procedures, which are the activities in the VE project. The level 3 are the risk events, which will cause the risk in the procedures for different sub-objective. The level 4 are the risk factor of the risk event. As mentioned above, two risk factors, risk probability and risk loss, are considered for each risk event.

Table 1 Rank criterion for risk probability

Severity	Incidental possibility description	Criterion for evaluation
0	Nil	0%—5%
1	Slight	5%—15%
2	Lower	15%—25%
3	Lower	25%—40%
4	Mediat	40%—60%
5	A bit high	60%—75%
6	High	75%—85%
7	Higher	85%—95%
8	Highest	95%—100%

Table 2 Rank criterion for risk lost

Severity	Lost description	Criterion for Evaluation
0	Nil	No influence on producting system
1	Slight	Slight influence but almost no product demands reproduction.
2	Lower	Producting system influenced,part of products demand reproduction
3	Lower	Producting system is operatable with a deteriorating capacity. Half products demand reproduction.
4	Mediat	Operatable producting system with a sharply-decreasing capacity, majoroty of products demand reproduction
5	A bit high	Producting system operates abnormally,no significant segment paralysed, reparable
6	High	Producting system operates abnormally,significant segment paralysed,reparable
7	Higher	Producting system damaged severely, almost disrepairable
8	Highest	Producting system breaks down , disrepairable and may endanger operator’s life

4. CASE STUDY

The example involves the real life problem of an enterprise, which bid for a market opportunity for the manufacturing lamp. The project consists of 5 processes, the precedence relationship represented by the Activity-on-Arc mode is shown in Figure 2. The owner has the ability of design and core manufacturing, while the bulb manufacturing, cap manufacturing, and assembly processes are finished by partner.

The objective of the VE is to minimize the general risk; the sub-objectives are to minimize cost risk, coordination risk, the time risk and the quality risk respectively. The weight of each sub-objective to the subjective is shown in table 4. The weight (W) of each procedure (P) to sub-objective (S) is shown table 5. The risk events are shown in table 6. Their relationship to each procedure under a sub-objective and the weights to the corresponding procedure are show in table 7. The weight of probability and loss to each risk event is shown in Table 6. The fuzzy description of probability and loss for each risk event is show in Table 8.

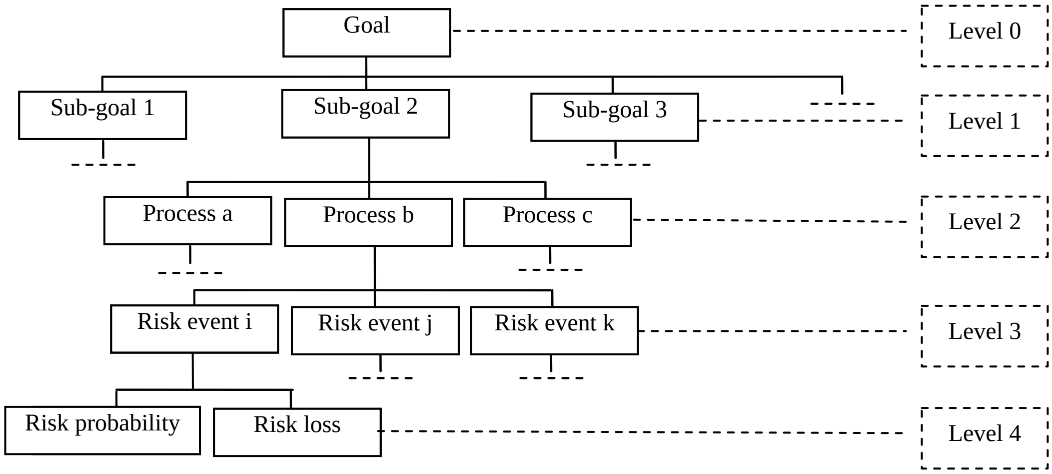

Figure 1 The hierarchical model for risk evaluation

Table 3 Integrated evaluation standard for risk level

Risk level	0	1	2	3	4	5	6	7	8
Description	Nil	Slight	Lower	Low	Mediate	A bit high	High	Higher	Highest

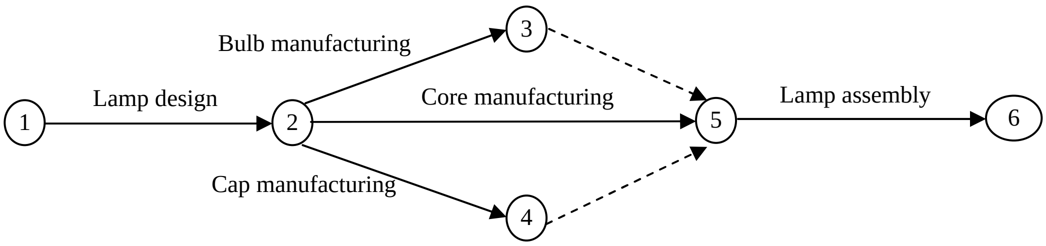

Figure 2 The network for the lamp manufacturing

Table 4 The weight of the sub-goals to the goal

Sub-goal	Cost	Coordination	Time	Quality
Weight	0.3	0.3	0.15	0.25

Table 5 The weight of the processes to the sub-goals

W \ P / S	Process 1	Process 2	Process 3	Process 4	Process 5
Sub-goal1	0.5	0.3	0.05	0.15	0
Sub-goal2	0.2	0.5	0.1	0.1	0.1
Sub-goal3	0	0.2	0.3	0.3	0.2
Sub-goal4	0	0	0.4	0.6	0

Table 9 shows the result of risk evaluation for the VE. According to the principle of maximum membership and the method of fuzzy synthetic evaluation, the result of integrated risk evaluation is 0.234, indicating a grade 3 risk.

5. CONCLUSION

In accordance with project organization mode and the great uncertainties and information fuzziness of virtual enterprise, a risk evaluation model is established in this paper based on procedures in project network and the theory of fuzzy synthetic evaluation, and the integrated consideration of influences of different factors. Examples have shown its simple, operability and charity for comprehension. The result reflects the integrated risk level effectively.

Table 6 The risk events and probability and loss weight of them

Risk event No.	Risk event	Risk probability	Risk loss
1	Design method	0.4	0.6
2	Designer’s level	0.5	0.5
3	Delay of bulb	0.4	0.6
4	Bad rate of core	0.35	0.65
5	Delay of cap	0.5	0.5
6	Communication with partner	0.35	0.65
7	Selection of bulb partner	0.8	0.2
8	Contract award	0.15	0.85
9	Strategy of partner	0.25	0.75
10	Selection of cap partner	0.3	0.7
11	Selection of assembly partner	0.7	0.3
12	The experience of the designer	0.5	0.5
13	The complexity of the product	0.6	0.4
14	Contract management	0.8	0.2
15	The capability of the enterprise	0.3	0.7
16	The experience of the worker	0.7	0.3
17	The capability of assembly partner	0.5	0.5
18	The reputation of bulb partner	0.2	0.8
19	The reputation of cap partner	0.65	0.35
20	The reputation of assembly partner	0.5	0.5

Table 7 The relationship and weight of risk event to the processes under the sub-goals

D / P / S	Process 1	Process 2	Process 3	Process 4	Process 5
Sub-goal1	Risk 1 (0.7) Risk 2 (0.3)	Risk 3 (1.0)	Risk 4 (1.0)	Risk 5 (1.0)	-
Sub-goal2	Risk 6 (1.0)	Risk 7 (0.5) Risk 8 (0.4) Risk 9 (0.1)	-	Risk 10 (1.0)	Risk 11 (1.0)
Sub-goal3	Risk 12 (0.2) Risk 13 (0.8)	Risk 14 (1.0)	Risk 15 (0.8) Risk 16 (0.2)	-	Risk 17 (1.0)
Sub-goal4	-	Risk 18 (1.0)	-	Risk 19 (1.0)	Risk 20 (1.0)

* P: process; S: sub-goal; D: relationship and weight of risk event to the processes under the sub-goals.

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Table 8 The fuzzy description of probability and loss for each risk event with no risk control

E \ D \ R		0	1	2	3	4	5	6	7	8
1	Probability	0.0	0.0	0.0	0.3	0.5	0.2	0.0	0.0	0.0
	Loss	0.0	0.0	0.0	0.0	0.2	0.8	0.0	0.0	0.0
2	Probability	0.0	0.0	0.3	0.3	0.3	0.1	0.0	0.0	0.0
	Loss	0.0	0.0	0.0	0.0	0.3	0.5	0.2	0.0	0.0
3	Probability	0.0	0.0	0.1	0.2	0.4	0.3	0.0	0.0	0.0
	Loss	0.0	0.3	0.4	0.3	0.0	0.0	0.0	0.0	0.0
4	Probability	0.0	0.0	0.0	0.0	0.0	0.6	0.4	0.0	0.0
	Loss	0.0	0.0	0.0	0.2	0.6	0.2	0.0	0.0	0.0
5	Probability	0.0	0.0	0.1	0.2	0.4	0.3	0.0	0.0	0.0
	Loss	0.0	0.3	0.4	0.3	0.0	0.0	0.0	0.0	0.0
6	Probability	0.0	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0
	Loss	0.0	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0
7	Probability	0.0	0.0	0.0	0.3	0.4	0.3	0.0	0.0	0.0
	Loss	0.0	0.0	0.1	0.2	0.3	0.3	0.1	0.0	0.0
8	Probability	0.0	0.0	0.1	0.8	0.1	0.0	0.0	0.0	0.0
	Loss	0.0	0.0	0.1	0.8	0.1	0.0	0.0	0.0	0.0
9	Probability	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0
	Loss	0.0	0.5	0.	0.0	0.0	0.0	0.0	0.0	0.0
10	Probability	0.0	0.0	0.0	0.0	0.3	0.4	0.3	0.0	0.0
	Loss	0.0	0.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0
11	Probability	0.0	0.1	0.3	0.5	0.1	0.0	0.0	0.0	0.0
	Loss	0.0	0.0	0.0	0.4	0.4	0.2	0.0	0.0	0.0
12	Probability	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.0
	Loss	0.0	0.0	0.0	0.3	0.5	0.2	0.0	0.0	0.0
13	Probability	0.0	0.0	0.4	0.3	0.3	0.0	0.0	0.0	0.0
	Loss	0.0	0.0	0.6	0.2	0.2	0.0	0.0	0.0	0.0
14	Probability	0.0	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0
	Loss	0.0	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0
15	Probability	0.0	0.0	0.4	0.3	0.3	0.0	0.0	0.0	0.0
	Loss	0.0	0.0	0.0	0.4	0.4	0.2	0.0	0.0	0.0
16	Probability	0.0	0.0	0.3	0.3	0.3	0.1	0.0	0.0	0.0
	Loss	0.0	0.0	0.0	0.0	0.3	0.5	0.2	0.0	0.0
17	Probability	0.0	0.0	0.0	0.0	0.0	0.2	0.4	0.4	0.0
	Loss	0.0	0.0	0.5	0.5	0.0	0.0	0.0	0.0	0.0
18	Probability	0.0	0.0	0.3	0.3	0.2	0.2	0.0	0.0	0.0
	Loss	0.0	0.0	0.0	0.2	0.2	0.2	0.4	0.0	0.0
19	Probability	0.0	0.0	0.0	0.0	0.0	0.6	0.4	0.0.	0.0
	Loss	0.0	0.0	0.00	0.2	0.6	0.2	0.0	0.0	0.0
20	Probability	0.0	0.8	0.2	0.0	0.0	0.0	0.0	0.0	0.0
	Loss	0.0	0.0	0.0	0.0	0.3	0.5	0.2	0.0	0.0

* E: risk event; R: risk level; D: fuzzy description.

Table 9 Result of risk evaluation for the VE

Risk level	0	1	2	3	4	5	6	7	8
Membership degree	0.074	0.081	0.100	0.234	0.212	0.209	0.070	0.020	0.00