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Fuzzy comprehensive evaluation modeled risk assessment of colleges and universities' sci-tech innovation

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Abstract. Risk, existing in various forms during the process of Colleges and Universities' Sci-tech Innovation (CUSTI) is a vital reason that restricts the innovation at colleges and universities. With the help of AHP, fuzzy comprehensive evaluation model, CUSTI's risk is recognized and calculated based on the characteristics of CUSTI. This research not only makes up the qualitative study of this problem, but also come up with the next research direction in the future.

Key words. Fuzzy evaluation, ahp, sci-tech innovation, risk, assessment.

1. Introduction

With the increasing number of CUSTI project, the Sci-tech innovation's (STI) risk increasingly stands out. Because of STI's expertise and complexity. The writer plans to establish the relevant assessment indicator system that addresses the risk of talents, technology and capital, etc, during CUSTI's stages of application, development and transformation.

2. The Current Situation of CUSTI Risk

CUSTI risk refers to the collection of elements that hinder the CUSTI field to apply series of technology innovation activities to create intellectual property (IP) rights, economic benefits and social benefits.[1] Blind project launching, insufficient research and development (R&D) ability, low achievement conversion rates, and along with other problems increase the risk cost of CUSTI in the processes of application, development and transformation.

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3. Establishing the AHP Model of CUSTI Risk Assessment Indicator System

3.1. Constructing the Assessment Indicator System

3.1.1. Risks during the Project Application Stage (C_1): There are mainly four types of risk involved in the application stage. Firstly, policy risk (C_{11}). Scientific activities are affected by the national science policy. Secondly, economic risk (C_{12}). STI activities are closely related to a country's overall plans of economic development. Thirdly, social risk (C_{13}) which represents basic information of the traditional culture and ethnic distribution. Lastly, environmental risk (C_{14}) which can lead to the corresponding STI's external risks.[2].

3.1.2. Risks during the Project Development Stage (C_2): Risk of Talents (C_{21}): Lack of technology ability would bring talent structure risk (C_{211}), talents exhaustion risk (C_{212}) and talents cultivation risk (C_{213}).[3] Technological risk (C_{22}): If the competitors quickly introduce the similar product to the market by imitation and reverse engineering, which would trigger technology maturity risk (C_{221}), technology life-cycle risk (C_{222}), technology implementation risk (C_{223}) and technical support risk (C_{224}). Management risk (C_{23}) is made up of the resource allocation risk (C_{231}), the project's cooperation risk (C_{232}) level. and the system risk (C_{233}).

3.1.3. Risks during the Achievement Transformation Stage (C_3): Market risk (C_{31}): Some research projects cannot meet the demand of the market. In this case, transformation difficulty risk (C_{311}), market acceptance risk (C_{313}) and the productive competition risk (C_{312}) occurs.[4] Capital risk (C_{32}): Insufficient supply of funds may lead to the investment risk (C_{321}) ,the accounting risk (C_{322}) and the financial risk (C_{323}). Legal risk (C_{33}): As for CUSTI, there are two specific legal risks: one is IP risk (C_{331}) and the other is the leak risk of the classified projects (C_{332}).

3.2. Establishing the Structure of Risk Level Analysis of Scientific Research in University

3.2.1. Establishing the Ladder Hierarchical Structure Model: Different stages of innovation projects have different risk types which was shown by Table 1. According to the above evaluation index, the risk hierarchy model of university's scientific innovation is constructed.

Table 1.The Technology Innovation Risk Hierarchical Structure Model of CUSTI

Object evaluation	**Factor evaluation**	**Factor evaluation**	**Indicator evaluation**
CUSTI Risk Assessment	C_1 Project's application risk	C_{11} policy risk	
		C_{12} economic risk	
		C_{13} social risk	
		C_{14} environmental risk	
	C_2 Project's development risk	C_{21} Talents risk	C_{211} talents structure risk
			C_{212} talents exhaustion risk
			C_{213} talents cultivation risk
		C_{22} Technological risk	C_{221} technology maturity risk
			C_{222} technology life-cycle risk
			C_{223} tech implementation risk
			C_{224} technical support risk
		C_{23} Management risk	C_{231} resource allocation risk
			C_{232} cooperation risk
			C_{233} system risk
	C_3 Achievement transformation risk	C_{31} Market risk	C_{311} transformation difficulty risk
			C_{312} productive competition risk
			C_{313}market acceptance risk

3.2.2. Distribution of Risk Assessment Index Weight by AHP: Structure the Risk Judgment Matrix. In order to reflect the importance of various indicators to CUSTI risk assessment index system, applying pairwise judgment of nn − 1/2 times on each indicator under the criterion layer, we establish the reciprocal matrix and comparison matrix$A = (a_{ij})_{n\text{xn}}$. a_{ij} refers to C_i-C_j ratio, and $\frac{1}{a_{ij}}$meansC_j-$C_i$ratio, whena_{ij}=$\frac{1}{a_{ji}}$ and $a_{ij} > 0$.

In $A = (a_{ij})_{n\text{xn}}$, the value of a_{ij} may be assigned empirically by experts according to the importance of the indicator. This risk evaluation system adopts Saaty's 9 element scale, specifically using 1 ˜ 9 and their reciprocals as a scale. Calculating

Weight Coefficients Calculating Maximum Eigenvalue $\lambda_{\max}$,$\lambda_{\max} = \sum_{i=1}^{n}(CW)_i/N \times W_i$ among them $(CW)_i$ is the i element of $(CW)_i$ vector. Using the summation method to calculate weight of the criterion layer and index layer. First, normalize element C, and get $\overline{\mathrm{C}}$= ($\overline{\mathrm{C}}_{\mathrm{ij}}$),$\overline{\mathrm{C}}_{\mathrm{ij}} = C_{ij}/\sum_{i=1}^{n} C_{ij}$.Then, calculate $\overline{\mathrm{C}}_{\mathrm{ij}}$ by the fuzzy matrix $\overline{W_i} = \sum_{i=1}^{n} \overline{C_{ij}}$, and get$\overline{W}$. Lastly, normalize $\overline{W}$, i.e. $W = \overline{W_i}/\sum_{i=1}^{n} \overline{W_i}$, so that we may obtain the set W of weight vectors in each criterion layer and index layer.

Table 2. Consistency Check R.I. Value

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Consistency Check. To verify the above calculated weighting to see whether it can be applied in the sorting of lower elements to upper elements, a consistency check should be applied and the CR value serves as the indicator of inconsistency in this check. CR=RI/CI; CI=(λmax-n)/n-1. RI is a correction coefficient of the matrix. Also, the author introduces R.I. value, the average random consistency check index (Table 2). When CR=RI/CI0.1,the judgment matrix meets with the consistency check and weighting distribution is reasonable.

4. Establishing the Fuzzy Evaluation Model of CUSTI Risk Assessment Indicator System

4.1. Establishing Evaluation Factor Set, Evaluation Set, Numeric Set, Weight Set and Membership Degree Subset

4.1.1. According to Table 1, We Get the Evaluation Factor Set As Follows: C=$\{C_1,C_2,C_3\}$

C_3=$\{C_{31},C_{32},C_{33}\}$ C_{31}=$\{C_{311},C_{312},C_{313}\}$$C_{32}$=$\{C_{321},C_{312},C_{313}\}$ C_{33}=$\{C_{331},C_{332}\}$

4.1.2. Construct the Evaluation Set and Numeric Set: The fuzzy Comprehensive evaluation is functioned as the model tool that builds the CUSTI risk assessment system and decides the collection of CUSTI achievement transformation assessment levels, i.e. V V_1,V_2,V_3,V_4,V_5 . And the risk is divided as five levels: V_1-high risk; V_2-comparatively high risk; V_3-risk existence; V_4-comparatively low risk; V_5-low risk. According to each assessment's indicating level, the risk classification is defined as Table 3.Evaluation Set V=$\{V_1,V_2,V_3,V_4,V_5\}$.Numeric Set N=$\{90,70,50,30,10\}$.

Table 3. Risk Score

Evaluation Set	$\boldsymbol{V_1}$	$\boldsymbol{V_2}$	$\boldsymbol{V_3}$	$\boldsymbol{V_4}$	$\boldsymbol{V_5}$
Numeric Set	***90***	***70***	***50***	***30***	***10***

4.1.3. Build The Weight Set of The Target Assignment: Using AHP to get the weight of every factor evaluation and indicator evaluation:

W={W_1,W_2,W_3} W_3={W_{31},
W_{32},W_{33}} W_{31}={W_{311},
W_{312},W_{313}} W_{32}={W_{321},
W_{312},W_{313}} W_{33}={W_{331},W_{332}}

4.1.4. Construct Membership Subset: Construct membership subset R to reflect the fuzzy relationship between factor set and evaluation set, R_i={R_{i1},R_{i2},. . . . . R_{in}}. R_i means the membership between factor set C and evaluation set V, R=(r_{in})=the number of the ith select a level of index V_i/headcount, After the normalization, we get the following membership subset.

R_{11}={a,b,c,d,e},(a+b+c+d+e=1 and a,b,c,d,e0)
R_{332}={a,b,c,d,e},(a+b+c+d+e=1 and a,b,c,d,e0)

4.2. Fuzzy Comprehensive Evaluation

The first level assessment operation: R is set as the fuzzy assessment operation, where?FR =(r_{in}), it means the fuzzy relationship between set C and evaluation set V. Because of the ambiguity of the index C_{ij}, we can get the degree of the ith belonging to comment V_i and constructing judgment matrix. We use $M(\bullet, \oplus)$ the weighted average model as fuzzy operator which is a very common model in comprehensive assessment.[5]

Use$M(\bullet, \oplus)$F

$$B_j = \sum_{i=1}^{n} (a_i r_{ij})(4-1)$$

The evaluation result

$$\mathrm{X} = \mathrm{W} * \mathrm{R} = [w_1, w_2, \ldots\ldots, w_n] * \begin{pmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{pmatrix} (4-2)$$

The second level assessment operation is based on the result of the first level assessment operation and the method is the same. The evaluation result

$$\mathrm{Y} = \mathrm{W} * \mathrm{X} = [w_1, w_2, \ldots\ldots, w_n] * \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ \mathrm{X_n} \end{bmatrix} (4-3)$$

The third level assessment operation result

$$\mathrm{Z} = \mathrm{W} * \mathrm{Y} = [w_1, w_2, \ldots\ldots, w_n] * \begin{bmatrix} \mathrm{Y}_1 \\ \mathrm{Y}_2 \\ \vdots \\ \mathrm{Y}_\mathrm{n} \end{bmatrix} (4-4)$$

Evaluation of the final score. Finally, according to the risk reflected by to table 3's N value calculation, get the final score of the school's scientific research and innovation risks as follows:

$$\mathrm{Z} = \mathrm{W} * \mathrm{Y} (4-5)$$

5. Empirical Study

Now BJXX University plans to have one Sci-tech achievement evaluated by STI risk assessment. Based on the materials provided by the STI group and the principle of Sci-tech risk assessment, the writer gets the following weight with the method of AHP.

5.1. To Determine the Index Weight

Using AHP to get the weight of every CUSTI's risk assessment factor evaluation and indicator evaluation. The value of judgement matrix C_I was < 0.01. It can scientifically and reasonably reflect the important degree of each index and the distribution of weight is reasonable.

W={0.6491,0.2790,0.0719}; W_1={0.3412,0.1282,0.0704,0.4602};
W_2={0.6986,0.2370,0.0643}; W_{21}={0.6250,0.1365,0.2385 };
W_{22}={0.2180,0.0685,0.1066,0.6069 }; W_{23}={0.7010,0.1061,0.1929 };
W_3={0.5695,0.0974,0.3331}; W_{31}={0.1603,0.1488,0.6908 };
W_{32}={0.5714,0.1429,0.2857 }; W_{33}={0.6667,0.3333 }

5.2. Constructing the Fuzzy Comprehensive Evaluation

20 experts will be surveyed anonymously on the evaluation index system of the CUSTI's risk evaluation. According to the five risk index system, after the normalization processing, obtain the membership subset.

5.2.1. The Fuzzy Calculation of Project Application Risk:

$$\eta = \frac{c}{4b} - \frac{\xi}{2} + \frac{1}{4} + \frac{c\xi}{2b}\,,\ \eta = -\frac{c}{4b} + \frac{\xi}{2} - \frac{1}{4} - \frac{c\xi}{2b}\,,\ \xi = -\frac{1}{2}\,,\ \xi = \frac{1}{2}\,.$$

Compound operation of fuzzy subset

$$G = \left(\frac{1}{a^2}\frac{\partial^2 w}{\partial \xi^2} + \frac{1}{b^2}\frac{\partial^2 w}{\partial \eta^2}\right)^2, \quad H = \frac{1}{a^2 b^2}\frac{\partial^2 w}{\partial \xi^2}\frac{\partial^2 w}{\partial \eta^2} - \left(\frac{1}{ab}\frac{\partial^2 w}{\partial \xi\, \partial \eta}\right)^2.$$

5.2.2. The Fuzzy Calculation of Project's Development Risk: The first level assessment operation:

$$T = \frac{ab}{2}\rho_0 h_0 \omega^2 \int_{-\frac{1}{2}}^{\frac{1}{2}} \int_{-\frac{c}{4b}+\frac{\xi}{2}-\frac{1}{4}-\frac{c\xi}{2b}}^{\frac{c}{4b}-\frac{\xi}{2}+\frac{1}{4}+\frac{c\xi}{2b}} p_1 p_2 \left[1-(1-\beta)\left(\xi+\frac{1}{2}\right)^2\right] w^2 \,\mathrm{d}\eta\,\mathrm{d}\xi$$

Similarly X_{22}=(0.1359 0.1819 0.1299 0.2733 0.279),X_{23}=(0.1246 0.1045 0.1019 0.3351 0.3339)

5.2.3. The Fuzzy Calculation of Project's Achievement Transformation Risk:

$$\mathrm{Z} = \mathrm{W} * \mathrm{Y} = [w_1, w_2, \ldots\ldots, w_n] * \begin{bmatrix} \mathrm{Y}_1 \\ \mathrm{Y}_2 \\ \vdots \\ \mathrm{Y}_n \end{bmatrix} (5-4)$$

5.2.4. Operation Results

$$\mathrm{Z} = \mathrm{W1} * \mathrm{Y} = w_1 * \begin{bmatrix} Y_1 \\ Y_2 \\ Y_3 \end{bmatrix}$$

$$= [0.6491, 0.2790, 0.0719, 0.2306] * \begin{bmatrix} 0.1494\ 0.1236\ 0.1723\ 0.3241\ 0.2306 \\ 0.1271\ 0.1542\ 0.1917\ 0.3261\ 0.2007 \\ 0.0281\ 0.086\ 0.2622\ 0.3546\ 0.2689 \end{bmatrix}$$

$$= [0.1345\ 0.1294\ 0.1842\ 0.3269\ 0.2250]$$

5.3. Final Score

Finally, according to the table 3, get the final score of CUSTI' s risks, as follows

$$\mathrm{Y} = \mathrm{W} * \mathrm{X} = [w_1, w_2, \ldots\ldots, w_n] * \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ \mathrm{X}_3 \end{bmatrix}$$

Therefore, we get the final score of 42.43 points in CUSTI' s risk assessment, it is obviously lower than the general risk level of scientific research project.

6. Conclusions

Based on the above construction of the assessment system and empirical study, the author believes that with increasing engagement of the project's application(A_1), development(A_2) and achievement transformation(A_3),because

(A_1<A_1+A_2<A_1+A_2+A_3),A=$\sum$Ai i=(1,2,3), so the overall risk (A) of the STI project increases.[6] Meanwhile, the risks' complexity and their interaction among each other should also be noticed along the whole process of STI, and the project is also influenced by S (Opportunity loss), i.e. Overall loss=A+S. During the process of CUSTI risk quantitative assessment research, we should thoroughly recognize, prevent and control the risk and scientifically design the risk assessment index system that measures and assesses the risk which may occur in the STI process.[7] This research provides a quantitative study approach to further establish the mechanism of STI risk management, assessment and transformation.

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