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RESEARCH

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Predict the logistic risk: fuzzy comprehensive measurement method or particle swarm optimization algorithm?

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Abstract

Risk analysis is an important fundamental basis of the decision-making process, and it has been applied in many fields. In order to improve the risk management of logistic, a new model based on particle swarm optimization (PSO) is proposed, which is a stochastic optimization method based on population. Through a comparison of performance with a Fuzzy Comprehensive Measurement Method (FCMM), the findings indicated that PSO can predict the logistic risk more accurately. The experimental results show that the model of logistic risk analysis and identification based on PSO algorithm is superior to FCMM model.

Keywords: Logistic risk, Particle swarm optimization, Fuzzy comprehensive measurement method

1 Introduction

With the promoting of the national logistic industry, the planning and establishing of logistic construction projects have also incurred an upsurge in major cities of China [1]. Although logistic construction projects have many meanings to the development of logistic in cities or regions, due to the inherent characteristics of project construction: strategically, non-profit, high investment, and long-term return period, they have brought unprecedented test to the operation and management after the completion of construction [2]. Many of the completed logistic construction projects have not been well managed and failed to achieve the expected results. Failure in the investment will not only cause huge waste on manpower, material, and financial resources, but also bring the negative effects on survival of enterprises. Therefore, in order to solve the problems in the logistic construction projects, we must be well prepared on pre-construction feasibility studies, conduct a comprehensive survey of construction projects, and arrange technical and economic feasibility studies of various possible scenarios for the project. The aim mentioned above is to analyze and evaluate the overall risk of the project and provide the basis for taking decisions on investment and also for risk-prevention measurements.

Through the discussion on the importance of logistic risk assessment, we can see that logistic risk refers to numbers of enterprises with complementary resources and technologies. Due to the fact that logistic risk does not change the independent legal personality in each node of enterprise in the market, it does not eliminate the potential conflicts of interest. Therefore, logistic also brings some new risk issues to alliance enterprises [3]. Risk is the uncertainty of the loss, that is, the possible negative deviation is combined with the expectation of the people's decisions about the future behavior and the uncertainty of the objective conditions. The risks in the logistic can be divided into two categories: one is from the external of the virtual logistic organization, including market risk, financial risk, political risk, and natural disaster risk; the other one is from the internal of the virtual logistic organizations, which includes capacity risk, collaboration risk, investment risk, and operational risk.

There are various risks being involved in the investment and construction of logistic projects. It is an important basis for the decision-making process to analyze the source and level of risk factors through the whole system and assessment. The development of logistic business needs to be based on a strong logistic system to reflect the advantages of low cost and high efficiency of

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logistic services. The company's logistic business needs to carry out large-scale logistic infrastructure construction and a lot of money on the basis of the original business and management experience, accompanied by a great risk in this process. Therefore, the scientific method of logistic risk comprehensive assessment may contribute to a better project development process by well prediction on the inevitable risks of the enterprise's own ability and the proceeds of trade-offs. For a decision-maker, there is a very important reference value.

About Fuzzy Comprehensive Measurement Method (FCMM) method, it is a branch of fuzzy mathematics which is created by a well-known electronic engineer and cybernetics expert L.A. Zadeh and dealt with the fuzzy phenomenon within mathematical method. With the characteristics of human thinking, the fuzzy theory is an effective tool for its phenomenon treatment, while the evaluation is a general view that the nature of thinking determines its fuzziness. As a result, the fuzzy mathematics method has been widely used in the field of systematic evaluation including logistic risk analysis. Thus, to evaluate the advantage of particle swarm optimization (PSO) algorithm, we chose FCMM method as our comparable object. Based on some specific cases of logistics projects, the risk of logistics projects was evaluated on two levels, and the risk aversion measures when implementing the projects were proposed. In order to overcome the limitation of the existing research methods, the research proposed an identification model based on PSO—a population-based random optimization method. Through a comparison of performance with a FCMM, the findings indicated PSO can predict the logistic risk more accurately [4]. From the test results, it is shown that model of risk analysis and identification of logistic risk based on PSO algorithm is superior to FCMM model.

2 Literature review of logistic risk management

In recent years, the research of logistic risk management has focused on different areas [10]. Usually, logistic risk relationships are defined as "long-term relationships where participants generally cooperating, sharing the information, and working together to plan and even modify their business practices to improve joint performance." The theoretical research on logistic risk management is accompanied by the formation and development of the international engineering construction market. At present, due to the investment and construction of logistic project, it is still a newborn thing in recent years, and a number of logistic construction projects have been successfully operated, but the geographical distribution is limited. This is because a long period of time is required for a logistic investment project from preliminary preparation to post-operation. Therefore, it causes limited findings in research literature regarding the quantitative analysis and evaluation of logistic construction projects [5]. The following is a summary of the collective risk researches related to logistic risk: Tranfield et al. [6] analyzed the main features and all kinds of risk factors existing in the construction of the logistic park. In the view of the actual situation of the construction of the logistic park, the research analyzed the obvious risks in the various stages of the construction of the logistic park and gave the corresponding risk management strategies and preventive measures. Fawcett et al. [7] considered the logistic relationship between city and city and the role of logistic parks in the urban logistic system, and it put forward the conditions to be considered in the construction of city logistic parks. There are problems in the construction of a logistic park, and it put forward corresponding countermeasures [7]. According to the characteristics of large-scale logistic projects such as large investment, high risk, and strong pertinence, Grawe evaluates the risks of logistic in the "Application of Risk Assessment in Logistic Projects" [8]. The first level considers the investment of logistic projects construction and operation of the various risk factors in the project as a whole part to assess the level of risk. The second level needs to combine the project overall risk assessment results and the core ability of profit forecast on logistic project investment and construction. The risk return method is used to analyze the economic risk of specific logistic project investment program and the range of project's economic risk. In the document "Operation Management of Logistic Park Market," Neuendorf [9] described the connotation of market operation risk in the logistic park; identified the market operation risk; divided the market operation risk into three categories: environmental risk, process risk, and regulatory risk and the possible consequences of the risk; and put forward the risk management measures. Cooper and Ellram analyzed the investment risk of logistic industry from four aspects which are return on investment, logistic solution, financial service, and product features in "Risk and Strategy of Logistic Investment" and put forward the investment risk response strategy in logistic industry [10]. Min et al. analyzed the fuzzy comprehensive evaluation method applied to the virtual logistic organization risk assessment in the middle [11]. Jin et al. analyzed all kinds of risk factors in the port logistic park, using fuzzy comprehensive evaluation of the risk evaluation [12]. Chen et al. aimed on the current situation of the construction of logistic parks in our country, analyzing the common system risks in the construction of logistic parks from the perspective of the government and makes quantitative research [13].

Based on these literatures, according to study, in some specific cases of logistic projects, the research evaluates the risks of logistic projects at two levels and brings up some measures for risk evasion in implementing the project. In order to overcome the limitations of the existing research methods, the research proposed a new identification model based on particle swarm optimization (PSO), a population-based stochastic optimization. Through a comparison of performance with a Fuzzy Comprehensive Measurement Method (FCMM), the findings indicated PSO more accurately predicts the logistic risk. From the test results, it is shown that model of risk analysis and identification of logistic risk based on PSO algorithm is superior to FCMM model.

3 Risk identification by fuzzy comprehensive measurement method

During the practical works, an assessment (or evaluation) usually involves a number of factors or indicators, which are evaluated based on these factors, but this does not apply to individual case. This is comprehensive evaluation. Fuzzy comprehensive evaluation is a very effective multivariate decision-making method for making a comprehensive assessment which is affected by many factors [14].

3.1 Basic model

First of all, we need to introduce the detail methods of Fuzzy Comprehensive Measurement Method (FCMM). Fuzzy comprehensive evaluation is a very effective multivariate decision-making method for making comprehensive assessment affected by many factors [15].

Assuming $U = \{u_1,\ u_2,\ u_3,\ \ldots\ ,\ u_n\}$ have n factors and $V = \{v_1, v_2, \ldots,\ v_m\}$ have m judgments, their number of elements and names can be subjectively defined by people according to practical problems. Due to the different status of various factors, so the role is not the same, and for sure, the weight and judgment are also different. People are not absolutely feeling positive or negative about m kinds of judgments, so the comprehensive judgment should be a fuzzy subset of V, and $B = \{b_1, b_2, \ldots, b_m\} \in \Phi(V)$, where $b_j(j = 1, 2, \ldots, m)$ reflects the j's position-v_j in the comprehensive judgment(that is v_j degree of membership of fuzzy sets: $B(v_j) = b_j$). Comprehensive judgment B depends on the weight of each factor, and each weight is a fuzzy subset $A = \{a_I, a_1, \ldots, a_n\} \in \Phi(U)$ on U, and $\sum_{I=1}^{n} a_I = 1$, a_I denotes the weight of the I factor. Therefore, once a weight is given, a comprehensive judgment B can be obtained accordingly.

According to the specific problems, we need to establish a fuzzy transformation T from U to V. If we make a separate judgment $f(u_i)$ for each factor u_i, this can be regarded as the fuzzy projection f from U to V, that is, $f: U \to \Phi(V)$ and $u_i \mapsto f(u_i) \in \Phi(V)$.

From f, we can derive a fuzzy transformation T_f from U to V, and we can regard T_f as the mathematical model of comprehensive evaluation B obtained from weight A.

From the above analysis, we can see that the mathematical model of fuzzy comprehensive evaluation consists of three elements, the steps are divided into four: (1) factor set $U = \{u_1,\ u_2, u_3, \ldots, u_n\}$; (2) judgment set $V = \{v_1, v_2, \ldots, v_m\}$; (3) single factor evaluation: $f: U \to \Phi(V)$ and $u_i \mapsto f(u_i) = (r_{i1}, r_{i2}, \ldots, r_{i1}) \in \Phi(V)$. Fuzzy mapping f can induce a fuzzy relationship $R_f \in (U \times V)$, that is $R_{f(u_i \times v_i)} = f(u_i)(v_i) = r_{ij}$, Thus R_f can be represented by the fuzzy matrix $R \in \mu_{n\times m}$: $R = \begin{bmatrix} r_{11}, r_{12}, r_{13}, r_{14}, r_{1m} & \\ r_{21}, r_{22}, r_{23}, r_{24}, r_{2m} & \\ \cdots \quad \cdots \quad \cdots & \cdots \\ r_{n1}, r_{n2}, r_{n3}, r_{n4}, r_{nm} & \end{bmatrix}$. We call R a single factor evaluation matrix, and the fuzzy transformation T_f from U to V can be induced by the fuzzy relation R. $U(U_1,\ U_2,\ \ldots,\ U_n)$ form a fuzzy comprehensive decision-making model, U_1, $U_2, \cdots$, U_n is the n elements of the model. (4) Comprehensive Evaluation: for the weight $A = (a_1\ a_2\ a_3\ a_4\ a_5\ a_6)$, according to fuzzy mathematical evaluation model formula $A\ *\ R = B$, fuzzy comprehensive evaluation operation, where $B = (b_1\ b_2\ b_3\ b_4\ b_5\ b_6)$ is the total assessment results. In accordance with the principle of maximum membership, the highest value of b_{jmax} in b_j corresponding to the grade V_j is the result of comprehensive evaluation, as result, the risk level of the object being evaluated.

3.2 Specific examples

A large state-owned enterprise has many years of transport, warehousing, freight forwarding, and other service experience, with strong financial strength. The indicator design is to divide into two layers and requires two fuzzy operations. According to the actual situation of the logistic project, with reference to domestic and foreign research results, we can set 23 indicators for the existence of six types of risk in the above-mentioned logistic project to evaluate the risk investment of the logistic project: (1) Market risk (U1): service innovation (U11); customer demand level (U12); logistic services competitors (U13); logistic market growth (U14); (2) management risk (U2): entrepreneurial style (U21); management quality (U22); management ability (U23); management moral hazard (U24); corporate culture (U25); (3) Technical risk (U3); substitutability of technology (U31); advanced technology (U32); technical applicability (U33); technical reliability (U34); (4) financial risk (U4): changes in interest and exchange rate (U41); changes in the rate of return on investment (U42); difficulties in property transactions (U43); financial risk (U44), (5) operational risk (U5): equipment condition (U51); operator condition (U52); standardization of operation (U53); (6) environment risk (U6): National Macro-political Economics Environment (U61); policies and regulations (U62); and micro basic environment of investment sites (U63). The risk level is divided into five levels: low risk (V_1), medium low risk (V_2), general risk (V_3), medium high risk (V_4), and high risk (V_5). The above five evaluation rank elements constitute the evaluation level set. V={V_1, V_2, V_3, V_4, (V_5}. For the six weights of the evaluation indicators, we used the Delphi method to issue a consultation letter to 10 experts (including scholars, business leaders, and managers) and scored the weight of six sub-sets of evaluation indicators (Table 1).

Apply mathematical model $A_i{}^*R_i = B_i$. The fuzzy subset $B_i = (b_{i1}b_{i2}b_{i3}b_{i4}b_{i5})$ $(i = 1,2,3,4,5,6, bij \in [0,1])$ is the first level of comprehensive evaluation results, indicating that each $U_i(i = 1,2,3,4,5,6)$ (Table 1) within the scope of the logistic project, respectively, to the extent of the percentage is in five levels: "low risk," "medium low risk," "general risk," "medium high risk," and "high risk". The calculated results: $B = (0.283\ \ 0.336\ \ 0.271\ \ 0.039\ \ 0.012)$. The result shows that the maximum membership degree of matrix B is 0.4, and the overall risk level of the logistic project is low risk.

4 Particle swarm optimization (PSO) algorithm

Due to the restriction of many kinds of influencing factors, the risk identification of the logistic enterprises is complex, fuzzy, and difficult to quantify completely. At the same time, the risk of the virtual logistic enterprises is transitive and accumulative [16]. It is difficult to establish the analytical relationship among the indirect natural logistic enterprise risk index. In order to overcome the limitations of the existing research methods such as FCMM we have mentioned above, in this part, we will propose a logistic alliance risk identification and analysis method which based on the particle swarm optimization (PSO) algorithm and also the penalty function method. These two methods are combined to analyze and calculate the optimization problem, which makes the result of virtual emergency logistic alliance risk identification more accurate and realistic.

4.1 Basic model

The Projection Pursuit Model of Virtual Emergency Logistic Risk Identification Model (PPEM) is a complex nonlinear optimization problem with $\{a(j)|j = 1, 2, \ldots, p\}$ as an optimization variable, and the conventional optimization method is difficult to deal with. In the paper, the particle swarm optimization algorithm is used to effectively solve the above problems. Assuming the population size of the particle is N,S_l represents the position of the particle of $l(l = 1,2,\cdots N)$;v_l represents the speed; f_l represents adapted value [17].

Table 1 Weight of evaluation index subset of logistic project

Evaluation index subset	U1	U2	U3	U4	U5	U6
Weight	0.24	0.19	0.27	0.22	0.36	0.16

In each iteration after the initial position and velocity are randomly generated, the extremum of the particle tracking individual $p_{best_l}(t)$ (the best position of the particle in the flight process) and the global extremum $g_{\text{best}}(t)$ (the best position of the particle swarm in the flight process) are updated. When the two optimal values are found at $t + 1$, the position and velocity of the particles are updated according to formula (1). Then based on the particles, we could evaluate the risk.

$$\begin{aligned} V_1(t+1) = wv_1(t) + c_1 b_1(t) p_{best1}(t) - s_1(t) \\ + c_2 b_2 t\left(g_{best}(t)\right) - s_1(t) s_1(t+1) = s_1(t) \\ + v_1(t+1) \end{aligned} \tag{1}$$

In this formula: w is inertial weight; $c1$ and $c2$ are particle individuals and learning factors, respectively; $b_1(t)$、$b_2(t)$ are the random numbers uniformly distributed between (0,1), respectively, describing the randomness of particle individuals and groups in the speed update process.

Assuming $f_l(t + 1)$ denotes the adaptation of particle l at time $t + 1$; $f(p_{best_l}(t))$ represents the best fit for individual history of particle l; $s_{max}(t + 1)$ represents the particle position corresponding to the largest $f(p_{best_l}(t))$ in all particles at time $t + 1$. Then the individual extremum and the global extremum of all particles for each random case of particle individuals and groups in the speed update process can be updated according to the following formula:

$$p_{best_l}(t+1) = \begin{cases} s_l(t+1) & f_l(t+1) \geq f(p_{best}(t)) \\ p_{best}(t) & f_l(t+1) < f(p_{best}(t)) \end{cases} \tag{2}$$

$$g_{best}(t+1) = s_{\max}(t+1)$$

However, since the optimization of the problem contains some constraints, the penalty function method (sequence unconstrained optimization method (SUMT)) is used in the research to solve the constraint-constrained optimization problem by changing the constraint optimization problem to the unconstrained optimization problem.

For constraint optimization problem:

, +

$$\min \quad f(x)$$

$$s.t. \begin{cases} g_i(x) & \leq & 0 \\ h_i(x) & = & 0 \end{cases} \tag{3}$$

$$i = 1, 2, \cdots, \quad m; \quad j = 1, 2, \cdots, \quad n$$

According to penalty function method, the constrained optimization problem is transformed into the minimization of augmented objective function. That is:

$$\min_{x \in R^n} F(x, r) = \min\{f(x) + r * p(x)\}$$

$$p(x) = \sum_{i=1}^{n} [\max g_i(x), 0]^2 + \sum_{i=1}^{m} [h_j(x)]^2 \quad (4)$$

of which$r$ is the penalty factor, $f(x)$ is the objective function without penalty, and $r^* p(x)$ is the penalty.

In $p(x)$, for the point x that does not satisfy the constraint condition, the penalty term $r^* p(x) > 0$ is a penalty when the constraint condition is not satisfied, and when the constraint condition is satisfied, $r^* p(x) = 0$. Then based on these theoretical models, we will use an example to apply these models to see what advantage these models have.

4.2 Results of PSO

According to the actual situation of the logistic project, with reference to domestic and foreign research results, we can set 23 indicators for the existence of six types of risk in the above-mentioned logistic project to evaluate the risk investment of the logistic project: (1) market risk (U1): service innovation (U11), customer demand level (U12), logistic services competitors (U13), logistic market growth (U14); (2) management risk (U2): entrepreneurial style (U21), management quality (U22), management ability (U23), management moral hazard (U24), corporate culture (U25); (3) technical risk (U3), substitutability of technology (U31), advanced technology (U32), technical applicability (U33), technical reliability (U34); (4) financial risk (U4): changes in interest and exchange rate (U41), changes in the rate of return on investment (U42), difficulties in property transactions (U43); financial risk (U44); and (5) operational risk (U5): micro basic environment of investment sites (U63). The risk level is divided into five levels: low risk (V_1), medium low risk (V_2), general risk (V_3), medium high risk (V_4), and high risk (V_5). The above five evaluation rank elements constitute the evaluation level set V={V_1, V_2, V_3, V_4, V_5}. For the six weights of the evaluation indicators, we used the Delphi method to issue a consultation letter to 10 experts (including scholars, business leaders, and managers) and scored the weight of six sub-sets of evaluation indicators.

To apply the model we are inventing above, we will use Matlab software to make an example. According to the established index system of virtual logistic risk identification and related data from reference, the first layer index includes external risk U_1 and internal risk U_2, among these the external risks include service innovation (U11), customer demand level (U12), logistic services competitors (U13), logistic market growth (U14), entrepreneurial style (U15), management quality (U16), management ability (U17), management moral hazard (U18), corporate culture (U19), technical risk (U110), substitutability of technology (U111), advanced technology (U112), technical applicability (U113), technical reliability (U114), changes in interest and exchange rate (U115), changes in the rate of return on investment (U116), difficulties in property transactions (U117), financial risk (U118), internal risk U_2 includes equipment condition (U21), operator condition (U22), standardization of operation (U23), national macro-political economics environment (U24), policies and regulations (U25). Using MATLAB simulation platform and referencing data, the parameters are set to population size $N = 500$, $c_1 = c_2 = 3$, inertia weight $w = 0.8298$, $v = 0.5$*rand(m,n), with maximum number of iterations $G_{max} = 60$. After 2000 iterative search calculation, the relationship between the projection template and the number of iterations could be achieved in Fig. 1.

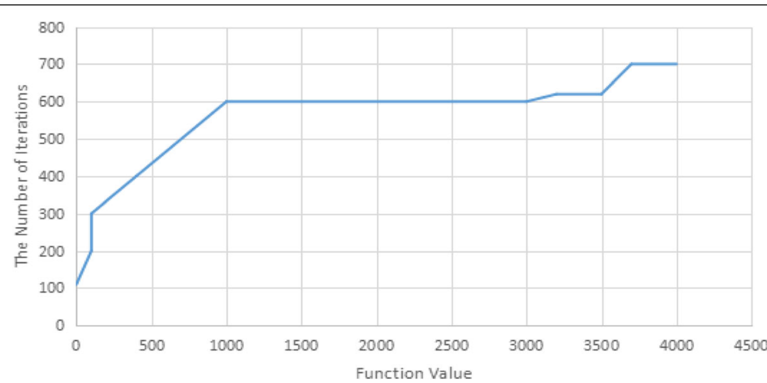

Fig. 1 The relationship between function value of projection objective and the numbers of iteration. Note: For this figure, the *x* axis represents the value of the numbers of iteration, while the *y* axis represents the value of projection objective. We could see that when we increase the numbers of iteration. The value of projective will also increase

Get the best projection direction *a* R1 (0.174, 0.185, 0.228, 0.136, 0.394)* of external risk R_1 (we choose the highest five) and *a* R1 (0.288, 0.132, 0.148, 0.100, 0.494)* of internal risk R_2 (we choose the highest five). According to the best projection direction *a* R1*、*a* R2*, we can see that the influence degree of each index on the identification of virtual logistic risk is in descending order: $U_{25} > U_{23} > U_{15} > U_{13} > U_{21} > U_{24} > U_{22} > U_{12} > U_{11} > U_{14}$. The results of error analysis of the results are shown in Table 2.

5 Which one is better?

From the above analysis, we could get the following results:

(1) For Fuzzy model, when we apply mathematical model, we could get the calculated results: $B = (0.283\ 0.336\ 0.271\ 0.039\ 0.012)$. The result shows that the maximum membership degree of matrix B is 0.4, and the overall risk level of the logistic project is low risk.

(2) For PSO model, when we use the Matlab to run the model, we could get the results that the influence degree of each index on the identification of virtual logistic risk is in descending order: $U_{25} > U_{23} > U_{15} > U_{13} > U_{21} > U_{24} > U_{22} > U_{12} > U_{11} > U_{14}$.

Fuzzy comprehensive evaluation method is a comprehensive evaluation method based on fuzzy mathematics. This comprehensive evaluation method converts qualitative evaluation into quantitative evaluation based on the membership theory of fuzzy mathematics which is using fuzzy mathematics to make an overall assessment on something or objects subjected to various factors. It has the characteristics of clear results and strong systematicness. It can solve the fuzzy and difficulties, also can quantify the problems, and is suitable for the solution of various non-deterministic problems [3].

Because of its simple algorithm, particle swarm optimization is easy to implement, and no gradient information is needed. The characteristics of small parameters are good for both continuous optimization problems and discrete optimization problems, especially because of their natural real-coded features are suitable for processing optimization [14]. In recent years, it has been became a hot topic in the field of intelligent optimization around the world. Particle swarm optimization (PSO) algorithm was first applied to the optimization of nonlinear continuous functions and neural network training and was newly used to solve constrained optimization problems, multi-objective optimization problems, and dynamic optimization problems [8].

For logistic risk analysis model, it is better to use the PSO algorithm [13]. The PSO algorithm is a kind of evolutionary algorithm that is similar to the simulated annealing algorithm; it also starts from the random solution and iteratively finds the optimal solution. It also evaluates the quality of the solution through fitness, but it is simpler than the genetic algorithm rules. It does not have the "crossover" and "mutation" operations of the genetic algorithm. It seeks the global optimum by following the current searched optimal value. This kind of algorithm has attracted much attention from the academic circles because of its advantages of easy implementation, high precision, and fast convergence. It also shows its superiority in solving practical problems [14]. Particle swarm algorithm is a parallel algorithm. The search scope of the particle swarm is limited to the conditional constraint cluster, so it is optimized within the range of feasible solutions.

6 Conclusions

Based on the characteristics of the risk of logistic, the research applies the theory of risk analysis and management to the field of logistic, follows the complete risk procedures, and carries out risk identification and risk evaluation in turn. Based on these, the research also summarized and established the overall risk index system and evaluated the risk as a whole and also a single factor to understand the key risk factors, which affecting the project to help managers to implement effectively risk management measures for the logistic risk management. The logistic risk analysis and management improve the feasibility study content of logistics construction project and enhance the credibility of the research results. Based on the theory of particle swarm optimization and Fuzzy Comprehensive Measurement Method, we went through these two different models, and compared their differences and advantages. The results indicate that the PSO algorithm not only can analyze and identify the risk of logistic comprehensively, but also analyze the main problems existing in each operation of logistic. According to the contribution rate of indicators, we can put forward countermeasures to solve the problems so as to provide scientific basis for the further development and improvement of logistic. Therefore, the research discovers that the new method based on the particle swarm optimization (PSO) based population-based stochastic optimization recognition model will be more effective in the research and more suitable for logistics project risk assessment.

Table 2 Error analysis of calculation result

Range	[0,0.05]	[0,0.1]	[0,0.15]	[0,0.2]	[0,0.25]	[0,0.3]	[0,0.35]	[0,0.4]
Percentage of errors in the interval (%)	35	75	85	90	105	120	150	500

Abbreviations
FCMM: Fuzzy Comprehensive Measurement Method; PPEM: Projection Pursuit Model of Virtual Emergency Logistic Risk Identification Model; PSO: Particle swarm optimization

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Authors' contributions
XD is the main author of this article. The main idea of this thesis is to propose an identification model based on particle swarm optimization (PSO)—a population-based stochastic optimization method. Compared with the performance of the fuzzy comprehensive measurement method (FCMM), the results show that the PSO can predict more accurately on logistics risks. JD have verified and compared the two models of logistics risk identification. LP gave guidance on the comparative analysis of the logistics risk identification tracking optimization model. All authors have read and approved the final manuscript.

Competing interests
The authors declare that they have no competing interests.

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