Risk Evaluation of Inter-Enterprise Cooperative R&D Projects

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Abstract: ***Under the background of economic globalization and internationalization of competition, more and more enterprises are aware of the importance of cooperation for enterprise survival and competition. Compared with independent research and development, cooperative R&D has many advantages such as reducing R&D costs, arranging resources more reasonably, and complementing the knowledge and capabilities among enterprises. On the other hand, there are large uncertainties in cooperative R&D between enterprises. Therefore, it is inevitable to face higher risks. Therefore, how to effectively conduct risk analysis and risk assessment has become one of the important issues considered by many enterprises, especially inter-enterprise cooperative R&D projects. This paper collects relevant data through expert questionnaire survey, combines fuzzy AHP and fuzzy comprehensive evaluation, evaluates the risk of cooperative R&D projects among enterprises, and attempts to propose corresponding risk control methods.***

Keywords: Cooperative research and development project, Risk assessment, Fuzzy analytic hierarchy process

1. Introduction

Collaborative R&D between enterprises is a research and development model in which the cooperation of multiple organizations is based on the premise of complementary cooperation. Cooperative R&D can effectively utilize external resources of the organization, reduce R&D costs and share R&D risks. At the same time, due to the participation of multiple organizations in R&D activities, the cooperation and competition between members of the organization exacerbates the technical and management complexity, and uncertainty. It is also easy to induce cooperative research and development risks. Therefore, identifying and controlling these risks can increase the success rate of cooperative R&D projects and promote R&D cooperation among enterprises.

The analysis and evaluation of the risk of cooperative R&D projects between enterprises is the premise of project risk management and the basis for formulating and implementing risk control and response measures. Due to the complexity, variability, and difficulty of data collection, the project members will be biased in the risk assessment. Therefore, selecting appropriate risk analysis and evaluation methods can effectively monitor and manage project risks. This paper combines fuzzy AHP and fuzzy comprehensive evaluation to quantitatively evaluate the risk of cooperative R&D projects among enterprises, in order to propose rational risk control basis and provide useful reference for project risk management.

2. The Trends and Risk Factors of Cooperative R&D among enterprises

In the 1960s and 1970s, the cooperative R&D of enterprises around the world showed a state of slow and steady growth. After entering the 21st century, the cooperation between enterprises and enterprises increased sharply. This has a very important relationship with the great changes in industry and technology at the same time, especially The rapid development of high-tech industries represented by the information technology industry has further promoted cross-regional and cross-industry competition. These changes in industry and technology have led to the increasing complexity, increasing uncertainty, increasing cost of research and development, and the shortening of innovation cycles.

Compared with internal R&D projects, cooperative R&D projects have their own characteristics. In cooperative R&D projects, the organizational form is often virtual and has a large randomness. Sometimes, the people involved in the cooperation are also constantly changing. The enterprises are not directly binding on the non-corporate researchers involved in the cooperation. Some effective management methods have great limitations in the application of cooperative R&D projects. Due to the large uncertainty of cooperative R&D between enterprises, it is inevitable to face higher risks. Based on the risk assessment research table for high-tech enterprise cooperative R&D projects, Zhou Kai (2010)[1] pointed out that in the process of cooperative R&D, the risks faced are: performance risks such as government policies, economic situation, partner capabilities; relationship risks such as partner ethics, Cultural differences, interest distribution, cooperation models, changes in strategic decision-making of partners, etc.; knowledge spillover risks such as the degree of sharing of key technologies, changes in market share, and the completeness of technical protection contracts.

Based on a large number of literatures and expert opinions, this paper divides the inter-enterprise cooperative R&D risk into four categories, including external factors, partner factors, cooperation agreement factors and cooperation technology factors. For more detailed research, Four major factors were further subdivided to obtain 17 secondary impact factors. The external factors include seven subdivision indicators: the market intellectual property risk index and the relevant legislation and policy of enterprise cooperation R&D; the partner factors include the technical strength of the enterprise, the economic strength of the enterprise, the degree of credit of the enterprise, the status quo of intellectual property management of the enterprise, the frequency of important employee turnover, the motivation of the cooperation of the enterprise, and the cooperation experience of the enterprise; the cooperation agreement factors include the completeness of the cooperation agreement, the communication and supervision mechanism of the cooperation parties, the rationality of the distribution of the results in the cooperation agreement, and the risk sharing in the cooperation agreement. Four sub-indicators of rationality of sharing; cooperative technology factors include four subdivision indicators: the achievability of cooperative technology, the uncertainty of cooperation technology prospects, cooperative technology assessment and background technology intellectual property search.

3. The Trends and Risk Factors of Cooperative R&D among enterprises

Risk assessment is a qualitative and quantitative analysis of the identified risks, assessing the probability of occurrence of the risk and the degree of impact on the project objectives, and determining whether to take control measures on the project. The risk evaluation of cooperative R&D projects is a multi-level and multi-factor comprehensive evaluation problem, which has many influencing factors, making the risk assessment problem more complicated. Some experts and scholars have done research. Liu Rong (2009) [2]has established a comprehensive evaluation index system for enterprise cooperation and innovation, and constructed a corresponding multi-level fuzzy comprehensive evaluation model, the validity of the model is tested by an example. Chen Keli (2014) [3]and Li Ruran (2013)[4] and other scholars also constructed a project engineering risk evaluation index system in their risk assessment research, and used AHP to determine the weight of risk evaluation indicators to provide reference for engineering project practice. Zhou Kai (2010)[1] proposed a cooperative R&D risk evaluation index system based on the characteristics of cooperative R&D projects. The artificial neural network method was used to establish a risk evaluation model and empirical analysis, and corresponding risk response strategies were proposed. Gao Yunli (2013) [5]established a risk assessment model for engineering projects based on cooperation using fuzzy reasoning method, and proposed a new method for risk analysis of engineering projects. Wang Hao (2011)[6] proposed a risk assessment method for engineering projects based on Bayesian network for the problems in the risk assessment of large-scale construction projects. This method is based on historical data of construction projects and combined with expert experience evaluated the probability of occurrence of risk. The objectivity and feasibility of the method are verified by a large-scale stadium construction project. Li Zhiwei (2008)[7] adopted the combination of AHP method and BP neural network technology to establish an emergency logistics risk assessment and prediction model. Firstly, the evaluation index system of emergency logistics risk assessment is established. The method of screening indicators by AHP analytic method is given. Then the evaluation and prediction steps of improved neural network model are designed. Xu Jiana (2004)[8]combined the artificial neural network credit risk assessment technology with the analytic hierarchy process to establish a credit risk assessment AHP-ANN model for commercial banks, and conducted a feasibility demonstration. The results show that the improved AHP-ANN model has a certain degree of improvement in the input index system simplification, output index measurement and model operation efficiency.

Project risk assessment is a multi-attribute decision-making problem. Many domestic and foreign scholars have proposed many evaluation methods in the research of risk assessment. The commonly used risk assessment methods are analytic hierarchy process (network analytic hierarchy process), fuzzy comprehensive evaluation method, neural network method, Monte Carlo simulation, Delphi method, Bayesian network method, etc. Although there are many methods that can be used for risk assessment, many methods have certain limitations, so many scholars use a combination of methods when conducting risk assessment studies. This paper attempts to combine fuzzy AHP and fuzzy comprehensive evaluation to evaluate the risk of cooperative R&D projects among enterprises.

4. Risk evaluation of cooperative R&D projects between enterprises based on fuzzy hierarchy evaluation method

In this paper, the fuzzy level comprehensive evaluation method is used to evaluate the risk of inter-enterprise cooperative R&D project. Based on the identification of various factors, the possibility of various factors leading to project risk is evaluated, and the weighting order of each influencing factor is obtained. In order for decision makers to take appropriate measures to control the factors with greater weight.

4.1 Establish an evaluation index system

According to the type of each index in the fuzzy level comprehensive analysis method, the influencing factors of the risk of inter-enterprise cooperative R&D projects are divided into three levels, which are the target layer, that is, the risks of cooperation between enterprises to develop intellectual property, the criterion layer, that is, external factors, partner factors, cooperation agreement factors, cooperative technology factors, factor layer, including market intellectual property risk, school-enterprise cooperation research and development related legislation and policies, cooperation parties' understanding of WTO rules, partner technical strength, partner economy strength this 19 factors.

4.2 Construct judging matrix for risk of cooperative R&D projects between enterprises

Constructing the judgment matrix of pairwise comparison is the basis for determining the weight of the index, and it is also an important basis for the whole fuzzy comprehensive analysis. When constructing the judgment matrix, the relative importance between the two factors is determined by the pairwise comparison for the same layer factor subordinate to the upper layer. Using the Delphi method, experts are invited to assign the judgment matrix one by one. The specific quantified value is measured by the 1-9 scale proposed by Saaty et al. The scale ranges from 1, 2, ..., 9 and their reciprocals. Ten experts were invited to score the criteria and indicator factors of intellectual property risk, and then the geometric mean of the ten expert scores was taken.

4.3 Calculate indicator weights

A judgment matrix A consisting of factors of the risk assessment criteria layer of the cooperative R&D project, the eigenvector W is calculated, and it is required to satisfy AW= λ max W, and W is normalized, that is, the component of W satisfies Σ W=1. The feature vector is obtained. After normalization, the feature vector W=(0.048702, 0.467946, 0.161453, 0.321898). The same method calculates the judgment matrix B composed of external factors, calculates its eigenvector W1, and satisfies BW1= λ maxW1, and normalizes W1, that is, the component of W1 satisfies Σ W1=1. The eigenvector is obtained. After normalization, the eigenvector W1=(0.124989, 0.875011). Next, according to the same steps, the partner factors, cooperation agreement factors, and cooperative technology factors are calculated to obtain the feature vectors W2=(0.029508,0.222598,0.299034,0.021751, 0.240303,0.167626,0.019180), W3= (0.095574, 0.03682, 0.280595, 0.587011), feature vector W4 = (0.661209, 0.175605, 0.077985, 0.085201).

4.4 Consistency test

In theory, if the judgment matrix A conforms to the consistency, then there is aij.ajk = aik, where i, j, k = 1, 2, ... n. However, due to the complexity of objective things, human understanding is also diverse. Usually, the initial judgment matrix is difficult to meet the above requirements. However, if the deviation is excessive, the reliability of the final result will be reduced. Therefore, it is necessary to test the consistency of the judgment matrix. Since it is difficult to achieve the complete conformity index, in the actual analysis, the relative consistency index (CR) is used to test the relative consistency of the judgment matrix. The calculation results show that CR=CI/RI=0.0183/ 0.89=0.0206<0.1, it is considered that the relative consistency of the judgment matrix is satisfactory and acceptable.

Table 3.1: Weighting table of risk factors for inter-firm cooperative R&D projects

Target layer	criterion layer	criterion layer weight	indicator layer	indicator layer weight	Overall impact of indicator	Indicator importance ranking
Weighting table of risk factors for inter-firm cooperative R&D projects	external factors B1	0.048702	Market intellectual property risk index C1	0.124989	0.006087	16
			Relevant legislation and policies C2	0.875011	0.042615	9
	Partner factors B2	0.467946	Technical strength of the enterprise C3	0.029508	0.013808	13
			Economic strength of the enterprise C4	0.222598	0.104164	4
			Corporate credibility C5	0.299034	0.139932	2
			Enterprise employee turnover frequency C6	0.021751	0.010178	14
			Corporate's cooperation motivation C7	0.240303	0.112449	3
			The status quo of enterprise intellectual property management C8	0.167626	0.078440	6
			Enterprise cooperation experience C9	0.019180	0.008975	15
	Cooperation agreement factors B3	0.161453	Cooperative contract completeness C10	0.095574	0.015431	12
			Communication and supervision mechanism C11	0.03682	0.005945	17
			Rationality of the distribution of cooperation results C12	0.280595	0.045303	8
			Rationality of cooperative risk sharing C13	0.587011	0.094775	5
	Cooperative technical factors B4	0.321898	The achievability of cooperative technology C14	0.661209	0.212842	1
			Uncertainty in the prospects of cooperative technology C15	0.175605	0.056527	7
			Cooperative technology assessment C16	0.077985	0.025103	11
			Intellectual property search of background technique C17	0.085201	0.027426	10

4.5 Setting of risk review set

The risk review set needs to be determined by experts through the Delphi method. According to the analysis purpose of this paper, the risk of inter-enterprise cooperative R&D project is divided into five levels, which are recorded as (very high, high, average, low, very low). Using the Delphi method, experts are invited to assess the risk factors of collaborative R&D projects at the criteria and indicator levels. Factors such as partner factors for the indicator layer, among the 20 experts, 10 think that the risk is very high, 5 think that the risk is high, 3 think the risk is average, 2 think the risk is low, 0 think the risk is very low, The proportions are 0.5, 0.25, 0.15, 0.1, and 0, and the evaluation vector R1 = {0.5 0.25 0.15, 0.10 0} in the evaluation matrix R. Ten experts were invited to evaluate the probability of each factor's risk. According to the above expert scores, the fuzzy judgment matrix is obtained as follows:

$$V=\begin{bmatrix} 0 & 0.4 & 0.3 & 0.2 & 0.1 \\ 0.6 & 0.3 & 0.1 & 0 & 0 \\ 0.5 & 0.2 & 0.2 & 0.1 & 0 \\ 0.7 & 0.1 & 0.1 & 0.1 & 0 \end{bmatrix}$$

$$V1=\begin{bmatrix} 0 & 0 & 0.1 & 0.4 & 0.5 \\ 0 & 0 & 0.5 & 0.3 & 0.2 \end{bmatrix}$$

$$V2=\begin{bmatrix}0.5&0.4&0.1&0&0\\0.4&0.5&0.1&0&0\\0.5&0.3&0.1&0.1&0\\0.2&0.1&0.3&0.2&0.2\\0.1&0.2&0.6&0.1&0\\0.2&0.2&0.4&0.1&0.1\\0&0&0.5&0.3&0.3\end{bmatrix}$$

$$V3=\begin{bmatrix}0.7&0.2&0.1&0&0\\0.3&0.4&0.2&0.1&0\\0.8&0.2&0&0&0\\0.5&0.3&0.2&0&0\end{bmatrix}$$

$$V4=\begin{bmatrix}0.5&0.4&0.1&0&0\\0.2&0.3&0.3&0.1&0.1\\0.1&0.1&0.1&0.3&0.4\\0.1&0.1&0.1&0.2&0.5\end{bmatrix}$$

Then, the weight matrix A of each factor is multiplied by the evaluation matrix V to obtain a comprehensive evaluation result of each factor. According to the above calculation steps, for the four factors of the criterion layer, VW = (0.5868, 0.2243, 0.1259, 0.0581, 0.0049). Two factors for external factors are V1*W1=(0,0,0.4500,0.3125,0.2375). For the partner facter, V2*W2=(0.3152, 0.2966, 0.2825, 0.0808, 0.0249). For the cooperative agreement factor, V3*W3=(0.5959, 0.2661, 0.1343, 0.0037, 0). For the technical factors of cooperation, V4*W4=(0.3820, 0.3335, 0.1351, 0.0580, 0.0914).

Through the above analysis, the following conclusions are drawn:

Among the four criteria factors listed in this paper, the partner factor is the most important, with a weight of 0.467946. The second important factor is the cooperative technology factor, which has a weight of 0.321898. The third important factor is the cooperation agreement factor. The weight is 0.161453, and finally an external factor with a weight of 0.048702. Therefore, when selecting a partner, the company must first consider the partner factor, consider the cooperation technology when the level of the partner is not much different, select the partner who is better at the cooperation technology, and then consider the cooperation agreement factor, It is necessary to pay attention to factors such as the completeness of the cooperation agreement proposed by the two parties, and finally consider external factors such as the market intellectual property risk index and related legislation and policies.

Among the partner factors, the most important factor is the degree of credibility of the enterprise; among the cooperative technology factors, the most important is the achievability of the cooperative technology; among the cooperation agreement factors, the most important one is the rationality of the cooperative risk sharing; Among the external factors, the more important ones are related legislation and policies.

5. Conclusions and Future Research Prospects

The common methods used in the risk evaluation of cooperative R&D projects often have certain limitations. Combined with fuzzy AHP and fuzzy comprehensive evaluation, the advantages of these two methods are combined and the shortcomings of the respective methods are overcome. The evaluation method proposed in this paper can not only find the relative size of each risk factor in the risk of cooperative R&D projects between enterprises, but also calculate the overall risk of the project, which will greatly help enterprises to carry out cooperative R&D projects. . Although the research in this paper has certain theoretical and practical significance, it still has certain limitations. First of all, this article only tries to select most of the risk factors of the cooperative R&D project between enterprises for analysis. There are some other important factors that may not be studied, such as financial risks. In actual application, it can be based on the specific situation. The evaluation index system is subject to certain revisions. At the same time, although the combination of the two evaluation methods eliminates some deficiencies, it does not mean that it is the best method for risk evaluation of cooperative R&D projects between enterprises. In combination with the actual implementation of cooperative R&D projects by enterprises, considering the application of other methods, it will have a beneficial impact on the implementation of cooperative R&D projects.

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