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The Model for Evaluating Risks of Venture Capital Projects

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Abstract: This paper explores the method for evaluating the risks of venture capital projects. Based on analyzing the factors affecting the risks of venture capital projects, I establish an index system for evaluating the risks. I present a model for evaluating the risk level of single venture capital project by applying the uncertain type analysis of hierarchy process and the extended weighted arithmetic averaging operator. Based on the uncertain multiple attribute decision making method, I establish a model for evaluating the rank of the risks of multiple venture capital projects. I give two examples about practical application to show the reasonableness and effectiveness of the models.

Keywords: Interval number, multiple attribute decision making, risk evaluation, venture capital.

1. INTRODUCTION

The venture capital refers to an investment behaviour, which mainly provides the equity capital to the high technology and high growth venture enterprises (risk project), participates the management of enterprise or project that is invested in some ways, provides the business management and consulting services and expects to obtain the mid-term and long-term capital gains through equity transfer after the invested enterprise (risk project) is developed maturely [1]. The nature of venture capital determines the main investment object is highly-uncertain and high-tech enterprises or projects. The venture capital is characterized in high gain and high risk [2]. The core of venture capital operation is a risk investment institute that is an organization engaging in the venture capital and a financial medium linking between the risk investors and venture entrepreneur. Generally, the venture capitalist (institutional investors and individual investors) found the venture capital institutions (fund) collectively in investment way, entrust the venture capitalist in the venture capital to be responsible for the daily operation and management of the venture capital. The venture capitalists, prior to investment, must make use of their long-term accumulative experience, knowledge and information network to analyze and evaluate the risk components and size of the preferred venture capital projects. The risk evaluation result of risk projects is not only the important basis for the venture capitalist to select the risk project, but also directly affects the distribution of control right and cash flow right of the risk project during operation, further affects the development of venture capital contract. Therefore, the risk evaluation of venture capital project is a precondition for the venture capitalist to control and manage the risks, directly associates to the success of the venture capital [3]. To research the risk evaluation issue of the venture capital project is realistic and significant.

Some scholars have investigated the risk evaluation issues of venture capital project and have scored some value results [4-10]. The research thinking of these results were: to construct the risk evaluation system, and then built the evaluation model of the risk assessment based on the analysis of risk factors in venture capital projects. However, many research methods had shortcomings: (1) in the process to determine the weights of evaluation indexes, some scholars make judgment on the relative importance of evaluation indexes by using the traditional analytic hierarchy process. However, the venture capital projects are mostly involved in high and new technologies. The technology, market and products are not mature and greatly uncertain. The venture capitalists cannot represent the relative importance of risk evaluation indexes using one definite value comparatively owing to their own conditions or their inadequacy of information and being unclear to the risk factors in project. Therefore, although the complex decision-making problems can be solved effectively using the analytic hierarchy process method as quantitative analysis mean for the non-quantitative events, it is improper to represent the relative importance of risk evaluation indexes using one definite value comparatively; (2) Some scholars used the fuzzy comprehensive evaluation method as the method of risk evaluation, the fuzzy subordinate degree of state-set function doesn't satisfy the "normalization condition" and "additivity rule", thus resulting in low credibility of evaluation results [11]. In addition, the fuzzy set "maximizing" and "minimizing" operation will lose a lot of useful information and lead to the unreasonable evaluation results.

From the perspective of venture capitalists, according to the shortcomings of existing researches and high uncertainty of venture capital projects, this paper constructed the risk evaluation index system, and resolved the problem about evaluating risk level of single venture capital project and the problem about evaluating the rank of the risks of multiple venture capital projects by creating two models.

2. CONSTRUCTION OF EVALUATION INDEX SYSTEM

The present paper considered to make several following risk factors as the risk evaluation indexes of the venture capital projects on the basis of risk evaluation indexes at home and overseas for the venture capital project according to the comprehensive, systematic, comparable, scientific nature and feasible principles [2, 12]:

(1) Technical risk u_1: According to the new technology life cycle theory [13], the risk project faces all kinds of risk factors due to the congenital shortcomings of new ideas and new technology, immature and imperfect technology and emergency of alternative new technology.

(2) Entrepreneur risk u_2: refer to the adverse selection risk, moral risk, difference risk in objects of venture capitalists and venture entrepreneurs due to the entrusting and agent relationship, etc.

(3) Management risk u_3: refer to the risk of project failure caused due to mismanagement; mainly refer to the risk in the scientific organization system and the structure, business and management mode, management ability and experience, incentive mechanism and talent management level, etc.

(4) Production risk u_4: refer to the risk in intellectual property, production personnel structure, level of production equipment and the energy & raw materials supply, etc.

(5) Market risk u_5: refer to the risks caused by uncertainty of new products and new technology market, such as, market demand level, product substitutability, product sales network, products life cycle, etc.

(6) Investment risk u_6: refer to the risk in choice of investment tool, investment size, scientific investment decision making method and enterprise's capital structure, etc.

3. RISK EVALUATION MODEL OF SINGLE PROJECT

When the risk investment institutions are facing a venture capital project, they can organize many venture capitalists for analysis of business plans submitted by the venture entrepreneur, and evaluate the risks according to the specific circumstances of the project (such as industry) and firstly determine the risk evaluation index weight of the project. In terms of the larger uncertainty of the venture capital project, the present paper uses the interval number to describe the relative importance between the evaluation indexes and then determines the index weight using the ranking vectors of the complementary judgment matrix.

3.1. Determination of Evaluation Index Weight

Note $\tilde{a}=[a^-,a^+]=\{x\,|\,a^-\leqslant x\leqslant a^+,a^-,a^+\in R\}$, a is called as an interval number [14].

Definition 1 [14]: provided $\tilde{a}=[a^-,a^+]$, $\tilde{b}=[b^-,b^+]$, and note $l_{\tilde{a}}=a^+-a^-$, $l_{\tilde{b}}=b^+-b^-$, then

$$p(\tilde{a}\geqslant\tilde{b})=\frac{\min\{l_{\tilde{a}}+l_{\tilde{b}},\max(a^+-b^-,0)\}}{l_{\tilde{a}}+l_{\tilde{b}}} \tag{1}$$

For $\tilde{a}\geqslant\tilde{b}$ possibility, and note $\tilde{a},\tilde{b}$ ranking relation as $\tilde{a}\underset{p}{\geqslant}\tilde{b}$.

As mentioned earlier, as the venture capitalists are difficult to grasp the accurate state of each risk factors in venture investment, the subjective uncertainty will produce. Therefore, it is unreasonable to analyze the relative importance between the evaluation indexes by constructing the judgment matrix using the analytic hierarchy process. No accurate judgment is needed for the relative importance among indexes by the venture capitalists in the uncertainty analytic hierarchy process, but an estimate interval is given only. Thus, the present paper transfers the elements in the judgment matrix with the interval numbers.

Firstly, according to the relative importance of all evaluation indexes, to construct the interval number judgment matrix of index $A=(A_{ij})_{6\times6}$, where $A_{ij}=[a_{ij}^-,a_{ij}^+]=\{t\,|\,1/9\leqslant a_{ij}^-\leqslant t\leqslant a_{ij}^+\leqslant 9\}$ is interval number, indicating the relative importance of index u_i against u_j, and satisfy $a_{ij}^-=1/a_{ji}^+$, $a_{ij}^+=1/a_{ji}^-$ $(i,j=1,2,\cdots,6)$. The specific method is as below:

Providing n venture capitalists participate in evaluation, take two indexes randomly, u_i, u_j, let each capitalist gives independent interval numbers of relative importance between u_i and u_j. Providing the h^{-th} venture capitalist gives the interval number: $A_{ij}^{(h)}=[a_{ij}^{-(h)},a_{ij}^{+(h)}]$ $(h=1,2,\cdots,n)$. Then, we gain $a_{ij}^-=\sum_{h=1}^{n}\alpha_h a_{ij}^{-(h)}$ and $a_{ij}^+=\sum_{h=1}^{n}\alpha_h a_{ij}^{+(h)}$ $(1\leqslant i\leqslant j\leqslant 6)$, where, α_h $(\sum_{h=1}^{n}\alpha_h=1,\ 0<\alpha_h<1)$ is the importance given by the h^{-th} venture capitalist, and the resultant interval number judgment matrix is $A=(A_{ij})_{6\times6}$.

Then, providing $A^-=(a_{ij}^-)_{6\times6}, A^+=(a_{ij}^+)_{6\times6}$, then $A=[A^-,A^+]$, using a ranking method (square root method), to gain the weight vector of matrixes A^-,A^+ respectively $w^-=(w_1^-,w_2^-,\cdots,w_6^-)$, $w^+=(w_1^+,w_2^+,\cdots,w_6^+)$, providing

$$k = \sqrt{\sum_{j=1}^{6}\frac{1}{\sum_{i=1}^{6}a_{ij}^{+}}}, m = \sqrt{\sum_{j=1}^{6}\frac{1}{\sum_{i=1}^{6}a_{ij}^{-}}} \quad (2)$$

Gives the interval number weight vector

$$W = (W_1, W_2, \cdots, W_6) = [kw^-, mw^+] \quad (3)$$

where,

$$W_i = [kw_i^-, mw_i^+] \quad (i = 1, 2, \cdots, 6) \quad (4)$$

If $0 < k \leqslant 1 \leqslant m$, it indicates that the interval number matrix A meets the consistent conditions, or otherwise, feed back to the venture capitalist for re-judgment.

Finally, compare all interval number weights $W_i = [kw_i^-, mw_i^+]$ $(i = 1, 2, \cdots, 6)$ using equation (1) in pairs, construct the possibility matrix $P = (p_{ij})_{6\times 6}$, where $p_{ij} = p(W_i \geqslant W_j)$. From the nature of possibility, the possibility matrix P is a complementary judgment matrix; the weights of all evaluation indexes can be given by using the ranking vector formula of the complementary judgment matrix:

$$w_i = \frac{1}{q(q-1)}\left(\sum_{j=1}^{q} p_{ij} + \frac{q}{2} - 1\right) \quad (i = 1, 2, \cdots, q) \quad (5)$$

3.2. The Evaluation of Risk Level Based on EWAA Operator

As the venture capital is a kind of innovation investment and the project is lack of historical data, the experts often evaluate the risk indexes of project in a linguistic form. Now, the evaluation indexes are classified into 9 levels according to the risk level and their corresponding linguistic scale sets $S = \{ s_{-4}$ =extremely low, s_{-3} =very low, s_{-2} =low, s_{-1} =lower, s_0 =common, s_1 =higher, s_2 =high, s_3 =very high, s_4 =extremely high$\}$.

An expanded linguistic scale $\overline{S} = \{s_{\overline{\beta}} \mid \overline{\beta} \in [-l, l]\}$ based on the original linguistic scale $S = \{s_{\beta} \mid \beta = -4, \cdots 4\}$ in order to facilitate the calculation and avoid losing the decision-making information, where l is a sufficiently large natural number, $\overline{\beta} = \sum_{i=1}^{q} w_i \beta_i, w = (w_1, w_2, \cdots w_q)$ is the weighted vector of linguistic data $s_{\beta_i} (i = 1, 2, \cdots, q)$.

Definition 2 [14]: if EWAA: $S \to \overline{S}$, providing

$$EWAA_w(s_{\beta_1}, s_{\beta_2}, \cdots, s_{\beta_q}) = w_1 s_{\beta_1} \oplus w_2 s_{\beta_2} \oplus \cdots \oplus w_q s_{\beta_q} = s_{\overline{\beta}} \quad (6)$$

The function EWAA is named as extended weighted arithmetic averaging operator.

Assuming the h-th venture capitalist's linguistic evaluation value of the i-th risk evaluation index is:

$$s_{\beta_i}^{h} (i = 1, 2, \cdots, 6, h = 1, 2, \cdots, n)$$

Using the equation (6), the risk linguistic evaluation value of the project by the h-th venture capitalist by clustering above index evaluation information is:

$$s_{\overline{\beta}^h} = w_1 s_{\beta_1}^{h} \oplus w_2 s_{\beta_2}^{h} \oplus \cdots \oplus w_6 s_{\beta_6}^{h} \quad (7)$$

where, $\overline{\beta}^h = \sum_{i=1}^{6} w_i \beta_i$.

Further, using the equation (6), the risk linguistic evaluation value of the project by the n-th venture capitalist by clustering above index evaluation information is:

$$s_b = \alpha_1 s_{\overline{\beta}^1} \oplus \alpha_2 s_{\overline{\beta}^2} \oplus \cdots \oplus \alpha_n s_{\overline{\beta}^n} \quad (8)$$

where, $b = \sum_{h=1}^{n} \alpha_h \overline{\beta}^h$ $(-4 \leqslant u \leqslant b \leqslant v \leqslant 4, v - u = 1, u, v \in Z)$.

Referring to the related research [15], and assuming b is a value of random variables uniformly distributed in $[u, v]$, then give the evaluation criterion of the project risk level:

(1) If $0 \leqslant b - u \leqslant 0.5$, then the level of project risk is s_u under the confidence level $(1 + u - b)\%$;

(2) If $0 \leqslant v - b \leqslant 0.5$, then the level of project risk is s_v under the confidence level $(1 + b - v)\%$.

From the above evaluation criteria, the constructed model in the present paper is different from the previous studies in: determining the risk level of project under a confidence level to avoid the absoluteness of evaluation result, thus more meeting the actuality of the risk evaluation of the venture capital project.

4. RISK RANKING MODEL OF MULTIPLE PROJECTS

It is clear from the risk evaluation model in Section 3, the risk evaluation method for the single venture capital project can determine the risk level under a confidence level. However, the venture capitalists often need to compare risk levels of multiple venture capital projects in the actual operation of venture capital and thus select the project according to the risk level. A natural idea is to evaluate the risk of each project according to the method as described in Section 3, and the compare the risk level. Nevertheless, such method may face a realistic problem: the specific score is not obtained by the risk evaluation method for the single project, but only the risk level is determined. Therefore, if the evaluation results of risk level are the same for several projects, then how to select the best project? To resolve the realistic problems, it is necessary to investigate into the risk evaluation method of multiple venture capital projects.

This paper presents a new risk assessment method for the venture capital project. With it, the risk level is described for the risk evaluation indexes with the interval number, and then, the comprehensive evaluation value of multiple projects is given using the uncertain multiple-attribute decision-making method with the interval-styled attribute weights and attribute values. The risk ranking can be achieved for multiple projects according to these evaluation values.

4.1. Determination of Evaluation Level

The risk of evaluation indexes of the venture capital projects is classified into 5 types owing to the risk ranking problems of multiple venture capital projects and easy computation: low risk V_1, lower risk V_2, common risk V_3, higher risk V_4, and high risk V_5. A level set is composed by above 5 evaluation level elements: $V=\{V_1,V_2,V_3,V_4,V_5\}$. With totally 5 scores, the values appropriate to 5 risk levels are 1, 2, 3, 4 and 5. If the index level is between 2 adjacent levels, the appropriate scores are 1.5, 2.5, 3.5 and 4.5.

4.2. Creation of Normalized Decision-Making Matrix

Supposed there are s venture capitals projects $x_1,x_2,\cdots,x_s$ at the choice of venture capitalists, these projects are evaluated from the risk factors of projects. The experts give scores of each indexes for these project, likewise, the information available to the experts is not enough to grasp the true state of evaluation index, the index judgment value will be given in interval number way, thus the project decision-making matrix is obtain. Supposed the project decision-making matrix $\tilde{C}=(\tilde{C}_{ij})_{s\times l}$, where, $\tilde{C}_{ij}=[\tilde{c}_{ij}^-,\tilde{c}_{ij}^+]=\{t\,|\,1\leqslant\tilde{c}_{ij}^-\leqslant t\leqslant\tilde{c}_{ij}^+\leqslant 5\}$ indicates the interval number of the j-th index in the i-th project.

The risk evaluation indexes of the venture capital projects are the cost-typed ones, and the decision-making matrix $\tilde{C}=(\tilde{C}_{ij})_{s\times l}$ can be transferred to normalized decision-making matrix $C=(C_{ij})_{s\times l}$ using the equation (9), where:

$$C_{ij}=[c_{ij}^-,c_{ij}^+]=\{t\,|\,0\leqslant c_{ij}^-\leqslant t\leqslant c_{ij}^+\leqslant 1\}$$

$$c_{ij}^-=\frac{1/\tilde{c}_{ij}^+}{\sqrt{\sum_{i=1}^{s}(1/\tilde{c}_{ij}^-)^2}},\quad c_{ij}^+=\frac{1/\tilde{c}_{ij}^-}{\sqrt{\sum_{i=1}^{s}(1/\tilde{c}_{ij}^+)^2}} \tag{9}$$

4.3. Uncertain multiple-Attribute Decision Making Model

In uncertain multiple-attribute decision-making method, the essence is to rank and select best one from a group of (finitely) alternative solutions with existing decision-making information. It mainly composes of two parts [16, 17]: (1) Acquisition of decision-making information. The decision-making information generally includes the attribute weights and attribute values (the former is in both real and interval number ways. The attribute values are in three ways: real number, interval number and language). (2) Clustering the decision-making information and rank and select the best one of solutions in a certain way. The decision-making information is often uncertain resultantly owning to the complexity and uncertainty of objective things and the ambiguity of human thinking (at least one of attribute weights and attribute values is non-real). Therefore, the uncertain multiple-attribute decision-making method can be broadly applied in the reality under uncertain environment.

The previous discussion suggested that it is more reasonable to indicate the index weight and index value with the interval number in dealing with the risk assessment problem of venture capital project. Therefore, the present paper created the following uncertain multiple-attribute decision-making model to rank the risk of the venture capital projects based on the linear planning model set forth.

$$\begin{cases}\max z(w)=\sum_{i=1}^{s}\sum_{j=1}^{l}(c_{ij}^+-c_{ij}^-)w_j\\ s.t\quad kw_1^-\leqslant w_1\leqslant mw_1^+,\cdots,kw_l^-\leqslant w_l\leqslant mw_l^+,\ \sum_{j=1}^{l}w_j=1\end{cases}$$

Supposed that the above model's optimal solution is $w=(w_1,w_2,\cdots,w_l)$, and then the comprehensive attribute value of the project x_i is the interval number $Z_i(w)=[z_i^-(w),z_i^+(w)]$, where,

$$z_i^-(w)=\sum_{j=1}^{l}c_{ij}^-w_j,\ z_i^+(w)=\sum_{j=1}^{l}c_{ij}^+w_j\quad(i=1,2,\cdots,s)$$

Using the equation (1), the interval numbers $Z_i(w)=[z_i^-(w),z_i^+(w)]\ (i=1,2,\cdots,s)$ were compared by pairs to create the possibility matrix $P=(p_{ij})_{s\times s}$, where, $p_{ij}=p\big(Z_i(w)\geqslant Z_j(w)\big)$. The matrix P is a complementary judgment matrix. With its ranking formula (5), give the rank vector $v=(v_1,v_2,\cdots,v_s)$ of the possibility matrix P, rank the interval number $Z_i(w)=[z_i^-(w),z_i^+(w)]\ (i=1,2,\cdots,s)$ according to the component size, and gives the risk rank of venture capital projects $x_1,x_2,\cdots,x_s$.

5. ANALYSIS OF EXAMPLES

5.1. Risk Level Evaluation Example of Single Project

Supposed that three venture capitalists evaluate the risk of a venture capital project, the evaluation index is described as in Section 2. Assuming that the importance level of three venture capitalists are the same, the interval number judgment matrix of three capitalists were treated (the specific calculation process is omitted), and the interval number judgment matrix is given as $A=(A_{ij})_{6\times 6}$

$$A=\begin{pmatrix} 1 & [2.33,3.33] & [2.00,3.00] & [2.67,3.67] & [0.33,0.50] & [3.33,4.33] \\ [0.30,0.43] & 1 & [0.33,0.50] & [2.00,3.00] & [0.25,0.33] & [2.33,3.33] \\ [0.33,0.50] & [2.00,3.03] & 1 & [2.00,3.00] & [0.33,0.50] & [2.67,3.67] \\ [0.27,0.37] & [0.33,0.50] & [0.33,0.50] & 1 & [0.20,0.33] & [2.00,3.00] \\ [2.00,3.03] & [3.03,4.00] & [2.00,3.03] & [3.03,5.00] & 1 & [3.67,5.33] \\ [0.23,0.30] & [0.30,0.43] & [0.27,0.37] & [0.33,0.50] & [0.19,0.27] & 1 \end{pmatrix}$$

Then,

$$A^-=\begin{pmatrix} 1 & 2.33 & 2.00 & 2.67 & 0.33 & 3.33 \\ 0.30 & 1 & 0.33 & 2.00 & 0.25 & 2.33 \\ 0.33 & 2.00 & 1 & 2.00 & 0.33 & 2.67 \\ 0.27 & 0.33 & 0.33 & 1 & 0.20 & 2.00 \\ 2.00 & 3.03 & 2.00 & 3.03 & 1 & 3.67 \\ 0.23 & 0.30 & 0.27 & 0.33 & 0.19 & 1 \end{pmatrix}$$

$$A^+=\begin{pmatrix} 1 & 3.33 & 3.00 & 3.67 & 0.50 & 4.33 \\ 0.43 & 1 & 0.50 & 3.00 & 0.33 & 3.33 \\ 0.50 & 3.03 & 1 & 3.00 & 0.50 & 3.67 \\ 0.37 & 0.50 & 0.50 & 1 & 0.33 & 3.00 \\ 3.03 & 4.00 & 3.03 & 5.00 & 1 & 5.33 \\ 0.30 & 0.43 & 0.37 & 0.50 & 0.27 & 1 \end{pmatrix}$$

With the square root method, give the normalized weight vectors of A^-, A^+:

$w^-=(0.231,0.127,0.169,0.095,0.307,0.071)$

$w^+=(0.227,0.126,0.171,0.097,0.310,0.069)$

From the equation (2), we gain: $k=0.913<1$, $m=1.103>1$, therefore, the interval number judgment matrix A meets the consistent requirement.

From the equation (3), gives the interval number weight vector:

$W_1=[0.211,0.250]$, $W_2=[0.116,0.139]$

$W_3=[0.154,0.189]$, $W_4=[0.087,0.107]$

$W_5=[0.280,0.342]$, $W_6=[0.065,0.076]$

With the equation (1), give the possibility between interval number weights and create the possibility matrix as below:

$$P=\begin{pmatrix} 0.5 & 1 & 1 & 1 & 0 & 1 \\ 0 & 0.5 & 0 & 1 & 0 & 1 \\ 0 & 1 & 0.5 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0.5 & 0 & 1 \\ 1 & 1 & 1 & 1 & 0.5 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0.5 \end{pmatrix}$$

With the equation (5), give the weight of all evaluation indexes:

$w=(0.217,0.150,0.183,0.117,0.250,0.083)$

Now, supposed the three venture capitalists give the evaluation value of project indexes as showed in Table **1**.

In Table **1**, $d_j(j=1,2,3)$ indicates the j-th expert.

With the equation (7), to aggregate the above index evaluation information, and give the linguistic evaluation values of the venture capital projects by the three venture capitalists:

$$s_{\bar{\beta}^1}=s_{-1.317},\ s_{\bar{\beta}^2}=s_{-0.550},\ s_{\bar{\beta}^3}=s_{-1.001}$$

With the equation (8), to aggregate the above index evaluation information, and give the linguistic evaluation values of the non-systematic risk in the projects by three venture capitalists:

$$s_b=s_{-0.8703}$$

According to the evaluation criterion (1) of risk level for the single project, the risk level of the project under confidence level 87.03% is s_{-1}, namely the risk of the project under the confidence level 87.03% is "lower" level.

5.2. Risk Level Evaluation Example of Multiple Projects

In term of the venture capitalist's investment problem, there are five alternative options. Now, three experts are asked to evaluate these projects form the project risk factors. The evaluation index is as described in Section 2. That is, the evaluation object space is:

$X=\{x_1,x_2,\cdots,x_5\}$. The evaluation index space is $U=\{u_1,u_2,\cdots,u_6\}$.

Through treatment of the interval number judgment matrix and decision-making matrix by the three experts, give the comprehensive interval number judgment matrix $A=(A_{ij})_{6\times 6}$ and decision-making matrix $\tilde{C}=(\tilde{C}_{ij})_{5\times 6}$ respectively:

Table 1. Evaluation value of investment indexes given by three venture capitalists.

	u_1	u_2	u_3	u_4	u_5	u_6
d_1	s_{-2}	s_1	s_{-2}	s_0	s_{-3}	s_1
d_2	s_{-1}	s_{-1}	s_{-1}	s_0	s_0	s_0
d_3	s_{-2}	s_1	s_{-1}	s_{-1}	s_{-2}	s_1

$$A=\begin{pmatrix} 1 & [2.33,3.33] & [2.00,3.00] & [2.67,3.67] & [0.33,0.50] & [3.33,4.33] \\ [0.30,0.43] & 1 & [0.33,0.50] & [2.00,3.00] & [0.25,0.33] & [2.33,3.33] \\ [0.33,0.50] & [2.00,3.03] & 1 & [2.00,3.00] & [0.33,0.50] & [2.67,3.67] \\ [0.27,0.37] & [0.33,0.50] & [0.33,0.50] & 1 & [0.20,0.33] & [2.00,3.00] \\ [2.00,3.03] & [3.03,4.00] & [2.00,3.03] & [3.03,5.00] & 1 & [3.67,5.33] \\ [0.23,0.30] & [0.30,0.43] & [0.27,0.37] & [0.33,0.50] & [0.19,0.27] & 1 \end{pmatrix}$$

$$\tilde{C}=\begin{pmatrix} [3,4] & [3,4] & [2,3] & [2,3] & [2,4] & [4,5] \\ [2,3] & [3,4] & [4,5] & [2,4] & [3,4] & [2,3] \\ [2,3] & [3,4] & [4,5] & [2,4] & [2,3] & [3,5] \\ [2,4] & [2,5] & [2,3] & [3,4] & [3,5] & [2,3] \\ [3,4] & [2,5] & [2,4] & [3,5] & [4,5] & [2,4] \end{pmatrix}$$

To derive the interval number weight vector by using the same method as in Section 5.1:

$$W=(W_1,W_2,\cdots,W_6)=[kw^-,mw^+]$$

Where,

$W_1=[0.211, 0.250]$, $W_2=[0.116, 0.139]$
$W_3=[0.154, 0.189]$, $W_4=[0.087, 0.107]$
$W_5=[0.280, 0.342]$, $W_6=[0.065, 0.076]$

And then, after the decision-making matrix $\tilde{C}$ is normalized, give the normalized decision-making matrix C as below:

As described in Section 4.3, to create the following optimal model:

$$\begin{cases} \max z(w)=1.947w_1+2.609w_2+1.903w_3+2.420w_4+2.017w_5+2.080w_6 \\ s.t \quad 0.211\leqslant w_1\leqslant 0.250,\ 0.116\leqslant w_2\leqslant 0.139,\ 0.154\leqslant w_3\leqslant 0.189 \\ 0.087\leqslant w_4\leqslant 0.107, 0.280\leqslant w_5\leqslant 0.342,\ 0.065\leqslant w_6\leqslant 0.076,\ \sum_{j=1}^{6} w_j=1 \end{cases}$$

To derive the solution to the model, and give the optimal weight vector of the index as below:

$$w=(0.211, 0.139, 0.154, 0.107, 0.313, 0.076)$$

Further derive the comprehensive attribute value of all projects:

$Z_1(w)=[0.287,0.729]$, $Z_2(w)=[0.284,0.659]$,

$Z_3(w)=[0.303,0.730]$, $Z_4(w)=[0.263,0.737]$,

$Z_5(w)=[0.237,0.635]$

With equation (1), to calculate the possibility between comprehensive attribute values in the project and create the possibility matrix as below:

$$P=\begin{pmatrix} 0.5 & 0.545 & 0.490 & 0.509 & 0.586 \\ 0.456 & 0.5 & 0.444 & 0.466 & 0.546 \\ 0.510 & 0.556 & 0.5 & 0.518 & 0.598 \\ 0.491 & 0.534 & 0.482 & 0.5 & 0.573 \\ 0.414 & 0.454 & 0.402 & 0.427 & 0.5 \end{pmatrix}$$

To calculate the ranking vector of possibility matrix P through the ranking formula of complementary judgment matrix:

$$v=(0.207, 0.196, 0.209, 0.204, 0.185)$$

From the ranking vector v and possibility in P, give the rank of interval number $Z_i(w)\ (i=1,2,\cdots,5)$:

$$Z_3(w)\underset{0.510}{\succ}Z_1(w)\underset{0.509}{\succ}Z_4(w)\underset{0.534}{\succ}Z_2(w)\underset{0.546}{\succ}Z_5(w)$$

Therefore, the rank of the five venture capital projects (in consideration of risk) is:

$$x_3\underset{0.510}{\succ}x_1\underset{0.509}{\succ}x_4\underset{0.534}{\succ}x_2\underset{0.546}{\succ}x_5$$

From the rank results, the project x_3 has the minimal risk and the project x_5 has the maximal risk.

CONCLUSION

The present paper creates the risk evaluation index system that is in line with China's actuality for the venture capital projects on the basis of risk assessment indexes at home and overseas; respectively creates the models to solve the risk level determination problem for single venture capital project and risk rank problems of multiple venture capital projects. During creating the risk evaluation model for single project, the account is fully taken into the uncertainty of the venture capital project and expert's subjective cognition. The relative importance level of risk evaluation indexes in venture capital projects is described with interval number to avoid the absoluteness of results obtained by traditional evaluation method. In creating the risk evaluation model of multiple projects, the risk level of indexes for the venture capital project is described. The uncertain multiple-attribute decision-making model is built. Thus, the risk rank is done for multiple venture capital projects. The interval number is

$$C=\begin{pmatrix} [0.254,0.521] & [0.274,0.645] & [0.357,0.828] & [0.338,0.859] & [0.282,0.889] & [0.208,0.414] \\ [0.338,0.781] & [0.274,0.645] & [0.214,0.414] & [0.254,0.859] & [0.282,0.593] & [0.347,0.828] \\ [0.338,0.781] & [0.274,0.645] & [0.214,0.414] & [0.254,0.859] & [0.376,0.889] & [0.208,0.552] \\ [0.254,0.781] & [0.219,0.967] & [0.357,0.828] & [0.254,0.573] & [0.226,0.593] & [0.347,0.828] \\ [0.254,0.521] & [0.219,0.967] & [0.267,0.828] & [0.203,0.573] & [0.226,0.445] & [0.260,0.828] \end{pmatrix}$$

used to characterize by fully understanding the uncertainty of the venture capital project and expert's subjective cognition. Therefore, the risk evaluation model constructed in the present paper is scientific and reasonable in line with the feature of venture capital.

CONFLICT OF INTEREST

The author confirms that this article content has no conflict of interest.

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