Risk Identification and Evaluation of Crowdsourcing Innovation Projects Based on the Improved FMEA Model

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Abstract. Crowdsourcing is an innovative model for enterprises acquiring external knowledge resources to achieve innovative targets. But it raises a lot of risks during the project operation process for unorganized, voluntary, liberal, purposive, information asymmetry, etc. This article constructs a crowdsourcing innovation project risk factors identification system by combing the operating process of the crowdsourcing and Social-technical system theory, including crowdsourcing participants risk, crowdsourcing innovative model risk, participants' relationship risk, crowdsourcing innovation project demand risk, technical complexity risk, and task structure risk. The failure modes of crowdsourcing innovation projects are assessed by the fuzzy evidential reasoning (*FER*) approach and ranked by grey theory. Internet marketing management website development project from *EPWK* (www.epwk.com) is taken as the example for empirical research. It is prospective for the achievement of this article could provide decision support for enterprises to effectively develop crowdsourcing innovative models, reduce the risks of crowdsourcing innovation, and help crowdsourcing platforms develop sustainably.

Keywords: Crowdsourcing innovation project · risk identification · FMEA model

1 Introduction

Crowdsourcing innovation, as a new type of innovation model, refers to a business model in which a company or organization transfers the issues internal innovation previously solved by contractors to the masses of external network (the public) [1]. The practice has proven that crowdsourcing innovation is an effective model to obtain the wisdom of the network group to solve innovation problems [2, 3]. Since the well-known crowdsourcing innovation platform, *InnoCentive* was founded in 2001, *P&G* has increased the proportion of innovation outside the company from 15% to 50%, and the R&D capability is increased by 60%. *IdeaStorm*-Dell's crowdsourcing innovation community has nearly 30,000 ideas submitted, and more than 550 ideas have been realized. Relying on the power of *MystarbucksIdea.com*, Starbucks continuously collect external ideas and

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promote brand awareness to get the product and service innovation concept. Through the efforts of players all over the world, *Foldit* solve the AIDS reverse transcriptase structural puzzle within ten days, which has plagued the scientists for fifteen years. The innovation pattern of the enterprise has been deeply affected by crowdsourcing innovation, and abundant different innovation patterns have been proposed.

However, as a new business pattern, crowdsourcing innovation is still in the groping stage, and the research achievements are fragmented [4]. Although the practice of crowdsourcing innovation has some achievement, it still has imperfections such as needing to improve the quality of innovation [5], user participating transiently [6, 7]. Chinese enterprises establish some crowdsourcing innovative virtual communities (e.g., HOPE, Midea Open Innovation Platform) and intermediary crowdsourcing platforms (e.g., Zbj, Taskcn, and Epwk) in recent years. But their applications remain in the primary scope of information processing and simple innovation tasks. And in China, only a few mainstream enterprises are willing to participate, which is in contrast to leading enterprises spare no pains to create crowdsourcing innovation models. One of the main reasons is that Chinese enterprises lack a systematic understanding of crowdsourcing innovation pattern, confidence in application, and theoretical guidance.

Crowdsourcing innovation is an open innovation model based on the Internet, which has virtuality organizational environment, loose organization, high participating subject mobility, and the incompatibility and difficulty of information exchange. Many opportunistic behaviors such as intellectual property theft, scheme fraud, malicious evaluation. Are easy to breed, which undoubtedly greatly increases the operational risk of crowdsourcing innovation projects. Some scholars have carried out useful explorations on crowdsourcing risk: Marjanovic et al. (2012) propose that ethical and legal risks are the main risks by combining the connotation and characteristics of crowdsourcing online [8]; Siala et al. (2013) point out ethical and legal risk should be paid more attention to in crowdsourcing project management [9]; Liu et al. (2019) consider there are seeker risk, relationship risk, solver risk, complexity risk, requirement risk and task risk in creative crowdsourcing project's [10]. In addition, some scholars analyze the sources of crowdsourcing innovation risks from crowdsourcing task types, crowdsourcing project cooperation process, and crowdsourcing platform competition [11–13] and explore the design of the risk management mechanism of crowdsourcing innovation from access system, program selection, credit evaluation, reward and punishment mechanism [14, 15]. The researchers mentioned exploring the crowdsourcing innovation risk from the aspects of crowdsourcing innovation risk identification and avoidance mechanism design, which have an important guiding value for improving the innovation performance of crowdsourcing projects.

But as a new business model, crowdsourcing innovation has complex and diverse innovation tasks, wide range of participations, and significant information asymmetry, which risk presentation will have more complex performance. In order to expand the theory and guide the popularization and application of crowdsourcing innovation models, it is necessary to systematically carry out the risk identification and evaluation of crowdsourcing innovation projects by combining the specific management practices. Therefore, this article constructs a multi-dimensional risk identification system for crowdsourcing innovation projects by combing Socio-Technical Theory and practice of crowdsourcing innovation project management. To evaluate the risk of crowdsourcing innovation projects, this paper presents a failure modes and effects analysis (FMEA) integrated fuzzy evidence reasoning (*FER*) approach and grey theory, and take the "internet marketing management website development project" form *epwk.com* to carry out empirical study.

2 Construction of Risk Identification System

2.1 The General Operation Process of Crowdsourcing Innovation Projects

This paper focuses on the operation process of crowdsourcing innovation projects based on third-party platforms. The main participants include seeker, crowdsourcing platform, solver. The seeker entrusts crowdsourcing platform to search for effective solutions to innovative problems by publishing tasks and pays the platform's operation costs and the intellectual contribution of the solver by providing remuneration. The crowdsourcing platform releases the crowdsourcing innovation task as an agent, searching for suitable contractors to complete the seeker's entrustment. The solvers use their knowledge, technology, and ability to solve innovation problems and obtain corresponding rewards. During this period, the crowdsourcing platform needs to provide a series of resources (such as communication technology, organizational skills, and human resources) to ensure the smooth completion of crowdsourcing projects and collect commissions. The general operation process of a crowdsourcing innovation project is shown in Fig. 1: (1) The seeker clarifies the innovation requirements, determines the reward, and submits the task; (2) The crowdsourcing platform reviews and releases the tasks, and collect commission in advance for safekeeping; (3) The solver selects appropriate innovative tasks, carries out work and completes the innovative tasks; (4) The solver submits the preliminary solvation and modify based on feedback; (5) The solver submits the final solvation. The seeker reviews the solvation whether meets the task requirements and lets the platform pay rewards to the solver.

It can be found that this kind of crowdsourcing innovation mainly adopts a principal-agent operation model with two principal-agent relationships. The first is the relationship

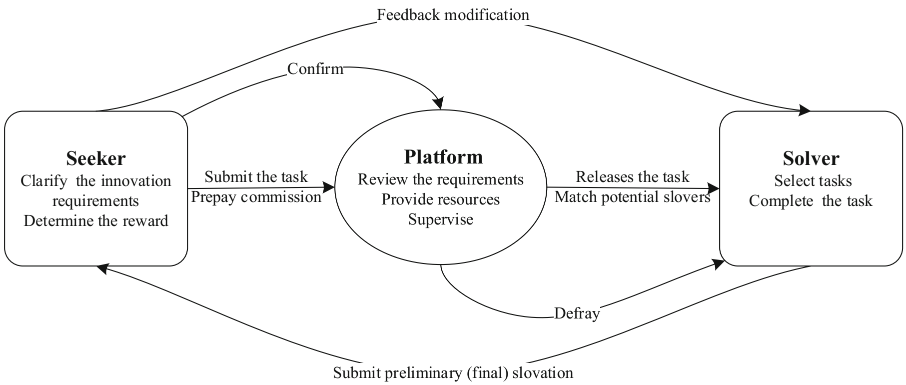

Fig. 1. The general operation process of the crowdsourcing innovation model

between the seeker and the crowdsourcing platform. The seeker entrusts the crowdsourcing innovation task to the crowdsourcing platform, and the crowdsourcing platform matches the solvers according to the specific needs of the task. The second is the relationship between the crowdsourcing platform and the solver. The crowdsourcing platform entrusts the crowdsourcing task to the appropriate solvers, and the solvers accept the entrustment and complete the task with their own knowledge, skills, and experience. Due to the inconsistency of the objective function between the principal and the agent, two principal-agent relationships have aggravated the information asymmetry and opportunistic behavior tendency, which cause difficulties in the supervision during the crowdsourcing innovation process and breed multi-dimensional crowdsourcing Innovation uncertainty.

2.2 Construction of the Risk Identification System from the Perspective of the Social-Technical System

The social-technical system theory is proposed by Bostrom et al. (1977) [16], which holds that the working system is composed of two interrelated subsystems: the technological system involves the process of transforming the input elements (such as raw materials) into the output elements (such as products); the society system focuses on the relationship between people and the attributes of people themselves; and the output of the entire system is the result of the mutual interaction between these two subsystems. The tasks of crowdsourcing innovation projects are complex and diverse. The source of solvers is wide, and they participate in a free and voluntary way. The entire operation process has strong social characteristics. In addition, the crowdsourcing platform uses the Internet to create a virtual opening-innovation environment for interaction and collaboration between the seekers and solvers, which shows strong technical characteristics. So does the process of making solutions. During the entire life cycle of crowdsourcing innovation projects, social interaction, and technology application work alternately, having an important impact on performance [17]. Therefore, the risk composition of crowdsourcing innovation projects can be identified from the perspective of the social-technical system, as shown in Table 1.

(1) The social risks of crowdsourcing innovation projects. It refers to the uncertainty related to the social environment during the implementation of crowdsourcing innovation projects. The risks mainly come from three aspects: the participants, the crowdsourcing innovation business model, and the relationship between the participants. Crowdsourcing participant risk is the uncertainty of the seekers and the solvers, such as the seekers underinvestment, with poor absorptive capacity or weak willingness, and the solvers lacking matching knowledge and skills, with insufficient participation experience. Crowdsourcing innovation business model risk is caused by the disadvantages of crowdsourcing innovation business model such as loose organization, broad organizational boundaries, information mismatch and difficulty in monitoring, which specifically expressed as the solver participating freely and voluntarily, difficulty in monitor solvers' behavior, the possibility of leaking the core-information, intellectual property ownership dispute, etc. Participant relationship risk is caused by the uncertainty interactive relationship built by the seekers

Table 1. The risk identification system for crowdsourcing innovation projects

Target	Dimensions	The specific risk	Specific manifestation
Identification of risks in crowdsourcing innovation projects	Social risk	Crowdsourcing participant risk	The seeker: Underinvestment, Poor absorptive capacity, Weak willingness, etc. The solver: Lacking matching knowledge, Insufficient participation experience, etc.
		Crowdsourcing innovation business model risk	The solver participating freely and voluntarily, Difficulty in monitor solvers' behavior, the possibility of leaking the core-information, Intellectual property ownership dispute, etc.
		Participant relationship risk	Lack of trust, Poor communication, Untimely feedback, Speculative tendency, etc.
	Technical risk	Requirement risk	Inaccurate description of task requirements, vague understanding of requirements, etc.
		Technical complexity risk	The task itself is of great difficulty, Requiring complex technology and diverse knowledge to complete, etc.
		Task structure risk	Tasks are not easy to decompose and subtasks are highly dependent, etc.

and the solvers in the virtual environment, which is specifically expressed as lack of trust, poor communication, untimely feedback, and speculative tendency, etc. [18].

(2) The technical risks of crowdsourcing innovation projects. This kind of risk comes from the uncertainty of technology to solve innovation problems during the implementation of crowdsourcing innovation projects. It mainly includes requirement risk, technical complexity risk, and task structure risk. Requirement risk refers to the uncertainty related to task requirements, such as inaccurate description of task requirements and vague understanding of requirements. Technical complexity risk

is the uncertainty caused by the complexity of the task itself, the required knowledge and technology. For example, the innovation task itself is of great challenge and requires complex technology and diverse knowledge to complete, which will breed technical complexity risks. Task structure risk arises because the structure of crowdsourcing innovation projects is complex, systemic, leading to its tasks are not easy to decompose and subtasks are highly dependent. These factors will bring greater uncertainty and generate risks related to task structure.

2.3 Risk Assessment Based on Improved FMEA Model

Failure modes and effects analysis (FMEA) as a reliability risk analysis method, identifies possible failure modes through team discussion. And FMEA calculates the risk priority number through parameters such as occurrence (O), severity (S), and detectability (D) to make a comprehensive assessment of risks. FMEA can detect risks systematically and deeply. Crowdsourcing innovation as a new business model has strong characteristics such as uncertainty and complexity. Therefore, this paper uses the FMEA model to explore risk assessment of crowdsourcing innovation projects.

However, the traditional FMEA model has many defects, such as difficulty in evaluating risk factors with specific numbers, ignoring the relative weight of risk factors, the calculation method of RPN values inaccurate [19–21]. In order to accurately evaluate the risk of crowdsourcing innovation project, this paper improves FMEA model by integrating fuzzy evidential reasoning (*FER*) approach and grey theory.

2.4 Failure Mode Assessment Integrated Fuzzy Evidence Reasoning

Suppose the FMEA evaluation team has K evaluation members TM_k ($TM_1, TM_2,\ldots, TM_k$). The experts evaluate risk factors ($RF_1, RF_2,\ldots, RF_m$) in N failure modes ($FM_1, FM_2,\ldots, FM_n$). The Weight of each member is λ_k ($\lambda_k > 0$), and $\sum_{k=1}^{K} \lambda_k = 1$.

(1) Evaluate risk factors O, S, D with fuzzy language. Evaluate the risk factors with the standard $H_F = \{H_{11}, H_{22}, H_{33}, H_{44}, H_{55}\} = \{VeryLow, Low, Moderate, High;, VeryHigh\}$. The Membership functions of fuzzy language are shown in Fig. 2. The fuzzy ratings for linguistic terms are shown in Table 2.

(2) Calculate the comprehensive weight of the risk factor. The comprehensive weight of RF_m the K team members is denoted as

$$\tilde{W}_m = \sum_{k=1}^{K} \lambda_k \tilde{w}_m = \left(\sum_{k=1}^{K} \lambda_k w_{ma}, \sum_{k=1}^{K} \lambda_k w_{mb}, \sum_{k=1}^{K} \lambda_k w_{mb} \right), m = 1, \ldots, M \quad (1)$$

(3) Establish the fuzzy evaluation belief decision matrix. The K team members' comprehensive evaluation of the failure mode FMn for each risk factor is $\beta_{ij}(FM_n, RF_m)$, and is determined by

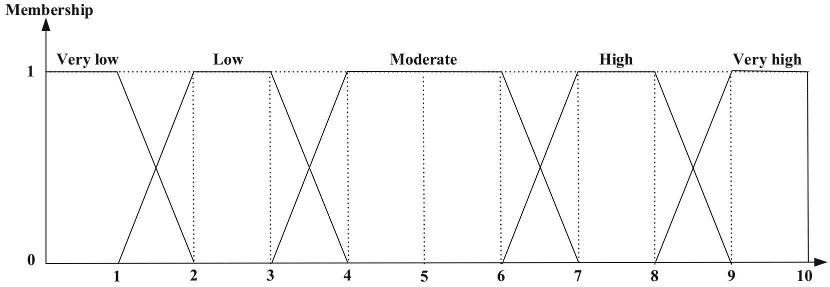

Fig. 2. The Membership functions of fuzzy language

Table 2. The fuzzy ratings for linguistic terms

Linguistic terms	**Fuzzy number**
Very low (VL)	(0, 0, 1, 2)
Low (L)	(1, 2, 3, 4)
Moderate (M)	(3, 4, 6, 7)
High (H)	(6, 7, 8, 9)
Very high (VH)	(8, 9, 10, 10)

$$\beta_{ij}(FM_n, RF_m) = \sum_{k=1}^{k} \lambda_k \beta_{ij}^k(FM_n, RF_m), i = 1, \ldots, 5; j = 1, \ldots, 5; n = 1, \ldots, N \tag{2}$$

The final fuzzy evaluation belief decision matrix is:

$$\tilde{X} = \begin{bmatrix} FM_1 \\ FM_2 \\ \vdots \\ FM_N \end{bmatrix} = \begin{bmatrix} \tilde{X}_1(1) & \tilde{X}_1(2) & \cdots & \tilde{X}_1(M) \\ \tilde{X}_2(1) & \tilde{X}_2(2) & \cdots & \tilde{X}_2(M) \\ \vdots & \vdots & \cdots & \vdots \\ \tilde{X}_N(1) & \tilde{X}_N(2) & \cdots & \tilde{X}_N(M) \end{bmatrix} \tag{3}$$

(4) Defuzzify and establish the crisp belief decision matrix. Using *Eq. (4)* to defuzzify the fuzzy belief decision matrix $\tilde{X}$ into crisp belief decision matrix X, where h_{ij} is the defuzzified crisp number of H_{ij}.

$$h_{ij} = \frac{\sum_{i=0}^{n}(b_i - c)}{\sum_{i=0}^{n}(b_i - c) - \sum_{i=0}^{n} a_i - d}, i = 1, \ldots, 5; j = 1, \ldots, 5 \tag{4}$$

The overall assessment of the failure mode *FMn* is also a crisp number, called overall belief structure, which can be aggregated by the following equation:

$$X_n(m) = \sum_{i=1}^{5}\sum_{j=1}^{5} h_{ij}\beta_{ij}(FM_n, RF_m), n = 1, \ldots, N; m = 1, \ldots, M \tag{5}$$

So, the crisp belief decision matrix is shown as follows:

$$X = \begin{bmatrix} FM_1 \\ FM_2 \\ \vdots \\ FM_N \end{bmatrix} = \begin{bmatrix} X_1(1) & X_1(2) & \cdots & X_1(M) \\ X_2(1) & X_2(2) & \cdots & X_2(M) \\ \vdots & \vdots & \cdots & \vdots \\ X_N(1) & X_N(2) & \cdots & X_N(M) \end{bmatrix} \tag{6}$$

2.5 Risk Ranking Based on Grey Theory

Grey theory one of the effective methods to deal with the decision-making problems of poor information and small samples. The basic idea is to determine the corresponding evaluation vector of the optimal solution under ideal conditions according to the actual background of the decision-making problem and to determine the order of its superiority and inferiority according to the degree of correlation between the actual evaluation vector and the ideal evaluation vector [22]. This paper uses grey theory to obtain the priority of each failure mode based on the failure mode assessment integrated fuzzy evidence reasoning.

(1) Establish comparative series and the standard series. In FMEA, the comparative series of risk factors is its crisp belief decision value. And the standard series of risk factors is determined by the ideal level of failure mode. It can be seen that the lowest level of linguistic terms is the standard series, which can be described as the following matrix:

$$X_0 = \{x_0(m)\} = \begin{bmatrix} h_{11} & \cdots & h_{11} \\ \vdots & \cdots & \vdots \\ h_{11} & \cdots & h_{11} \end{bmatrix} \tag{7}$$

h_{ij} is the crisp belief decision value of the fuzzy evaluation level H_{11}

(2) Calculate the grey relation coefficient. The gray correlation coefficient $V(X_0(m), X_n(m))$ is calculated by *Eq. (8)*, and the value α is usually 0.5 [22].

$$\begin{aligned} V(X_0(m), X_n(m)) &= \frac{\min_n \min_m |X_0(m) - X_n(m)| + \alpha_{\max_n \max_m |X_0(m)-X_n(m)|}}{X_0(m) - X_n(m)| + \alpha_{\max_n \max_m |X_0(m)-X_n(m)|}} \\ &= \frac{l + \alpha_M}{\triangle_{0_n}(m) + \alpha_M}, n = 1, \ldots, N; m = 1, \ldots, M \end{aligned} \tag{8}$$

Finally, the matrix of gray correlation coefficients is seen as below:

$$V = \begin{bmatrix} V_{01(1)} & V_{01(2)} & \cdots & V_{01(M)} \\ V_{02(1)} & V_{02(2)} & \cdots & V_{02(M)} \\ \cdots & \cdots & \cdots & \cdots \\ V_{0N(1)} & V_{0N(2)} & \cdots & V_{0N(M)} \end{bmatrix} \tag{9}$$

(3) Calculate the degree of relation. The degree of grey relation is calculated by multiplying the grey relation coefficient $V(X_0(m), X_n(m))$ and the comprehensive weights of risk factors $\tilde{W}_m$. The Equation is as follows:

$$\tau(X_0, X_n) = \sum_{m=1}^{M} \tilde{W}_m V_{\{X_0(m), X_n(m)\}} \tag{10}$$

(4) Rank the failure modes. The grey correlation degree of relation represents the relationship between the risk level of the potential failure mode and the ideal level. The higher the gray correlation degree of the failure mode is, the lower the risk is; and the lower the gray correlation degree is, the higher the risk is. The priority ranking of the failure modes is depending on the value of each failure mode's gray correlation degree.

3 The Empirical Study

3.1 Case Background

EPWK (www.epwk.com) was established on July 1, 2010. It is an emerging creative product trading platform based on crowdsourcing, which is also the leading crowdsourcing innovation platform in China. On this platform, the tasks mainly adopt the bidding-employment crowdsourcing model, which is usually a professional customized crowdsourcing task with complex task structure, strong professionalism, and diverse needs. Correspondingly, the task is well paid (see Fig. 3). The series of media marketing management website development tasks (https://task.epwk.com/705893/) released by the user o5952****32084 is one of the typical representative projects. The cumulative reward of this crowdsourcing innovation project is 180,000 yuan. The first phase lasted for 35 days and received 8 submissions. Finally, the solver *XIAOJINGYU* won the bonus.

3.2 Results of Risk Assessment

The FMEA evaluation team was composed of five members (the seeker, the platform leader, the winning solver, and two crowdsourcing innovation experts). Through interviews with five members, 10 failure modes of the project are identified, as shown in Table 3. Because team members have different professional backgrounds, they are given different decision weights in the evaluation process, as shown in Table 4.

Step 1: The FMEA team evaluates the relative importance of *O, S, D* of the crowdsourcing innovation project risk, as shown in Table 4. The assessment of project failure modes is shown in Table 5. The comprehensive weight of risk factors is calculated by *Eq. (1)*, as shown in Table 4.

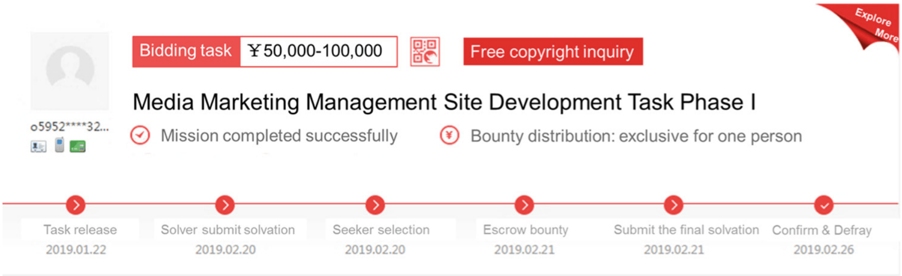

Fig. 3. The series of media marketing management website development tasks

Step 2: Use *Eq. (2)* to calculate the comprehensive value of each failure mode for each risk factor, and establish a comprehensive assessment table, as shown in Table 6.

Step 3: Use *Eq. (4)* and *Eq. (5)* to calculate the defuzzified crisp number of fuzzy assessment grades, as shown in Table 7. The defuzzified crisp number of each failure mode is as in Table 8.

Step 4: Calculate the grey relation coefficient and the degree of relation. First, establish comparative series (X_a) and the standard series ($X_{0.}$). This paper studies the risk assessment of crowdsourcing innovation projects, so $X_0 = 0$ is selected. And according to *Eq. (8)*, the matrix of gray correlation coefficients is available.

$$X_a = \begin{bmatrix} 0.291 & 0.545 & 0.685 \\ 0.690 & 0.771 & 0.666 \\ 0.606 & 0.576 & 0.680 \\ 0.428 & 0.565 & 0.642 \\ 0.210 & 0.757 & 0.680 \\ 0.417 & 0.617 & 0.614 \\ 0.366 & 0.323 & 0.525 \\ 0.204 & 0.487 & 0.518 \\ 0.245 & 0.338 & 0.587 \\ 0.314 & 0.594 & 0.394 \end{bmatrix}, \ R_a = \begin{bmatrix} 0.778 & 0.577 & 0.504 \\ 0.502 & 0.468 & 0.513 \\ 0.543 & 0.559 & 0.507 \\ 0.655 & 0.565 & 0.525 \\ 0.876 & 0.474 & 0.507 \\ 0.663 & 0.537 & 0.539 \\ 0.705 & 0.745 & 0.589 \\ 0.884 & 0.613 & 0.593 \\ 0.831 & 0.731 & 0.553 \\ 0.754 & 0.549 & 0.682 \end{bmatrix}$$

The degree of grey relation can be calculated by using *Eq. (10)*.

$$\tau_a = \begin{bmatrix} 0.778 & 0.577 & 0.504 \\ 0.502 & 0.468 & 0.513 \\ 0.543 & 0.559 & 0.507 \\ 0.655 & 0.565 & 0.525 \\ 0.876 & 0.474 & 0.507 \\ 0.663 & 0.537 & 0.539 \\ 0.705 & 0.745 & 0.589 \\ 0.884 & 0.613 & 0.593 \\ 0.831 & 0.731 & 0.553 \\ 0.754 & 0.549 & 0.682 \end{bmatrix} \begin{bmatrix} 0.217 \\ 0.322 \\ 0.461 \end{bmatrix} = \begin{bmatrix} 0.587 \\ 0.496 \\ 0.531 \\ 0.566 \\ 0.576 \\ 0.565 \\ 0.664 \\ 0.663 \\ 0.671 \\ 0.655 \end{bmatrix}$$

Table 3. Failure modes of the project

Risk	**Number**	**Failure mode**	**Cause for failure**	**Consequences of failure**
Crowdsourcing participant risk	*FM1*	The seeker is underinvest.	The seeker does not really recognize the crowdsourcing model.	Task progress is slow, and the solution is ineffective.
	FM_2	The solver lacks matching knowledge.	The solver did not accurately assess the match between the task requirements and his own capabilities.	The seeker's time is wasted.
Crowdsourcing innovation business model risk	*FM3*	Intellectual property ownership is disputed.	The seeker and the solver did not reach an agreement on the ownership of intellectual property.	It is prone to disputes over intellectual property rights.
	FM_4	The solver leaks the core-information.	The solver did not fulfill the confidentiality obligation	The seeker's core interests are damaged.
	FM5	The solver participates freely and voluntarily.	The solver can exit the task at any time.	No solver submits results.
Participant relationship risk	FM_6	The seeker and the solver lack of trust between each other.	Reputation issues occur frequently.	Crowdsourcing tasks are difficult to complete.
	FM_7	Communication between the seeker and the solver is poor.	Difficult to understand the true meaning of the other party.	It consumes the patience of both parties, leading to the crowdsourcing model be abandoned.

(*continued*)

Table 3. (*continued*)

Risk	**Number**	**Failure mode**	**Cause for failure**	**Consequences of failure**
Requirement risk	FM_8	The description of task requirements is inaccurate.	The task requirement description is unclear and ambiguous.	The solution did not meet the requirements.
Technical complexity risk	FM_9	The task is too difficult.	The seeker did not evaluate the intellectual resources of the platform in advance	Only a few solvers accept the task.
Task structure risk	FM_{10}	Subtasks are highly dependent.	Task division is bad.	Subsequent tasks cannot be carried out, and solutions are difficult to meet real needs.

Table 4. The relative importance of O, S, D

Team member	**Member weight**	**Risk factor**		
		Occurrence	Severity	Detection
TM_1	0.3	*M*	*M*	*H*
TM_2	0.2	*VL*	*M*	*M*
TM_3	0.2	*L*	*L*	*VH*
TM_4	0.15	*M*	*H*	*M*
TM_5	0.15	*L*	*M*	*H*
The crisp value of comprehensive weight		0.217	0.322	0.461

The degree of relation of the ten failure modes gives the priority ranking as FM_2, FM_3, FM_6, FM_4, FM_5, FM_1, FM_{10}, FM_8, FM_7, FM_9. Figure 4 shows the resistance of the project to the ten failure modes.

Table 5. Assessment information of project failure modes

Risk factor	Team member	Member weight	Failure mode									
			FM_1	FM_2	FM_3	FM_4	FM_5	FM_6	FM_7	FM_8	FM_9	FM_{10}
Occurrence	TM_1	0.3	H_{12}	H_{45}	H_{34}	H_{22}	H_{11}	H_{33}	H_{23}	H_{11}	H_{12}	H_{22}
	TM_2	0.2	H_{12}	H_{44}	H_{44}	H_{33}	H_{11}	H_{22}	H_{22}	H_{11}	H_{12}	H_{12}
	TM_3	0.2	H_{22}	H_{34}	H_{34}	H_{33}	H_{11}	H_{22}	H_{22}	H_{12}	H_{12}	H_{23}
	TM_4	0.15	H_{13}	H_{44}	H_{44}	H_{23}	H_{33}	H_{33}	H_{22}	H_{22}	H_{11}	H_{22}
	TM5	0.15	H_{22}	H_{44}	H_{33}	H33	H_{22}	H_{33}	H_{33}	H_{22}	H_{22}	H_{22}
Severity	TM_1	0.3	H_{33}	H_{44}	H_{33}	H34	H_{44}	H_{44}	H_{23}	H_{22}	H_{12}	H_{44}
	TM_2	0.2	H_{34}	H_{45}	H_{33}	H_{34}	H_{44}	H_{34}	H_{12}	H_{23}	H_{22}	H_{33}
	TM_3	0.2	H_{33}	H_{55}	H_{34}	H_{33}	H_{44}	H_{44}	H_{22}	H_{33}	H_{12}	H_{33}
	TM_4	0.15	H_{44}	H_{55}	H_{44}	H_{44}	H_{55}	H_{33}	H_{12}	H_{44}	H_{22}	H_{44}
	TM5	0.15	H_{33}	H_{44}	H_{44}	H_{33}	H_{55}	H_{33}	H_{22}	H_{44}	H_{44}	H_{33}
Detection	TM_1	0.3	H_{44}	H_{34}	H_{44}	H_{24}	H_{44}	H_{44}	H_{34}	H_{33}	H_{33}	H_{23}
	TM_2	0.2	H_{34}	H_{44}	H_{44}	H_{44}	H_{34}	H_{44}	H_{23}	H_{33}	H_{33}	H_{23}
	TM_3	0.2	H_{44}	H_{44}	H_{34}	H_{34}	H_{44}	H_{44}	H_{23}	H_{23}	H_{33}	H_{22}
	TM_4	0.15	H_{45}	H_{44}	H_{44}	H_{55}	H_{44}	H_{33}	H_{33}	H_{33}	H_{55}	H_{33}
	TM5	0.15	H_{44}	H_{44}	H_{44}	H_{44}	H_{44}	H_{22}	H_{44}	H_{44}	H_{44}	H_{22}

3.3 Implications in Practice

Based on the risk identification and assessment result of the task, in order to reduce the risks of crowdsourcing innovation projects and improve the performance, this paper put forward the following management inspiration:

(1) Build a crowdsourcing platform talent pool to boost the confidence of the seekers to implement the crowdsourcing model. The crowdsourcing innovation model is difficult to attract mainstream enterprises to participate. One of the main reasons is that the seekers lack confidence in the experience and relevant knowledge and skills of the solvers. And the seekers have to take a lot of time to select the effective solution, which is contrary to the desire of enterprises to reduce costs and improve innovation efficiency and effectiveness through crowdsourcing. First of all, the crowdsourcing platform should gather a group of high-quality crowdsourcing talents to build its own talent database and assess the talents by their knowledge, skills, and the completion of crowdsourcing projects, which is the key to solve the problem. In addition, the platform should guide the enterprise to complete the change of identity from "the seeker" to "the solver". The reserve of enterprises' knowledge and skills are much more than the individual's. If the platform could acquire a large number of enterprise-level solvers, it will make the enterprises participate crowdsource more confident. Therefore, in order to fundamentally dispel the concerns of the solver lacking capability from the seekers, the platform needs to build a professional team by recruiting talent resources of Web development and internet marketing management.

Table 6. The comprehensive assessment of project failure modes

Failure mode	Occurrence	Severity	Detection
FM1	$(0.5H_{12}, 0.15H_{13}, 0.35H_{22})$	$(0.65H_{33}, 0.2H_{34}, 0.15H_{44})$	$(0.2H_{34}, 0.65H_{44}, 0.15H_{45})$
FM2	$(0.2H_{34}, 0.5H_{44}, 0.3H_{45})$	$(0.45H_{44}, 0.2H_{45}, 0.35H_{55})$	$(0.3H_{34}, 0.7H_{44})$
FM3	$(0.15H_{33}, 0.5H_{34}, 0.35H_{44})$	$(0.5H_{33}, 0.2H_{34}, 0.3H_{44})$	$(0.2H_{34}, 0.8H_{44})$
FM_4	$(0.3H_{22}, 0.15H_{23}, 0.55H_{33})$	$(0.35H_{33}, 0.5H_{34}, 0.15H_{44})$	$(0.3H_{24}, 0.2H_{34}, 0.35H_{44}, 0.15H_{55})$
FM5	$(0.7H_{11}, 0.15H_{22}, 0.15H_{33})$	$(0.7H_{44}, 0.3H_{55})$	$(0.2H_{34}, 0.8H_{44})$
FM6	$(0.4H_{22}, 0.6H_{33})$	$(0.3H_{33}, 0.2H_{34}, 0.5H_{44})$	$(0.15H_{22}, 0.15H_{33}, 0.7H_{44})$
FM7	$(0.55H_{22}, 0.3H_{23}, 0.15H_{33})$	$(0.35H_{12}, 0.35H_{22}, 0.3H_{23})$	$(0.4H_{23}, 0.15H_{33}, 0.3H_{34}, 0.15H_{44})$
FM8	$(0.5H_{11}, 0.2H_{12}, 0.3H_{22})$	$(0.3H_{22}, 0.2H_{23}, 0.2H_{33}, 0.3H_{44})$	$(0.2H_{23}, 0.65H_{33}, 0.5H_{44})$
FM_9	$(0.15H_{11}, 0.7H_{12}, 0.15H_{22})$	$(0.5H_{12}, 0.35H_{22}, 0.15H_{44})$	$(0.7H_{33}, 0.15H_{44}, 0.15H_{55})$
FM_{10}	$(0.2H1_2, 0.6H_{22}, 0.2H_{23})$	$(0.55H_{33}, 0.45H_{44})$	$(0.35H_{22}, 0.5H_{23}, 0.15H_{33})$

Table 7. The crisp number of fuzzy assessment grades

Assessment grade	Defuzzified crisp number	Assessment grade	Defuzzified crisp number
H11	0.130	H_{25}	0.541
H_{12}	0.259	*H33*	0.500
H13	0.394	H_{34}	0.567
H_{14}	0.459	*H35*	0.606
H15	0.500	H_{44}	0.708
H22	0.292	H_{45}	0.741
H_{23}	0.433	*H55*	0.870
H_{24}	0.500		

(2) Optimize the matching mechanism and improve the efficiency of crowdsourcing innovation. The flood-irrigated ground task recommendation mechanism and the fully open contracting mechanism are one of the fundamental reasons for the poor

Table 8. The defuzzified crisp number of each failure mode

Failure mode	Occurrence	Severity	Detection
FM1	0.291	0.545	0.685
FM2	0.690	0.771	0.666
FM3	0.606	0.576	0.680
FM4	0.428	0.565	0.642
FM5	0.210	0.757	0.680
FM6	0.417	0.617	0.614
FM7	0.366	0.323	0.525
FM8	0.204	0.487	0.518
FM_9	0.245	0.338	0.587
FM_{10}	0.314	0.594	0.394

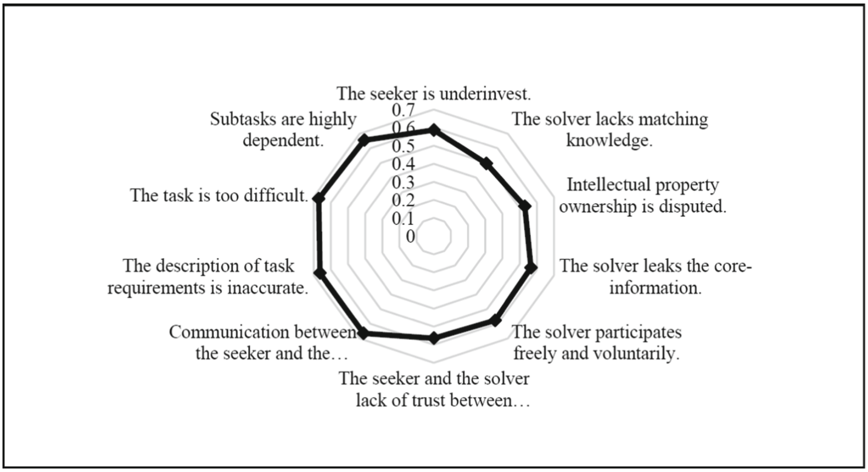

Fig. 4. The resistance of internet marketing management website development project to the ten failure modes

effect with high cost in crowdsourcing innovation. It is why the seekers insist FM_2 needs to be solved first. The platform should take the crowdsourcing project requirements as the leading factor to establish a task requirement form and optimize the matching mechanism by designing the matching algorithm with the capacity of the solver as the main parameter. In this case, the crowdsourcing platform can establish the standard matrix based on its task requirement form and the comparative matrix by quantifying the knowledge, skills, and experience of the solver in the talent pool. Then the algorithm matches the appropriate solvers and invites them to complete the task.

(3) Increase penalties for malicious disclosure and strengthen the protection of intellectual property. The solvers have a low sense of confidentiality and usually reveal the core information of the project unconsciously, which is the main cause for the core information leakage of most crowdsourcing innovation projects. Therefore, the crowdsourcing platform engages in precautionary action, and strengthens the confidentiality awareness of the solvers in two stages: the first stage, add the information confidentiality education to the user registration to make the solvers develop a preliminary concept of confidentiality; the second stage, before the task begins, the solvers need to sign the confidentiality agreement to strengthen the confidentiality awareness. The other part of the core information leakage is caused by the solvers maliciously leaking the information. This requires platform designing a strict punishment mechanism, such as regularly publishing the blacklist, reporting to the credit information system immediately. *Zbj* effectively reduces the risk of leakage of project core information by publishing blacklists regularly to expose bad solvers.

(4) Activate the vitality of the crowdsourcing platform community and promote the formation of collaborative crowdsourcing team. In order to solve complex innovation tasks, it is generally necessary to professionally decompose complex innovation projects to form relatively independent crowdsourcing subtasks, during the operation process of crowdsourcing innovation projects. However, there is some certain correlation between subtasks. The seeker has to integrate the solutions of each subtask to solve the final crowdsourcing project task. This complex process of decomposition and integration will undoubtedly generate certain risks. Therefore, it is necessary to fully activate the vitality of the multi-participants of the crowdsourcing platform community, enhance the interactive communication between the participants. And guide the solvers with passion for participation, complementary knowledge and skills, and consistent goals to form crowdsourcing teams spontaneously to improve the ability to complete complex tasks.

4 Conclusions

As a new business model, the risk presentation of crowdsourcing innovation is more complex. How to identify the operational risks of crowdsourcing innovation projects and adopt effective avoidance strategies to improve innovation performance is of great significance. One of the contributions is that combining social-technical theory, this paper constructs a risk identification system for crowdsourcing innovation projects from two dimensions (social risk and technical risk) based on the operation process of crowdsourcing innovation projects on third-party platforms. Take the FMEA model's disadvantages (such as difficulty in quantifying risk factors, ignoring the relative weight of risk factors) into consideration, this paper proposes an improved FMEA model integrated fuzzy evidence reasoning and grey theory and carries out empirical research with the project from Chinese famous crowdsourcing platform-EPWK. This research has certain guiding value for companies to effectively implement crowdsourcing innovation strategies, reduce crowdsourcing innovation risks, and guide the healthy development of crowdsourcing platforms.

The research also has the following shortcomings: (1) The differences in different types of crowdsourced innovation projects are not fully considered. The risk factors of competition-type crowdsourcing innovation differ from that of collaborative crowdsourcing innovation, which need further research. (2) The influence between each risk is still not clear. These risks identified from one crowdsourcing innovation project have complex impact mechanisms. And in order to adopt more effective risk avoidance strategies, it is necessary to explore the impact mechanisms in the future.

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