LOGISTICS RISK RESEARCH OF PREFABRICATED HOUSE CONSTRUCTION ENGINEERING BASED ON CREDIBILITY METHOD

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ABSTRACT

In recent years, the prefabricated house industry has rapid development,.Because of fewer suppliers, higher demand transport scheme and complex quality test, the risks of construction engineering logistics links are relatively high. Studying how to effectively evaluate the risks of construction engineering logistics links is significant. According to the characteristics of the prefabricated house construction engineering, we analyse the construction engineering logistics risks and use the combined weights method to determine the weight of indexes which contains both subjective and objective factors, to improve the scientific value and the validity of the assessment. Based on credibility measure method, a new logistics risk evaluation model in prefabricated housing is established to estimate the risk during making prefabricated house construction engineering. The presented model can avoid the subjectivity of selecting the membership function and solve the problem of how to comprehensively assess the construction engineering logistics risk in a certain extent.

KEYWORDS

Construction engineering, Prefabricated house, Logistics, Risk, Credibility theory

1. INTRODUCTION

With the great changes in the real estate market, the traditional way of residential construction engineering is being challenged by a rapid rise in labor costs, energy saving and environmental protection; besides people's demand for housing quality. All of these provide a good external environment for the development of prefabricated house construction engineering, which will be the inevitable trend of the housing industry. In recent years, with the active promotion of government and enterprises, the prefabricated house industry has rapid development, and the residential component and its industrialization have reached certain extent. Because of fewer suppliers, higher demand transport scheme and complex quality test, the risks of construction engineering logistics links are relatively high. Therefore, there are good theoretical and practical significance to use effective methods to evaluate the risks of construction engineering logistics links in order to improve the construction efficiency and reduce the loss caused by risks.

The project logistics or engineering logistics are generally looked as complex system engineering, they have the characteristics of professional, complex, integrated, comprehensive and so on [1]. So it is difficult to accurately describe their risk degree. In recent years, domestic and foreign scholars have studied it from different aspects. Chen Hao et al. [1] constructed a fuzzy comprehensive evaluation model from the route, inventory, schedule, management organization and external environment to evaluate the project logistics risks; they presented a mathematical method to analyse and deal with a large number of fuzzy problems in risk assessment by qualitative and quantitative analysis [2]. Jia et al. [3] analysed the logistics risk factors in hydropower equipment by the three-dimensional model, then according to the method of fault tree analysis, from qualitative and quantitative perspectives to analyse the occurrence of the minimum cut sets, the minimum path sets, top event probability and the probability importance degree. Wang Qiong [4] studied the risk assessment of the project logistics by fuzzy comprehensive evaluation method that using AHP (Analytic Hierarchy Process) determining weights with six indexes which including transportation, technology, progress, management, decision-making, environment .In Xiao et al. [5], a multi-level fuzzy comprehensive evaluation model is constructed by taking the materials supply chain in cascade hydropower station construction Yalong River for example. Adil et al. [6] established the reverse logistics network design model by using fuzzy linear programming method combined with the decision maker's attitude to risks, and based on the uncertainty level and the attitude of the decision maker to risks, the new model is established by using the fuzzy decision variables. In order to facilitate the decision making process in warehouse operations, H.Y. Lam et al. [7] proposed an intelligent system, namely the knowledge-based logistics operations planning system (K-LOPS) to formulate a useful action plan by considering the potential risks faced by the logistics service providers. Kannan Govindan et al. [8] analysed the interrelationships between risks faced by third party logistics service providers (3PLs, third-party logistics) in relation to one of its customers using DEMATEL (Decision-Making and Trial Evaluation Laboratory). Novel analysis of both within and between risk categories and generation of threshold value to prioritize risks generate useful insights. Kwanho Kim et al. [9] suggested an intelligent risk management framework for ubiquitous cold chain logistics UCCL, namely i-RM, which is designed to accommodate various types of risk situations by introducing the notion of context-aware real-time risk management. More specifically, i-RM takes a divide-and-combine approach where rules for risk management functions, context identification, risk detection, and response action judgment are defined in semantic ontology. A. El Mokrini et al. [10] contributed to the literature by presenting a decision model that takes into consideration risks of outsourcing logistics in the pharmaceutical supply chain. Qinquan Cui et al. [11] studied a risk-averse retailer’s optimal decision of introducing her store brand product by using the mean–variance formulation. The effects of the substitution factor, the capital constraint, and the development cost are examined. Taking the product quantities as the decision variables, the risk deducted surplus of the store brand product and the substitution factor play a vital role in the retailer’s optimal policies. Tsan-Ming Choi et al. [12] explores risk management of logistics systems in several critical areas, namely disruption risk management, operational risk control, disaster and emergency management, and logistics service risk analysis. In Wisinee Wisetjindawat et al. [13], a multi-agent model was developed to represent the situation of petroleum fuel supply chain before and after a disaster event. The results identify both the broad sweep of vulnerable locations in key regions in Queensland as well as particular issues for communities in Cape York in far north Queensland. C. Díaz-Delgado et al. [14] deals with the relationship between a flood risk assessment and the humanitarian logistics process design related to emergency events caused by flooding. Patrick Filla et al. [15] present a risk survey approach, based on the knowledge of existing methodologies for the ramp-up management, and et al [16][17]. The applicability of these methods and tools depend on the project-specific risks within the sub-processes of the ramp-up phase.

For Prefabricated house construction engineering, Cassidy Johnson [18] recognized what problems exist with temporary housing in the long term (that is after 5 years) and to identify, using the systems approach, the origin of these problems within the project process for temporary housing. Using the Logical Framework Approach to highlight the projects’ outcomes, the investigation focuses on the case study of the prefabricated temporary housing for the 1999 earthquakes in Turkey and on four temporary housing projects in Düzce, one disaster-affected town. Timothy O. Adekunle et al. [19] investigated the indoor thermal conditions and overheating risk in prefabricated timber buildings focusing on two buildings built in the last decade in the UK, Oxley Woods and Bridport. The study employed a combination of different methods: post-occupancy evaluation, thermal comfort surveys, monitoring and simulation. Yan Wang et al. [20] reported an experimental study on the indoor thermal environments in an experimental prefabricated house located in the subtropics. Rui Jiang et al. [21] aimed to establish the prefabricated housing ecosystem in China based on the business ecosystem theory and to analysed the interrelationships among the major participants.

The traditional fuzzy comprehensive evaluation method is a kind of the method based on the fuzzy set theory. Due to the lack of the theoretical system like probability theory, the determination of membership function of fuzzy set has great subjectivity. With the development of fuzzy mathematics, Liu Baoding, a mathematician, uses measure theory to complete the fuzzy axiom system. Since both fuzzy theory and probability theory are all based on the measurement theory, the comprehensive evaluation method of axiomatic fuzzy and random is obtained. This branch is the credibility theory [22] [23] [24], as shown in Figure 1.

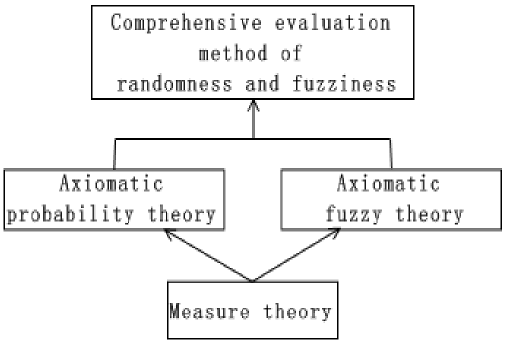

Fig. 1: The origin of the comprehensive evaluation method of randomness and fuzziness

This theory avoids the subjectivity of choosing membership function in the traditional fuzzy set theory effectively, and, because of the self duality of the credibility measure, the result based on the credibility measure is easy to be understudied and accepted [25] .The introduction should present the scientific background of the study and state clearly its objectives.

2. THE DETERMINATION METHOD OF INDEX WEIGHTS

Credibility theory is a branch of actuarial science used to quantify how unique a particular outcome will be compared to an outcome deemed as typical. It was developed originally as a method to calculate the risk premium by combining the individual risk experience with the class risk experience. The kind of method is introduced as follows. Φ is a non empty , $P\{\Phi\}$ is the power set of Φ .If P_{os} satisfies the axiom 1 to axiom 3, we call it the possibility measure, where $(\Phi, P(\Phi), P_{os})$ is called the possibility space. A is a set of $P(\Phi)$,and A^c is the opposite set of A ,so $N_{ec}\{A\}=1-P_{os}\{A^c\}$ is the necessity measure of A ; $C_r\{A\}=1/2(P_{os}(A)+N_{ec}\{A\})$ is the credibility measure of A .And it meet the following four axioms:

Axiom 1: , where $P_{\mathrm{os}}\{\cdot\}$ is the possibility measure

Axiom 2: $P_{\mathrm{os}}\{\phi\}=0$

Axiom 3: For any set of $\{A_{\mathrm{i}}\}$ in $P\{\Phi\}$, $P_{\mathrm{os}}\{\cup A_{\mathrm{i}}\}=\sup_{\mathrm{i}} P_{\mathrm{os}}\{A_{\mathrm{i}}\}$ in the formula sup is the upper bound.

Axiom 4: If （i=1,, ··n）is a no, empty set, $P_{\mathrm{os}}\{\cdot\}$,defined on Φ_{i} ,meet the first three theorems, and $\Phi=\Phi_1\times\Phi_2\times\cdots\times\Phi_{\mathrm{n}}$,then for any $A\in P(\Phi)$, $P_{\mathrm{os}}\{A\}=\sup_{(\theta_1,\theta_2,\cdots,\theta_{\mathrm{n}}\in A)} P_{\mathrm{os1}}\{\theta_1\}\wedge P_{\mathrm{os2}}\{\theta_2\}\wedge\cdots\wedge P_{\mathrm{osn}}\{\theta_{\mathrm{n}}\}$,in the formula $\wedge$ is minimizing operator.

Theorem: For the fuzzy variables ξ,whose membership function is μ,if B is a set of $P(\Phi)$, B^{c} is the opposite set of B on $P(\Phi)$,then $C_{\mathrm{r}}\{\xi\in B\}=1/2\left(\sup_{x\in B}\mu(x)+1\text{-}\sup_{x\in B^{c}}\mu(x)\right)$.

The subjective weighting method is too dependent on the decision maker’s subjective judgment, and is vulnerable to subjective factors, while the objective weighting method may be affected by the index sample of random error even if it avoids the man-made factors, so we cannot obtain satisfactory weighting results by simply using any of them. Combing with subjective and objective weight information, can not only makes full use of the objective information, and can satisfy the decision of subjective desires, to make the final combined weight react the truth of the evaluated system better [26].

2.1. The determination of subjective weight of G1 method

G1 method is a preferred index method. It can directly express the subjective information. To a certain extent, it overcomes the problems of consistency check and the difficulty to guarantee the accuracy when the number of comparisons elements is more in the AHP, so its calculating process is simple.

The main steps of G1 method are shown as follows:

Step 1: Calculate the order relation of indicator x_{j} .Namely experts determine the relative importance degree of the index of x_{j} and x_{j-1} according to experience, and calculate the order relation:

$x_1^*>x_2^*>\cdots>x_m^*$ .Where x_i^* is the ith evaluating indicator after order relations $(i=1,2,\cdots m)$.

Step 2: Experts give the rational value of ω_{j-1}/ω_j ,the ratio of relative importance of x_{j} and x_{j-1} according to experience. $r_k=\omega_{k-1}/\omega_k$, the specific valuation standard sees Table 1.

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Tab. 1: The value of r_k

r_k	explanation
1.0	Index x_{k-1} and index x_k are equally important
1.2	Index x_{k-1} is slightly more important than index x_k
1.4	Index x_{k-1} is obviously more important than index x_k
1.6	Index x_{k-1} is strongly more important than index x_k
1.8	Index x_{k-1} is extremely more important than index x_k
1.1,1.3,1.5,1.7 is between the two respectively	

Step 3: Determinate the subjective weight of the jth index. The subjective weight of each index can be obtained by the following Equation (1)

$$\begin{cases} \omega_k = \left(1+\sum_{k=2}^{m}\prod_{i=k}^{m} r_i\right)^{-1} \\ \omega_{k-1} = r_k\omega_k, (k = m, m-1, \cdots, 2) \end{cases} \tag{1}$$

So the subjective weight of each index is

$\omega' = (\omega_1', \omega_2', \cdots, \omega_n')$

2.2 The determination of objective weight of entropy weight method

Step 1: Assume that the initial data matrix $X = \{x_{ij}\}_{m\times n}$ of n evaluating index of m sample has been obtained; where x_{ij} is the value of the ith samples based on jth index.

Step 2: Because the dimension, the order of magnitude and the orientation of each index are very different, it is necessary to do the non dimensional treatment of initial data. The normalized matrix is

$$Y = \{y_{ij}\}_{m\times n}, \quad y_{ij} = x_{ij} / \sum_{i=1}^{m} x_{ij} \tag{2}$$

Step 3: Calculate the jth index information entropy:

$$e_j = -k\sum_{i=1}^{m} y_{ij} \ln y_{ij} \tag{3}$$

In the formula, the constant k is : $k = 1/\ln m \qquad 0 \le e_j \le 1$

Step 4: Determine the weight of each index based on normalized method.

$$w_j = \frac{1\text{-}e_j}{\sum_{j=1}^{n}(1-e_j)} \tag{4}$$

Then the objective weight of each index is $\omega^{''} = \left(\omega_1^{''}, \omega_2^{''}, \cdots, \omega_n^{''}\right)$

2.3 The determination of combined weights

Assume k_1, k_2 are the importance degrees of subjective and objective weight, the combined weight is $\omega = k_1\omega^{'} + k_2\omega^{''}$

Assume $k_1^2 + k_2^2 = 1(k_1, k_2 > 0)$, obviously, the key problem of the combined assignment weight method is to ermine the coefficient k_1, k_2.The comprehensive evaluation value of the evaluated object X_i is

$$X_i = \sum_{j=1}^{n} \omega_j x_{ij} = \sum_{j=1}^{n}\left(k_1\omega^{'} + k_2\omega^{''}\right)x_{ij}, i = 1, 2, \cdots m \tag{5}$$

(5)The principle of determining the combination weight coefficient is to make the comprehensive evaluation value as far as possible to disperse and reflect the difference between different objects in multi index evaluation [8]. The problem of combined weight can be converted into the following optimized problem:

$$\begin{cases} \max F(k_1, k_2) = \sum_{i=1}^{m} X_i = \sum_{i=1}^{m}\left(\sum_{j=1}^{n}(k_1\omega^{'} + k_2\omega^{''})x_{ij}\right) \\ s.t. k_1^2 + k_2^2 = 1(k_1, k_2 > 0) \end{cases} \tag{6}$$

(6) According to the Lagrange Condition Extremum Principle:

$$k_1^* = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\omega_j^{'}x_{ij}}{\sqrt{\left(\sum_{i=1}^{m}\sum_{j=1}^{n}\omega_j^{'}x_{ij}\right)^2 + \left(\sum_{i=1}^{m}\sum_{j=1}^{n}\omega_j^{''}x_{ij}\right)^2}}$$

$$k_2^* = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\omega_j^{''}x_{ij}}{\sqrt{\left(\sum_{i=1}^{m}\sum_{j=1}^{n}\omega_j^{'}x_{ij}\right)^2 + \left(\sum_{i=1}^{m}\sum_{j=1}^{n}\omega_j^{''}x_{ij}\right)^2}} \tag{7}$$

k_1^*, k_2^* does not satisfy the normalized constraint condition, so it need be normalized:

$$k_1 = k_1^* / (k_1^* + k_2^*), k_2 = k_2^* / (k_1^* + k_2^*) \tag{8}$$

So the combined weight is

$$\omega = k_1 \omega^{'} + k_2 \omega^{''} \tag{9}$$

3. ESTABLISHING A RISK ASSESSMENT MODEL BASED ON THE CREDIBILITY METHOD

Step 1: Calculate the weight vector of the set of the main factor $U = (\mu_1, \mu_2, \cdots, \mu_n)$ and the factor $\mu_i = \{\mu_{i1}, \mu_{i2}, \cdots, \mu_{im}\}$ by combined weighting method. The results are $\omega_i = (\omega_{i1}, \omega_{i2}, \cdots, \omega_{im})$ $(i = 1,2,\cdots, n)$ and it is a fuzzy subset of the set of factors.

Step 2: Calculate the membership degree g_{ijl} of the evaluation $v_l (l = 1,2,\cdots, k)$ of the index factors $\mu_{ij} (i = 1,2,\cdots, n; j = 1,2,\cdots, m)$ g_{ijl} is the ratio of the number of experts who considered the indicators μ_{ij} belong to v_l and the total number of experts.

Step 3: Calculate the single factor credibility measure evaluation vector γ_{ij} of the factor μ_{ij} , $\gamma_{ij} = \{\gamma_{ij1}, \gamma_{ij2}, \cdots, \gamma_{ijk}\}$ where $\gamma_{ijl} = Cr\{v_l = g_{ijl}\}$ is the credibility measure of fuzzy event $\{v_l = g_{ijl}\}$. That is to say it is the credibility measure belongs to the comments v_l of factors' attribute value g_{ijl} $(i = 1,2,\cdots, n; j = 1,2,\cdots, m; l = 1,2,\cdots, k)$ .Based on the credibility of the inversion formula, γ_{ijl} meet the next type

$$Cr\{v_l = g_{ijl}\} = \frac{1}{2}\left(\mu_{ij}(t) + 1 - \sup_{t \neq g_{ijl}} \mu_{ij}(t) \right) \tag{10}$$

Where $\mu_{ij}(t)$ is the membership degree of t to the comment v_l .Obviously, the credibility measure evaluation vector of the single factor γ_{ij} is also a fuzzy subset of the evaluation set.

Step 4: Normalize $\gamma_{ij} = \{\gamma_{ij1}, \gamma_{ij2}, \cdots, \gamma_{ijk}\}$, then the credibility evaluation factors of normalized vector μ_{ij} can be obtained by: $\bar{\gamma}_{ij} = \{\bar{\gamma}_{ij1}, \bar{\gamma}_{ij2}, \cdots, \bar{\gamma}_{ijk}\}$

$$\bar{\gamma}_{ijl} = \gamma_{ijl} / \sum_{l=1}^{k} \gamma_{ijl} (l = 1,2,\cdots, k) \tag{11}$$

Step 5: Array the normalized credibility measure evaluation vector of μ_{ij} $(j = 1,2,\cdots, m)$, and we can get the credibility measure evaluation matrix on μ_i :

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$$R_i = \left(\bar{\gamma}_{ijl}\right)_{m\times k} = \begin{bmatrix} \bar{\gamma}_{i11} & \bar{\gamma}_{i12} & \cdots & \bar{\gamma}_{i1k} \\ \bar{\gamma}_{i21} & \bar{\gamma}_{i22} & \cdots & \bar{\gamma}_{i2k} \\ \cdots & \cdots & \cdots & \cdots \\ \bar{\gamma}_{im1} & \bar{\gamma}_{im2} & \cdots & \bar{\gamma}_{imk} \end{bmatrix} \tag{12}$$

Step 6: Do Fuzzy linear transformation to the credibility measure matrix R_i, then fuzzy subset of comment set on μ_i can be obtained:

$$D_i = \omega_i * R_i = \left(d_{i1}, d_{i2}, \cdots, d_{ik}\right) \tag{13}$$

Where operator * is multiplication of matrices, d_{il} is integrated credibility of μ_i about comment set v_l, which will reflect the extent of the pros and cons of μ_i more objectively.

Step 7: Calculate the credibility measure vector of the main factor $U = \left(\mu_1, \mu_2, \cdots, \mu_n\right)$. Array the credibility measure evaluation vector $D_i = \left(d_{i1}, d_{i2}, \cdots, d_{ik}\right)$ of μ_i $\left(i = 1,2,\cdots,n\right)$, and we can get the credibility measure evaluation matrix on U:

$$R = \left(d_{ij}\right)_{n\times k} = \begin{bmatrix} d_{11} & d_{12} & \cdots & d_{1k} \\ d_{21} & d_{22} & \cdots & d_{2k} \\ \cdots & \cdots & \cdots & \cdots \\ d_{n1} & d_{n2} & \cdots & d_{nk} \end{bmatrix} \tag{14}$$

Step 8: Do Fuzzy linear transformation to the credibility measure matrix, the fuzzy subset of comment set on U can be obtained by:

$$D = W * R = \left(d_1, d_2, \cdots, d_k\right) \tag{15}$$

Then, according to the principle of maximum credibility measure, choose the evaluation v_l corresponding to the largest element d_l in $D = \left(d_1, d_2, \cdots, d_k\right)$ as the final results.

4. CASE STUDY AND RESULTS

4.1 Construction engineering overview

This construction engineering consists of five residential buildings, an underground garage and commercial buildings; the total construction area is 140000 square meters. The residential building has two floors underground and 25~28 layer on the ground. The pre-cast reinforced concrete parts were used in this construction engineering and the distance is about 80km. According to the characteristics of this engineering, the automobile is mainly used to carry on the component transportation, and the transportation vehicle is the largest tonnage truck or the flat trailer. The prefabricate size of this construction engineering is very different, it has more than ten kinds of sizes including top plate, air conditioner plate, balcony plate, stair board, stair partition board, stair cross beam. In addition, the top plate also has 5 different sizes according to the size of room, including 1500mm * 5150mm, 2150mm * 5150mm, 1890mm * 4250mm, 1600mm * 5350mm, 2700mm * 5350mm.

4.2 The determination of risk index and its weight about prefabricated house construction logistics

It is very difficult to produce, transport, stack, lift and support prefabricated component due to the different sizes. So as to establish a scientific and reasonable index system is the key to improve the accuracy and stability of the logistics risk assessment of prefabricated house construction engineering. For prefabricated house construction engineering, its logistics risk evaluation index system is established in this paper through investigating the actual construction engineering, reviewing literature, consulting expert, and using SPSS to analysis important degree and the dispersion degree of the primary indicator (Table 1).

The determination of index weights is given as follows by taking the first order index as an example. The assessment team believes that the relationship between the logistics risk factors of this construction engineering μ_1、μ_2、μ_3、μ_4 is $\mu_1 > \mu_2 > \mu_3 > \mu_4$,and $r_2 = 1.2$, $r_3 = 1.6$, $r_4 = 1.2$. According to the G1 method, the subjective weight of each index can be calculated by the Equation 1 , $\omega' = \left(\omega_1', \omega_2', \cdots, \omega_n'\right)$ = (0.3587, 0.2989, 0.1868, 0.1557) . Objective weight can be calculated by the Equation (2) - (4), $\omega'' = \left(\omega_1'', \omega_2'', \cdots, \omega_n''\right)$ = (0.3834, 0.1843, 0.2936, 0.1386) . So the combined weight is $\omega = k_1\omega' + k_2\omega''$ = (0.3697, 0.2479, 0.2344, 0.1481) according to the Equation (5) - (8).The same method was used to determine the weight of the second level indexes. The results are shown in Table 2.

Tab. 2: the index system of logistics risk in prefabricated house construction engineering and comment set

	Risk type and its weight	The secondary factor and its weight	Low	Relatively low	Moderate risk	Relatively high	high
The Index System of Logistics risk of prefabricated house construction engineering	The risk of purchasing μ_1 (0.3697)	The risk of purchasing of component not timely μ_{11} (0.3324)	0.5	0.4	0.1	0	0
		The risk of material supplier selection (0.3083)	0.3	0.5	0.1	0	0.1
		The risk of contracting in purchasing μ_{13} (0.1572)	0.7	0.3	0	0	0
		The risk of component price μ_{14} (0.1258)	0.4	0.4	0.1	0	0.1
		Other unexpected risks μ_{15} (0.0763)	0.6	0.3	0.1	0	0
	The risk of handling (0.2479)	The risk of component damage μ_{21} (0.7208)	0.3	0.4	0.1	0.2	0
		The risk of casualties μ_{22} (0.1357)	0.4	0.4	0.1	0.1	0

	The risk of damage to hoisting equipment μ_{23} (0.1435)	0.5	0.3	0.2	0	0
The risk of in transportation μ_3 (0.2344)	The risk of component transport route selection (0.4327)	0.3	0.4	0.3	0	0
	The risk of road disruption μ_{32} (0.2031)	0.7	0.3	0	0	0
	The risk of component transport tool selection μ_{33} (0.3324)	0.2	0.5	0.2	0.1	0
	The risk of Force Majeure μ_{34} (0.0318)	0.4	0.4	0.1	0.1	0
The risk of inventory μ_4 (0.1481)	The risk of wrong data μ_{41} (0.1039)	0.6	0.2	0	0.1	0.1
	The risk of material loss and stolen μ_{42} (0.0925)	0.3	0.4	0.1	0.1	0.1
	The risk of component price decline μ_{43} (0.3725)	0.5	0.2	0.1	0.1	0.1
	The risk of component inventory cost μ_{44} (0.2862)	0.7	0.2	0	0.1	0
	The risk of Force Majeure μ_{45} (0.1449)	0.5	0.2	0.2	0	0.1

4.3 Credibility measure evaluation of logistics risk in prefabricated house construction engineering

It is reasonable to classify the risk for five level according to the factors that affect the prefabricated house construction engineering logistics combined with its characteristics, then we can establish comment set $V=\{v_1,v_2,v_3,v_4,v_5\}$ ={normal, general, large, major and serious}, which indicate low risk, lower risk, medium risk, high risk, extreme risk. The evaluation criteria are given in Table 3. The standard is determined by industry experts.

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Tab. 3: the evaluation standard of risk level

level	Low	Relatively low	Moderate risk	Relatively high	High risk
Numerical interval	[90,100]	[80,90]	[75,80]	[70,75]	[0,70]
Meaning	The assessed objectives are in a safe condition, the protection measure is proper, and the management is perfect.	The assessed objectives can meet the normal operation requirements, and the management is not perfect.	The assessed objectives are likely to have an accident, and have accident records, the management is poor.	The assessed objectives are in the period of serious accident and have multiple accident records, the management is poorer.	The assessed objectives cannot meet the normal operation requirements and there are serious problems in management.

According to the actual situation of this construction engineering, ten experts are invited to score according to Table 3. The membership degree of the risk index $v_i\left(i=1,2,3,4,5\right)$ can be calculated according to the expert scoring. It is the ratio of the number of experts who considered the risk level is $v_i\left(i=1,2,3,4,5\right)$the total number of experts. The specific membership degree is shown in table 3.

According to Table 3，the fuzzy evaluation vector ($\mu_{11}$is r*=（0.5，0.4, 0.1, 0, 0).

The credibility measure vector r_{11} of μ_{11}can be formulated according to Equation (10), r11= (0.55, 0.45, 0.3, 0.25, 0.25).

The normalized credibility measure vector of ca, be formulated ($\bar{r}_{11}$=（0.3056，0.2500，0.1667，0.1389，0.1389）.

The same method to calculate the normalized credibility measure vector of、μ_{13}、μ_{14}、μ_{15}.The credibility evaluation matrix R_1 of the factor set $\mu_1=\left\{\mu_{11},\mu_{12},\mu_{13},\mu_{14},\mu_{15}\right\}$ can be obtained by arranging μ_{12}、μ_{13}、μ_{14}、μ_{15} according to the Equation (12).

$$R_1=\begin{bmatrix} 0.3056 & 0.2500 & 0.1667 & 0.1389 & 0.1389 \\ 0.2162 & 0.3243 & 0.1622 & 0.1351 & 0.1622 \\ 0.4828 & 0.2069 & 0.1034 & 0.1034 & 0.1034 \\ 0.2500 & 0.2500 & 0.1750 & 0.1500 & 0.1750 \\ 0.3939 & 0.2121 & 0.1515 & 0.1212 & 0.1212 \end{bmatrix}$$

Then the comprehensive evaluation vector of credibility measure of factor can be obtained according to the Equation (12), $D_1 = \omega_1 * R_1 = (0.3056, 0.2632, 0.1565, 0.1322, 0.1449)$

Similarly, the comprehensive evaluation vector of credibility measure of factor $\mu_2, \mu_3, \mu_4\ \mu_1$ can be obtained,

$$D_2 = \omega_2 * R_2 = (0.2387, 0.2583, 0.1740, 0.1839, 0.1452)$$

$$D_3 = \omega_3 * R_3 = (0.2622, 0.2789, 0.1828, 0.1424, 0.1328)$$

$$D_4 = \omega_4 * R_4 = (0.3832, 0.1861, 0.1421, 0.1471, 0.1414)$$

The credibility measure evaluation matrix R of factor set $\mu=\{\mu_1,\ \mu_2,\ \mu_3,\ \mu_4\}$ by arranging $\mu_1, \mu_2, \mu_3, \mu_4$ according to the Equation (14),

$$R=\begin{bmatrix} 0.3056 & 0.2632 & 0.1565 & 0.1322 & 0.1449 \\ 0.2387 & 0.2583 & 0.1740 & 0.1839 & 0.1452 \\ 0.2622 & 0.2789 & 0.1828 & 0.1424 & 0.1328 \\ 0.3832 & 0.1861 & 0.1421 & 0.1471 & 0.1414 \end{bmatrix}$$

Then the credibility measure vector of the main factor is $D = \omega * R = (0.2906, 0.2546, 0.1650, 0.1497, 0.1417)$

According to the principle of the maximum membership degree, the risks of the construction engineering are normal.

5. CONCLUSIONS

In recent years, the industrialization of the construction industry has been greatly developed due to the promotion of the country, which is the inevitable requirement of the economic structure adjustment and economic growth mode transformation, and also the direction and goal of the construction industry in China. The influence of production, lifting, transportation of the component should be considered while taking into account the rationality and economy of the prefabricated house construction engineering. Therefore, it is necessary to study the risks of construction engineering logistics.

Enterprises can accurately determine the level of construction engineering logistics risks in the construction process, master the direction of system management, and improve the initiative of construction engineering logistics management according to this model of logistics risk assessment. The example shows that this model effectively avoids the influence of human factors on the evaluation results, and solves the difficulty to reflect the risk assessment of construction engineering logistics system objectively because of less date.

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