The Contracting Risk Measurement and Evaluation of International Construction Project Based on the Cloud Theory and Extension Methods——A Study of China International Contractor

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Abstract: A contracting risk assessment index system for international construction projects was established. The contracting risk measurement and evaluation for international construction project was put forward based on the integration of cloud theory and extension methods. First, considering the international project risk factors, this paper constructs international project risk evaluation index system from political risk, social risk and so on; then, this paper measures the contracting risk by use of cloud theory; finally, it uses extension method to evaluate the contracting risk of international engineering. The empirical study shows that it is feasible and reliable to use this method for the contracting risk measurement and evaluation of international construction project.

Keywords: international; construction; project; contracting risk; cloud theory; extension method

1. Introduction

Since 2001, the Chinese Government formally implemented the "going out" strategy. With the implementation of export-oriented economic development strategy, the abilities of china international contractors have been continuously strengthened. According to the ministry of commerce statistics, china international contractors completed business turnover of $154.07 billion in 2015, an increase of 8.2% over 2014. Compared with domestic engineering, the contracting risk of international engineering project is numerous and complicated, involving politics, economy, culture, market and technology, etc [1]. Thus, looking for a suitable risk measurement and evaluation method has important practical significance for Chinese engineering construction enterprise to enter and expand the international market.

At present, the risk evaluation methods of international project mainly include the analytic hierarchy process [2], fuzzy mathematics method [3] and BP algorithm [4], etc. Each of the evaluation method has its own characteristics and plays a certain reference role on risk evaluation. But the existing research results are insufficient in index measure which not fully considers the fuzziness and uncertainty of targeted value. Therefore, it is necessary to break through the limitations of the existing project evaluation methods. In addition, existing literatures study the international project risk from the perspective of social risk, economic risk and so on, but not formed a set of perfect contracting risk evaluation index system for international project.

Therefore, the purpose of the article, which regards Chinese contracting foreign projects as the research object, is to explore the contracting risk measurement and evaluation of international construction project. First, considering the international project risk factors, this paper constructs international project risk evaluation index system from political risk, social risk and so on; then, this paper measures the contracting risk by use of cloud theory which can realize the uncertainty knowledge transform between the qualitative concept and quantitative description; finally, it uses extension method to evaluate the contracting risk of international engineering.

2. Contraction Risk Evaluation Index System

The choice of evaluation index is the first steps to assess the contracting risk of international construction project. According to the characteristics of international engineering project, the principle of index selection, the research results of the existing literature [5-8], this article emphasizes setting up the contracting risk evaluation index system which follows the research route that "Literature research→frequency analysis→experts survey →index reduction". The index system includes six first class indicators, 20 second class indicator, as listed in Table 1.

Table 1. The contracting risk evaluation index system

First class indicator	Second class indicator
Political risk F1	Political stability C1
	Government credit degree C2
	Protectionist C3
Economic risk F2	Inflation C4
	Foreign exchange risk C5
	Interest rate risk C6
	National economic structure C7
legal risk F3	the perfection of legal system C8
	the differences of Legal policy C9
	The stability of legal policy C10
Social risk F4	Culture difference C11
	Religious beliefs affect C12
	Language differences C13
	social order stability C14
Natural risk F5	Natural disaster risk C15
	Construction conditions risk C16
Technology and quality risk F6	Design risk C17
	Construction technology risk C18
	Material risk C19
	Personnel quality risk C20

3. Contraction Risk Measurement and Evaluation

Index set F is a set which is made up of primary evaluation index F_i, that is $F=\{F_1 \quad F_2 \quad \cdots \quad F_t\}$; Index set C is a set which is made up of secondary evaluation index C_j, that is $C_j=\{C_1,C_2,\cdots,C_m\}$; The secondary evaluation indexes values is V. In order to properly represent risk indexes values and ensure the accuracy of Measurement and evaluation results, the measure value is determined by delphi method and cloud generator.

3.1. Contracting Risk Measure Model Based on Cloud Theory

Cloud theory, which can realize the uncertainty knowledge transform between the qualitative concept and quantitative description, is put forward by the Chinese famous scholar de-yi li that is used to represent uncertainties in the natural and social sciences [9].

The measure value is determined by the panel's score, Delphi method and cloud generator [10]. It uses cloud generator to realize the uncertainty knowledge transform between the qualitative concept and quantitative description: first, it generates the digital characteristics $\{E_x, E_n, H_e\}$ of cloud model by reverse cloud generator; then, the digital characteristics of cloud model generates cloud picture through positive cloud generator. Influenced by personal experience and knowledge, experts score results have randomness and fuzziness. In order to determine the parameter values scientifically and reasonably, digital characteristics of cloud model should be determined by more than once expert evaluation process. We should feedback the panel's score to experts in time, repeating the scoring procedures that step by step visual control the convergence speed, quality and direction of expertise, until the panel is agreed. We finally get expectations E_x, entropy E_n and hyper entropy H_e, and make expectations E_x as measure values of indicators risk C_j.

3.2. Contracting Risk Evaluation Model Based on Extension Methods

3.2.1. Matter-element Analysis Model

Extension method is put forward by the Chinese famous scholar Cai Wen which the objects of study are contradictory problems in the realistic world and its theoretical pillars are matter element theory and extension set theory, We use an ordered triad $R=(N,C,V)$ as the basic element for describing things, called matter-element , where N represents the matter; C , the characteristics ; V is the $N's$ measure about the characteristic C [11].

3.2.2. Determine the Classical Domain Matrix and Joint Domain Matrix

(1) Classical domain matrix

First of all, it set up classical domain matrix based on contracting risk evaluation index system of international construction project:

$$R_o=\left(N_o,C_i,V_o\right)=\begin{bmatrix} N_o, & c_1, & v_{o1} \\ & c_2, & v_{o2} \\ & \cdots & \cdots \\ & c_m, & v_{om} \end{bmatrix}$$

$$=\begin{bmatrix} N_o, & c_1, & (a_{o1},b_{o1}) \\ & c_2, & (a_{o2},b_{o2}) \\ & \cdots & \cdots \\ & c_m, & (a_{om},b_{om}) \end{bmatrix} \quad (1)$$

In the formula (1), $N_o(o=1,2,\cdots,\mathrm{n})$, $N_o(o=1,2,\cdots,\mathrm{n})$ represents risk level; $c_i(i=1,2,\cdots,\mathrm{m})$ represents characteristics of the risk level N_o ; v_{oi} is the value range of risk level N_o ,that is Classical field (a_{oi},b_{oi}) .

(2) Joint domain matrix

Joint domain matrix:

$$R_p=\left(P,C,V_p\right)=\begin{bmatrix} P, & c_1, & v_{p1} \\ & c_2, & v_{p2} \\ & \cdots & \cdots \\ & c_m, & v_{pm} \end{bmatrix}$$

(2)

In the formula (2), P represents all the risk level; V_{pi} is the value range of risk level P, that is Classical field (a_{pi},b_{pi}).

3.2.3. Determine the Evaluation Matrix

$$R=\left(P,C,V\right)=\begin{bmatrix} P, & c_1, & v_1 \\ & c_2, & v_2 \\ & \cdots & \cdots \\ & c_m, & v_m \end{bmatrix} \quad (3)$$

In the formula (3), P is the degree of risk; $c_i(i=1,2,\cdots,\mathrm{m})$ is characteristic of risk factor; $v_i(i=1,2,\cdots,\mathrm{m})$ is the measurements of an index

3.2.4. Determine the Related Degree and Weight Coefficient

(1) Related degree

Correlation functions quantitatively describe the degree of risk and determine the risk degree of extensibility. It calculates the correlation function values of each risk evaluation index, that is related degree:

$$k_i(v_o)=\begin{cases} \dfrac{-\rho\left(v_o,v_{oi}\right)}{\left|b_{oi}-a_{oi}\right|},(v\in v_o) \\ \dfrac{\rho\left(v_o,v_{oi}\right)}{\rho\left(v_o,v_{pj}\right)-\rho\left(v_o,v_{oi}\right)},(v\notin v_o) \end{cases} \quad (4)$$

In the formula (4), $\rho\left(v_o,v_{oi}\right)=\left|v_o-\frac{1}{2}(a_{oi}+b_{oi})\right|-\frac{1}{2}(b_{oi}-a_{oi})$,that is the distance of point to internal.

(2) Weight coefficient

According to risk metrics, the analytic hierarchy process (AHP) is used to determine the weight coefficients $\omega=(\omega_1,\omega_2,\omega_3,\cdots,\omega_m)$ of each evaluation index.

3.2.5. Comprehensive Assessment

By formula (4) to calculate the correlation of each index to each risk level and using analytic hierarchy process (AHP) method obtains index weights, the article takes correlation degree and index weights into the formula and obtains comprehensive evaluation value.

$$K_o=\sum_{i=1}^{m}\omega_i k_i(v_o) \quad (5)$$

After calculation, article get comprehensive evaluation value that each index to each risk level and preference value of the comprehensive evaluation value through formula (5). The preference value is that $K_{o*}=\max K_o$,{ o =1,2⋯, n }.

4. Case Analysis

A company planed to bid in a project to expand international business in Africa. According to contracting risk measurement and evaluation of international construction project, this company conducted the decision evaluation on the risk project. Therefore, the company convened a panel of 10 experts who familiar with international engineering to score the risk indexes based on own experience and related standards.

4.1. Contracting Risk Measure Model Based on Cloud Theory

The measure value is determined by the panel's score, delphi method and cloud generator. Evaluation criteria set five reviews {highest, higher, average, lower, lowest}, the corresponding score interval}={0-20,21-40,41-60,61-80,81-100}.

A convenience sample of 10 experts score, in this paper, it realized the uncertainty knowledge transform between the qualitative concept and quantitative description by Cloud theory. At the same time, expert selection covers college related scholars, experienced international project management personnel. As listed in Table 2

Table 2. The risk index value and weight

Index	Index Value	Weight	Index	Index Value	Weight
F1	81.12	0.081	F11	24.89	0.04
F2	55.54	0.055	F12	31.47	0.051
F3	72.91	0.072	F13	33.14	0.055
F4	74.57	0.039	F14	44.72	0.073
F5	69.88	0.037	F15	75.33	0.074
F6	83.74	0.044	F16	74.42	0.073
F7	42.12	0.022	F17	79.81	0.036
F8	67.07	0.052	F18	82.45	0.038
F9	47.54	0.037	F19	72.31	0.033
F10	79.31	0.062	F20	60.86	0.027

"Protectionist" index, for example, it respectively run reverse cloud generator and positive cloud generator based on the score of 10 experts. Through three rounds of expert evaluation, three characteristics of cloud model are Numbers (72.91, 7.98, 5.28). Therefore, E_x =72.91= 72.91 is the value of "protectionist" indicator. The process is as follows: the first round, influenced by personal experience and knowledge, the understanding of "protectionist" is a certain degree of difference which need further deepen and unified, and the performance of cloud picture is that the expert evaluation more scattered, the digital characteristics of entropy and hyper entropy is bigger, cloud is fog, as shown in figure 1. After feedback the panel's score to experts, staff invited experts to a second grade that digital features of entropy and entropy decreases and the performance of cloud picture is from fog to the standard normal cloud, as shown in figure 2; Feedback again, staff invited experts to a third grade that the value of entropy and entropy further decreases, and the performance of cloud picture is cloud cohesion significantly enhanced that means formed the standard normal cloud, as shown in figure 3. The same is true of other risk index.

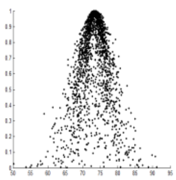
Figure 1

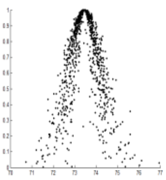
Figure 2

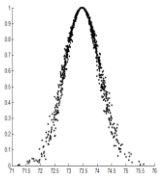
Figure 3

4.2. Contracting Risk Evaluation Model Based on Extension Methods

4.2.1. Determining Index Weights

First of all, the expert group determines the weight value of the first level evaluation index F_i by AHP. The important of the two level indexes are compared to each other through the 1-9 scale which is based on the expert group method. By calculation, $C.I.$=0.025, $C.R.$=0.05<0.1, so the judgment matrix is tested by means of consistency and the weight values of the selected first level indexes are obtained $\omega_i=(\omega_1\ \ \omega_5\ \ \omega_6\ \ \omega_7\ \ \omega_8\ \ \omega_9)$ =(0.207 0.142 0.151 0.219 0.147 0.134), By the weights of the above indicators can be known that political risk and social risk are more heavily weighted in the international engineering project, so we should pay more attention to it. Secondly, calculating the weight value of the corresponding two level index ω_{ij}.

4.2.2. Comprehensive Assessment

By formula (4) to calculate the correlation of each index to each risk level and using analytic hierarchy process (AHP) method obtains index weights, the article takes correlation degree and index weights into the formula and obtains comprehensive evaluation value. The comprehensive evaluation value is {highest, higher, average, lower, lowest}={-0.566,-0.374,-0.265,-0.013,-0.234}.The preference value is that $K_{o*} = \max K_o$,{ o =1,2 $\cdots$, n }. Thus, from the risk assessment result, the company knows that the contracting risk is lower. But according to the result of single index analysis, the company should attach importance to the risk of cultural practices, beliefs, language differences. such as advance to formulate corresponding measures, to eliminate the influence. At the same time, the company shall formulate measures in advance to eliminate the influence.

5. Conclusion

This paper regards the contracting risk measurement and evaluation of international construction project as the research object: first, considering the international project risk factors, this paper constructs international project risk evaluation index system from political risk, social risk and so on; then, this paper measures the contracting risk by use of cloud theory which can realize the uncertainty knowledge transform between the qualitative concept and quantitative description; finally, it uses extension method to evaluate the contracting risk of international engineering. The empirical study shows that the evaluation index system and methods can measure and evaluate the contracting risk which can provide reference for decision that Chinese engineering construction enterprise to enter and expand the international market.

References

[1] Shao, J.Y.; Dong, K.T.; Han, G. et al. Research on risk evaluation for international construction projects. *Journal of engineering management*, 2011, Volume 2:pp. 187–190.

[2] Shen, L.F.; Fan, X.R. Venture capital project evaluation and decision based on analytic hierarchy process (ahp). *Construction optimization*, 2002, Volume 4: pp. 20 – 22.

[3] Qi, B.K.; Zhang, X.Y. Risk assessment study of international construction projects based on the AHP-Fuzzy comprehensive evaluation method. *Journal of shenyang architecture university (social science edition)*, 2013, Volume 4:pp. 369–373.

[4] Hu, W. BP algorithm evaluation model of political risk in international construction projects. *Journal of chongqing university of architecture*, 2006, Volume 4:pp. 98–100.

[5] Walewski J, Gibson G. International project risk assessment: Methods, procedures, and critical factors. Center for Construction Industry Studies, University of Texas at Austin, *Report, 2003*, Volume 31,pp. 23.

[6] Han S H, Kim D Y, Kim H, et al. A web-based integrated system for international project risk management. *Automation in construction*, 2008, Volume 3: pp. 342–356.

[7] Chen, X.Z.; Hu, X.M. A study on social risk assessment of major projects: from the perspective of social exception. Journal of Beijing University of aeronautics and astronautics, *social sciences*, 2013, Volume 2, pp. 15-18.

[8] Hou, J.; Liu, Y.S. The risk identification of international project contracting risk management. *Journal of building economy*, 2013, Volume 7, pp. 22-25.

[9] Li, D.; Di, K.; Li. D. Mining association rules with linguistic cloud models. *Journal of Software*, 2000, Volume 2, pp. 143-158.

[10] Wei, D.; Ma, D.H. Comprehensive evaluation for city ability of reducing earthquake disasters based on cloud model. *Journal of Beijing University of technology*, 2010, Volume 6, pp. 764-770.

[11] Cai, W. Extension theory and its application. *Chinese Science Bulletin*, 1999, Volume 17, pp. 1538-1548.