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Risk Identification and Evaluation of Science and Technology Collaborative Innovation in Jiangxi Province

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Abstract

Accelerating the construction of an innovative country is an important task in the construction of a modern economic system.In recent years, Jiangxi Provincial Science and Technology Collaborative Innovation System has developed rapidly.In this paper, 50 science and technology collaborative innovation institutions in Jiangxi Province were investigated by field investigation method to identify their existing risks.The risk evaluation system of collaborative innovation body was constructed by fuzzy analytic hierarchy process and fuzzy comprehensive evaluation method, and the risk assessment of technological collaborative innovation body in Jiangxi Province was carried out, and the relevant suggestions were put forward.

Keywords

Scientific and Technological Collaborative Innovation; Risk Identification; Risk Evaluation; Fuzzy Comprehensive Evaluation Method.

1. Introduction

At the 18th National Congress of the People's Republic of China, it was clearly stated that Scientific and technological innovation provides strategic support for the improvement of social productive forces and overall national strength, and must be placed at the core of China's overall development. In August 2013, the seventh plenary session of the thirteenth session of the Jiangxi provincial party committee put forward the sixteen-word policy of *development and upgrading, well-off and speed-up, green rise, and solid work* to revitalize Jiangxi. It requires that industrial upgrading be the core connotation of development and upgrading, and focus on key industries to promote collaborative innovation, support innovation elements to gather in enterprises, and give full play to the main role of enterprises to promote collaborative innovation.In this context, in order to implement the decision of the provincial Party committee and government on vigorously promoting scientific and technological collaborative innovation, Jiangxi Province initiated the mode of scientific and technological collaborative innovation body to leverage the government, enterprises, banks and social capital to invest in scientific research.

The definition of collaborative innovation body has not been clearly described in the current literature. However, according to the *The decision of Jiangxi Provincial People ' s Government of the Communist Party of China on vigorously promoting scientific and technological collaborative innovation*, collaborative innovation entities take the leading enterprises in the province as the main body, the advantage associated enterprises participate, the interests as the link, and all kinds of advantages such as domestic and foreign enterprises, colleges and universities, scientific research institutes and financial institutions are gathered. To overcome the key, core and common technology of the industrial chain, a group of science and technology collaborative innovation entities operating under the market mechanism are established according to the principles of clear property rights, clear and effective supervision and corporate operation.

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The existing literature on enterprise risk management analysis has been detailed, but the research literature on the new mode of *collaborative innovation body* is very rare, and the research on the risk assessment of collaborative innovation body is even less. Many theoretical and practical issues need to be paid attention to and studied urgently.

2. The Status Quo of Science and Technology Collaborative Innovation Bodies in Jiangxi Province

2.1. Basic Information of Jiangxi Science and Technology Collaborative Innovation Bodies

Jiangxi Province ' s science and technology collaborative innovation body is based on market demand, with joint-stock system as the core, provincial leading enterprises as the main body, combined with upstream and downstream affiliated enterprises within and outside the province, attracting investment in universities, research institutions and natural persons 'technology, attracting investment and shares of banks, venture capital companies and other social capital. The key task is to attack industrial technology and achieve joint R & D, joint industrialization and joint development of R & D institutions. Through independent innovation, the affiliated enterprises become the connotative growth combination with hematopoietic function, so as to promote the innovation, upgrading and rapid development of strategic emerging industries in Jiangxi Province.

From 2014 to the end of 2019, a total of 102 science and technology collaborative innovation bodies were set up in the province. A total of 119 core key generic technologies have been broken through, including 169 domestic leading technologies, 29 international advanced technologies, 15 international leading technologies, 173 invention patents, 95 technical standards, 106 independent brands, and 101.086 billion yuan in main business income. The province's 102 collaborative innovation bodies cover nine industrial areas of strategic emerging industries, as shown in Table 1.

Table 1. Industry types and the number of enterprises of S&T collaborative innovation bodies in Jiangxi Province

Industry type	Quantity
The new material	40
Biological and new pharmaceutical industries	15
Energy conservation and environmental protection	14
Equipment manufacturing	11
The new generation of information technology	9
Green products	5
Lithium-ion and electric vehicles	3
Aviation manufacturing	3
New energy	2
A combined	102

2.2. Current Situation and Problems of Risk Management of Science and Technology Collaborative Innovation in Jiangxi Province

Jiangxi Science and Technology Collaborative Innovation Institute was developed in 2013. Due to its short development period, lack of reference cases for relevant operation modes, and imperfect laws and regulations, enterprises of Science and Technology Collaborative

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Innovation Institute have a low risk awareness and no risk assessment and control mechanism has been established.Is an important characteristic of cooperative innovation of science and technology innovation, scientific research projects of investment, long cycle and low success rate is a big risk control points of the industry, if not a professional risk assessment mechanism to the enterprise risk identification, assessment, will further increase the risk of a business survey and research the risks of cooperative innovation of science and technology in Jiangxi province [1].

3. Risk Identification of S & T Collaborative Innovation Bodies

According to the feedback of collaborative innovation companies in the province, and referring to the risk system constructed by Liu Liping (2017) [2] and Yan Xiaoyan (2017) [3], this paper summarizes the main risks faced by science and technology collaborative innovation in our province, and analyzes its risk sources and main manifestations, as shown in Table 2.

Table 2. Risk situation of scientific and technological collaborative innovation bodies

Source of risk	Risk categories	The main performance
Technical factors	Technology research and development risk	Large R&D investment
	Risk of technology transfer	Low achievement conversion rate
	Risk of technological substitution	Fast technology update
Internal factors	Industrial risk	Integration risk, cooperation risk
	Human resource risk	Talent gap is big, resource allocation structure is unreasonable
	Capital risk	Less capital source channels, financing difficulties
External factors	Policy risk	Policy support is not enough
	Market risk	Customer demand grasp is not accurate, consumer preferences are constantly changing

3.1. Internal Factors of Collaborative Innovation Partners

The internal factors of the partners refer to the possibility of innovation failure caused by the wrong decision-making of of the collaborative innovation in the process of innovation projects. In the actual process of collaborative innovation, such factors as the fair distribution of innovation benefits, the publicity of innovation investment, the trust mechanism of partners, the clarity of subject ' s responsibility and the communication between various subjects have strong uncertainties. They have different degrees of influence on the risks of collaborative innovation. This paper summarizes them as industrial risks, human resources risks and capital risks.

3.1.1. Industrial Risks

Firstly, the industrial risk is reflected in the different organizational culture of the main units. Because the technology collaborative innovation body is a combination of multiple horizontal and vertical enterprises, when realizing technology collaboration, the organizational culture of each subject is not compatible, and its focus and evaluation mechanism and evaluation system are inconsistent, so that the two sides cannot form a unified collaborative goal, which leads to the integration risk of compatibility in the technology interface of different enterprises. Secondly, the ownership of property rights and the distribution of interests among the subjects are not clear. At present, there is still a lack of corresponding intellectual property policy and interest distribution system to support the identification of the ownership of scientific and

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technological collaborative innovation achievements produced by enterprises, universities and scientific research institutes in the province, which is prone to cooperative risks such as the allocation of intangible assets property rights and credit subjects.

3.1.2. Human Resource Risks

First of all, Jiangxi science and technology collaborative innovation body lacks effective talent incentive system. Since Jiangxi Province is still in a relatively backward area and lacks attraction for innovative talents, many outstanding talents will choose developed provinces and cities with larger development space. Moreover, the current Jiangxi provincial government on science and technology innovation body in-service talent incentive, incentive policy is relatively lacking, unable to mobilize the enthusiasm and creativity of innovation personnel, so that innovation personnel will not actively participate in the project, talent gap. Secondly, the talent allocation structure of S & T collaborative innovation is unreasonable. At present, there is no integrated service platform for talents of science and technology collaborative innovation bodies in the province, so that each innovation body cannot connect and collaborate with R & D personnel of research institutes, universities and research institutions in the same industry at home and abroad in combination with enterprise and market demand.

3.1.3. Capital Risks

The capital risks faced by science and technology collaborative innovation entities in Jiangxi Province are mainly reflected in two aspects : less sources of funds and financing difficulties of science and technology innovation.One is the lack of sources of funding. According to the survey, the operation funds of most sci-tech collaborative innovation entities in Jiangxi Province mainly come from leading enterprises and government subsidies. First of all, since the establishment of collaborative innovation body, it has been provided by leading enterprises with funds and places to spend. Once the leading enterprises encounter funds or business difficulties, it will lead to the rupture of the capital chain of the collaborative innovation body. Secondly, the current research funds provided by the government are limited and not enough to support the funding needs of the whole project.The second is the financing difficulty of scientific and technological innovation. Most of the scientific and technological innovation companies in Jiangxi Province belong to small and medium-sized enterprises, and their own funds are often difficult to meet the operational needs of project funds. Most of them need to loan to financial institutions, while small and medium-sized enterprises are facing many restrictions from financial institutions.

3.2. External Environmental Factors of Collaborative Innovation Body

Technological innovation occurs within a certain framework of economic structure, so the external environment of social economy directly affects the innovation results. Because the external environment factors are mainly composed of consumer preferences, government behavior and laws and regulations, and these factors have certain uncertainty, this paper divides the uncertainty of the external environment into two types : market risk and policy risk.

3.2.1. Market Risks

The market risk of technological innovation is caused by the uncertainty of market scale, the inaccurate grasp of customer demand and the continuous change of consumer preferences.On the one hand, due to the impact of technology introduction, the existence of imitators and intellectual property issues make new products not effectively accepted by the market ; On the other hand, the shortening of product life cycle and too fast market iteration can also cause asset specificity problems, which increase market risks by creating lockup problems in transactions.

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3.2.2. Policy Risks

The policy risks faced by science and technology collaborative innovation entities in Jiangxi Province are mainly reflected in the adjustment and change of government policies and regulations and the lag of policy formulation and implementation.One is the adjustment of government policies and regulations. According to the survey, it is found that most collaborative innovation bodies in the province rely too much on the government 's welfare policies related to collaborative innovation. If the government 's supporting funds are not in place, the enterprise capital chain will break, which seriously affects the R & D process. Most enterprises indicate that if the preferential policies of the government to support technological innovation are changed, the established S & T collaborative innovation body will not be able to successfully complete the task of technological R & D, and will not be able to operate continuously.The second is the lag of policy formulation and implementation. Since the science and technology innovation synergy is a project proposed in Jiangxi Province in recent years, the relevant policies formulated by the government have not kept pace with the times, and there are still many lagging places.

3.3. Technical Factors of Collaborative Innovation Body

Because the collaborative innovation process requires close cooperation between the parties in innovation technology research and development, innovation market demand analysis and collaborative support platform support, this increases the difficulty of collaborative innovation [4]. In this paper, the technical factors mainly include the following risks : technology R & D risk, technology substitution risk, technology transfer risk.

3.3.1. Technology Research and Development Risk

The ultimate goal of science and technology collaborative innovation body is innovation, and let the innovation achievements realize industrialization, bring the best interests to all parties, and R & D project due to its own creativity, destined to have a certain risk. At present, due to the uncertainty of the innovation environment in the technological projects of provincial science and technology collaborative innovation bodies, technological R & D has certain complexity, resulting in a generally long period of technological R & D and increasing R & D risks. Moreover, from the perspective of product life cycle, technology research and development belongs to the initial stage of science and technology collaborative innovation body. Although science and technology collaborative innovation body attaches great importance to innovation at this time, new technologies and new ideas are in the exploratory stage, and the difficulty of research and development makes the success rate of technology research and development low.

3.3.2. Risk of Technology Transferring

At present, in the operation process of collaborative innovation bodies, enterprises have low digestion and absorption capacity for successful R & D technologies, and often only focus on projects that can generate benefits efficiently and rapidly. However, for some technologies and projects with large capital and equipment needs and immature market, they only stay in the stage of theoretical design and laboratory. The low success rate of technology transformation in enterprises makes the technical products developed with long time and high investment cannot be put into actual production and operation, resulting in many patented technical achievements cannot be popularized and difficult to realize market value.

3.3.3. Risk of Technology Substitution

Due to the time uncertainty of product R & D, experiment, production and large-scale sales, when collaborative innovators complete a technological innovation, a more advanced technology may appear, which makes the technology lose value and leads to collaborative innovation failure. Technical substitution can be divided into two kinds.One is the overall

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substitution, the process is irreversible .The other is local substitution, there is overlap between the two technologies. In either case, however, the risk of technological substitution will lead to the inability of collaborative innovators to recover the investment and time costs of technological innovation, making all previous investments sunk, thereby discouraging a new round of innovation cooperation.

4. Risk Assessment of Science and Technology Collaborative Innovation Entities

In this paper, the fuzzy analytic hierarchy process and fuzzy comprehensive evaluation method are combined to construct the risk evaluation system of collaborative innovation body. Firstly, the fuzzy consistent discriminant matrix is constructed by fuzzy analytic hierarchy process, and the judgment of each index is collected by questionnaire survey. After integrated calculation, each index is given the corresponding weight according to its influence on the evaluation effect. Then, the fuzzy evaluation model is constructed by fuzzy comprehensive evaluation method combined with the weight value calculated in the previous step, and the membership function of risk at all levels is calculated. Fuzzy analytic hierarchy process (FAHP) has been improved on the basis of analytic hierarchy process (AHP). The principle of fuzzy mathematics is introduced to construct the fuzzy consistent judgment matrix for the comparison of indicators, and the application scope is more extensive. Fuzzy comprehensive evaluation method (FCEM) is a comprehensive evaluation method that uses the principle of fuzzy mathematics to transform qualitative evaluation into quantitative evaluation and conduct overall evaluation of objects affected by multiple factors. It has the characteristics of strong systematicness and clear calculation results. Combined with fuzzy analytic hierarchy process, it can effectively evaluate the risk of science and technology collaborative innovation. The specific steps are as follows.

4.1. Determining the Weight of Risk Assessment Indicators

4.1.1. Establishment of Hierarchical Risk Assessment Model of Scientific and Technological Collaborative Innovation

The risk assessment index system of science and technology collaborative innovation body consists of three layers : target layer, criterion layer and index layer. Among them, the target layer is reflected by the criterion layer, and the criterion layer is reflected by the specific decision index layer.

(1) Target layer A: The overall risk of S & T collaborative innovation is the target layer, which reflects the risk status of innovation in general.

(2) Criterion layer B_i. The criterion layer consists of three parts : technical factor B_1, internal factor B_2 and external environment B_3

(3) Index layer Bij: the indicator layer is composed of eight indicators, and the detailed indicator system is shown in Table 3.

4.1.2. Determination of Weights and Consistency Test

(1)Determination of index layer weights

This paper selects 10 experts from universities and research institutions who have been engaged in the research of science and technology collaborative innovation body for a long time. The nine-level scale method is used to compare the indexes at the same level, and then the arithmetic average method is used to determine the scale, construct a pair of comparison matrix, and calculate the weight of the index at the level to the upper level. By analogy, the weight vector of each index to the target layer is finally obtained.

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Table 3. Risk Hierarchy Structure Model of Collaborative Innovation Body

A target layer	Rule layer B_i	Index layer B_{ij}
Total Risk A	Technical factor B_1	Technology development risk B_{11}
		Technology transfer risk B_{12}
		Technology substitution risk B_{13}
	Internal factor B_2	Industrial Risk B_{21}
		Human resource risk B_{22}
		Capital Risk B_{23}
	External factors B_3	Policy Risk B_{31}
		Market Risk B_{32}

Table 4. Scales determined by each element in the judgment matrix

Aij	Two targets compared
1	The i factor is as important as the j factor
3	The i factor is as important as the j factor
5	The i factor is as important as the j factor
7	The i factor is as important as the j factor
9	The i factor is as important as the j factor
2,4,6,8	The importance of factors i and j is between the two adjacent judgment scales mentioned above
The inverse of each of these	The two goals are compared in reverse

(2) Consistency testing

Consistency testing is needed to verify whether the pairwise comparison matrix and weight are within the allowable range. The corresponding weight vector of the pairwise comparison matrix is calculated by software yaahp10.2, and the consistency test is carried out, namely, the maximum eigenvalue λmax and the consistency ratio CR [6]. If CR ≤ 0.1, the consistency check is passed, otherwise the pairwise comparison matrix should be readjusted.

Table 5. Weight value and consistency test results of first-level indicators

Level indicators	The weight	Consistency check
B_1	0.3445	λmax = 3.0536, CR = 0.0516 Consistency check passed.
B_2	0.5469	
B_3	0.1085	

Table 6. Weight value and consistency test results of second-level indicators

The secondary indicators	The weight	Consistency check
B_{11}	0.6870	λmax = 3.0940, CR = 0.0904 Consistency check passed.
B_{12}	0.1865	
B_{13}	0.1265	
B_{21}	0.3425	λmax = 3.0940, CR = 0.0904 Consistency check passed.
B_{22}	0.2789	
B_{23}	0.3786	
B_{31}	0.3333	λmax = 2, CR = 0 Consistency check passed.
B_{32}	0.6667	

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4.2. Fuzzy Comprehensive Evaluation of Risk of S&T Collaborative Innovation Body

In order to calculate the risk level of the collaborative innovation body of science and technology, this paper refers to Sun Chenhui et al. [7] To measure the risk, the 5-point Likert scale was used to conduct a questionnaire survey on all subjects of the collaborative innovation body (1 means strongly disagree, 2 means disagree, 3 means uncertain, 4 means agree, and 5 means strongly agree).During the investigation, 230 questionnaires were sent out and 216 were returned. The specific results are shown in Table 7.

Table 7. Statistical situation of risk indicators of S & T collaborative innovation bodies

Level indicators		The secondary indicators		rating				
indicators	The weight	indicators	The weight	Strongly agree (%)	Agree (%)	Unsure (%)	Disagree (%)	Strongly disagree (%)
B_1	0.3445	B_{11}	0.687	17.25	38.56	29.62	8.32	6.25
		B_{12}	0.1865	19.25	26.63	24.32	15.54	14.26
		B_{13}	0.1265	11.57	19.25	30.25	27.41	11.52
B_2	0.5469	B_{21}	0.3425	13.24	23.57	32.68	16.84	13.67
		B_{22}	0.2789	25.32	35.69	20.32	9.82	8.85
		B_{23}	0.3786	23.35	42.67	18.65	9.75	5.58
B_3	0.1085	B_{31}	0.3333	23.89	29.54	27.64	5.67	13.26
		B_{32}	0.6667	13.35	21.85	23.69	23.26	17.85

Establishment of multi-level evaluation model and fuzzy comprehensive evaluation. The calculation method is based on the fuzzy comprehensive evaluation model, whose general form is as follows:

$$Z = X.Y = (x_1, x_2, \cdots, x_3).\begin{bmatrix} y_{11} & \cdots & y_{1m} \\ \vdots & \ddots & \vdots \\ y_{n1} & \cdots & y_{nm} \end{bmatrix}$$

The letter Z is the result of fuzzy comprehensive evaluation, X is the weight set of fuzzy evaluation indexes, is an n-dimensional row vector, and Y is an (n × m) matrix.For example, the risk calculation for technical factors is as follows:

$$(0.687, 0.1865, 0.1265) \bullet \begin{pmatrix} 3.8 \\ 3.21 \\ 2.92 \end{pmatrix} = 3.58$$

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Table 8. Risk measurement results of S & T collaborative innovation entities

	Level indicators		The secondary indicators	
	indicators	Risk assessment	indicators	Risk assessment
Overall risk 3.52	Technical factors	3.58	Technology research and development risk	3.80
			Risk of technology transfer	3.21
			Risk of technological substitution	2.92
	Internal factors	3.55	Industrial risk	3.06
			Human resource risk	3.59
			Capital risk	3.95
	External environmental factors	3.20	Policy risk	3.80
			Market risk	2.90

According to the weighted calculation, the overall risk of scientific and technological collaborative innovation body is 3.52, which is at a relatively serious level according to the maximum membership principle.Among them, the risk of technology research and development is the largest among technical factors, the risk of capital is the largest among internal factors, and the risk of policy is the largest among external environmental factors.

5. Conclusion and Suggestions

Based on the existing research literature, this paper identifies and summarizes the key risk factors system of S & T collaborative innovators from the perspective of organizational structure and external environment : technical factors (including technology R & D risk, technology transfer risk, technology substitution risk), internal factors (including industrial risk, human resource risk and capital risk), and external environmental factors (policy risk and market risk). In this paper, the risk is measured by the fuzzy AHP-fuzzy comprehensive evaluation method. The results show that : (1) the overall risk of collaborative innovation is relatively serious, and the internal factors have the greatest impact on the overall risk. (2) Technology R & D risk is higher in technical factors, capital risk is higher in internal factors, and policy risk is higher in external environmental factors. The comprehensive evaluation model established by combining the risk weight and the fuzzy evaluation matrix can allow collaborative innovation entities to take targeted measures to prevent possible risks in the process of technological innovation. In order to prevent the risk of collaborative innovation, it is suggested to implement different financing modes and disperse the risk of capital control;Establish talent introduction mechanism, design talent incentive mechanism ; Clearly define the ownership of property rights, the establishment of interest distribution mechanism ; Improve resource sharing platform to achieve coordinated development of technology.

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