Risk Identification and Analytical Research of African Engineering Project

He Guangjia[1, a]

[1]GUANGJIA INTERNACIONAL.LDA, Luanda, Angola

[a]friend_hgj@126.com

Keywords: African Engineering Project, Identification, Model, Management

Abstract. In this paper, the author constructed the risk identification system design of African engineering project, put forward the comprehensive evaluation method of engineering project risk, established the risk of third leveled fuzzy synthetic evaluation model of specific engineering project, calculated the weight function of each index as well as analyzed the importance degree. Through combining with the specific case of Jili Water Plant Project in the Republic of Congo as well as the specific application of project risk management theory and method in practice, practice proved such method had guidance significance for the project risk management practice.

Introduction

As China and each country in Africa have traditional amicable relations[1,2,3], the project for Africa offered by China has occurred since long time ago. In recent years, more and more Chinese project contracting enterprises have responded national call for "Step Out", they positively expanded projects and contracted services in Africa. Africa has already become the area that has the fastest increase in new contract singing amounts and the accomplishment of business turnover of overseas project contracting operations for China. However, it becomes especially important[5,6] to manage the risk when implementing general contracting project in Africa due to the complex historical reasons and special political, economy, geography, resources and environment.

Based on the risk factor analysis of engineering project, this paper studied the construction principle, target, function, structure and operation mode of risk management system in the engineering project, in order to establish tracking the changing tendency of the project risk factor, evaluate the status of risk through the engineering risk evaluation system to get the purpose, such as give out early warning signal, give the alarm to owner, project supervisor and construction side immediately, so as to gain more time for decision maker to grasp and control risk, which makes them take effective measures to prevent and resolve project risk at early time. In the meanwhile, this paper also used analytic hierarchy process combining with project practice to construct risk evaluation index system as well as analyzed the importance degree of index weight.

Risk Management of General Contract Project in African Engineering

General contract project of international engineering includes the general contract project of design, purchase and construction (Engineering-Procurement-Constmction,EPC), the geneal contract project of design and contruction (Design-Build, D-B) ; the turnkey geneal contract model; the general contract model of design, purchase (Engineering-Procurement,E-P), the general contract model for construction and others [7,8]. In Africa, no matter technology and market protection are both fierce market competition, which are all reflected by project risk. Table 1 is the statistical results of the common risks met by Chinese engineering contract enterprises in exploiting overseas market.

Table 1 Risks met by Chinese engineering contract enterprises in exploiting overseas market

Risk event	Risk index
Risk due to war and disturbance	22
Risk due to exchange limitation	16
Risk due to policy change of the project in this country	8
Risk due to related standard and requirement of the project in this country	32
Risk due to nationalization and levy	1
Risk due to owner's default on construction cost	63
Risk due to price variation of raw materials and product	23
Risk due to exchange rate	72

The above risks consist of the main risks during the proces of "Step Out" of our country's overseas project cntracting operations. From the project risk management standpoint view, the above risks stay at the status of continous changes and some risks have the continous increasing tendency (see table 1). Owner's default on breaking the contract, default on behinding in payment, exchange rate variation and other commercial risks, which are still the most common issue for enterprises launching overseas service. Recently, since the turbulence situation of the Middle East and North Africa, war, revolt, assault and other national leveled risks have increased gradually too, which becomes the main risk. In Africa, the countries and areas whihc our country's enterprises involved with generally do not have well developed economy.The political situation of some countries and areas is still not stalbe, in addition, the culture and religious background differences are big, and special nature, geography, resource, environment and other conditions, which all determine huge risk will be faced when executing international engineering contract project.

The direct results after identifying risks are the risk identification table, within whih list risk factors as details as possible and classify the risk factors. See the risk identification process in figure 1, this figue will be the preparation for the follow-up risk analysis, evaluation and risk countermeasures. Risk identification is on the basis of collecting information to use a certain method to identify risk factors. Then, evaluate the risk possibility of occurence and loss to get risk analysis index system to well prepare risk analysis for the next step.

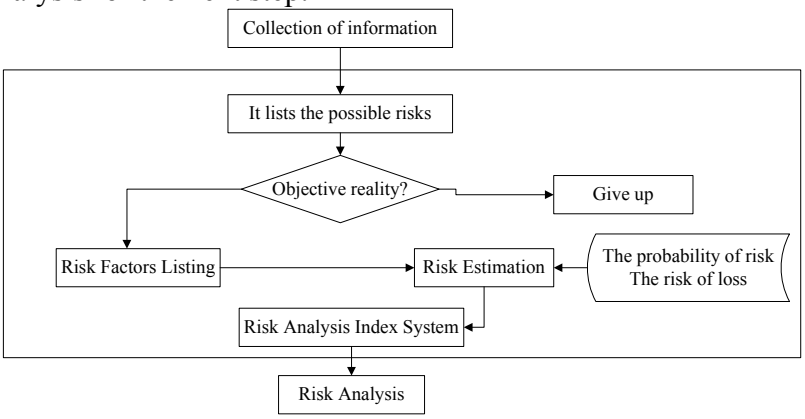

Figure 1 Risk identification flow chart

Risk Comprehensive Evaluation Method of African Engineering Project

Establishment of Evaluation Index System

On the basis of system analysis, decompose according to the logic relation between cause and effect, dependence and existene, demand and category, main and assistance. In the factor decomposition, describ and determine the lowest leveled factors by using several attribute indexes, to

form evaluation index system. And, the weight judgment method can be used for the specific mehtod of index selection.

Let evaluation index system F={f_1,f_2,… , f_n}, the corresponding weight collection is $\lambda = \{\lambda_1, \lambda_2, \ldots, \lambda_3\}$, where $\lambda_i \in [0,1]$(i=l,2,…,n). Let accepting or rejecting weight is $\lambda_k \in [0,1]$.

When $\lambda_i \le \lambda_k$, screen index; when $\lambda_i \ge \lambda_k$, retain this index f_i. The value of weight accepting or rejecting depends on estimator and the complex degree of evaluation target. The more factors involved by evaluation target, the smaller the value of weight you should choose; if not many involved factors, choose bigger value of weight. Generally, weight λ_k chooses 0.1 is more appropriate.

In risk investment, the risk factor index of risk subject is mostly qualitative index, which can be classified by degree language. According to psychology testing principle, the rank with specified rank V={v_1,v_2,… , v_m}, m=5±2,but qualitative index is commonly classified as:

V_1={high,higher,common,lower,low},

V_2={very high,high,slightly high,medium,slightly low, low,very low}

Evaluation Method of Index System

Let evaluation index system F={f_1,f_2,… , f_n}, the numbers of experts who attend the evaluation are S, the grade marked by the experts is $X = \{x_{1j}, x_{2j}, \ldots, x_{nj}\}$, and define the validity coefficient of index fi is β_i:

$$\beta_i = M \sum_{j=1}^{s} | \overline{x_i} - x_{ij} | / S \quad (1)$$

Where, $\overline{x_i}$ is the average of grades for evaluating index, $\overline{x_i} = \sum_{j=1}^{s} x_{ij} / S$, M is the optimal value of the remark collection for index f_i. And define the validity coefficient of evaluating index system F is β:

$$\beta = \sum_{i=1}^{n} \beta_i / n \quad (2)$$

The validity coefficient provides the cognitive deviation degree occured when weighing people using one evaluation index target. The smaller the absolute value of this index, the understanding of each expert using this evaluation index to evaluate target tends to the similar direction, the higher the validity of this evaluation index and evaluation index system, otherwise, the results are correspondingly different.

Take the average of all the evaluation results for one evaluation index as the theoretical value, and calculate the differential degree between the evaluation data and the theoretical value of this index. If the differential value is smaller, then the stability and reliability of this index system is higher. So, the related coefficient in mathematical statistics can be used as the reliable coefficient of evaluating index system.

Let the average data of the all the index $x_{ij}(i = 1,2,\ldots,n; i = 1,2,\ldots,s)$ given by the expert group as:

$$Y = \{y_1, y_2, \ldots, y_n\} \quad (3)$$

$$\rho_j = \sum_{i=1}^{n} (x_{ij} - \overline{x_j})(y - \overline{y}) / \{ \sum_{i=1}^{n} (x_{ij} - \overline{x_j})^2 \sum_{i=1}^{n} (y_i - \overline{y})^2 \}^{\frac{1}{2}} \quad (4)$$

$$\overline{x_j} = \sum_{i=1}^{n} x_{ij} / n \quad (5)$$

$$\overline{y_j} = \sum_{i=1}^{n} y_j / n \quad (6)$$

If p is bigger, it shows the reliability of this system is higher. If p is smaller, it shows the evaluation disagreement degree of index system to the same evaluation target is bigger, $p \in (0.90,0.95)$, it can be considered as the reliability of the index system is higher, but its reliability is poor. When $p \in (0.50,0.90)$, the experts consider as not bad generally, so the reliability of this index system is not bad. When $p \in (0,0.80)$,, it can be thought that the reliability of this index system is poor.

Determination Method of Index Weight

The commonly used methods are delphi mehtod, analytic hierarchy process, circulation grade method and others.Objective weighting method is to utilize index value to reflect objective information, which is oen method to determine weight[9], mainly includes variable coefficient, assignment method, principal component analysis and others. Specific to the practical condition of index weight determination in the risk evaluation of risk investment, assume m experts evaluate the weight for n indexes, and the weight matrix $(W_{ij})_{n\times n}$ is obtained.where, W_{ij} is No. i expert's evaluation value of j indexes. The following formulation calculates the similar degree between weights to judge the dispersion degree of the weight obtained by each expert.

Similar coefficient:

$$R_{ij} = 1 - (\frac{1}{n}\sum_{i=1}^{n} W_{ik} - W_{jk})^2)^{\frac{1}{2}} \qquad (7)$$

Where: R_{ij} is the similar degree of weight results from expert i and expert j: n is dimension of index weight; m is the total advice from experts. It can be seen from the similar coefficient $(R_{ij})_{n\times n}$, the smaller $R_{ij,}$ the smaller the similar weight is.

Let $P = \sum_{i=1}^{n} R_{ij}$, then P_i represents the dispersion degree between the weight advice obtained from No. i expert and the weight advice obtained from other expersts (including himself/herself). The smaller the value, the bigger the dispersion degree between No. Pi expert advice and other experts advice.

$p=(p_1、,p_2,\ldots,p_m:)^T$, can be concluded from Pi, dispersion degree coefficient calculation as follow:

$$D_i = \frac{p_{\max} - p_i}{p_{\max}} \times 100\% \qquad (8)$$

Set one threshold value D_0 (commonly 20%—30%). If $D_i > D_{O,}$ then this expert's weight evaluation will be eliminated. The threshold set up needs to consider practical condition, if too high threshold value is set, then one expert will not be eliminated. If too low threshold value is set, then too many experts will be eliminated, which will lose the effect of group evaluation.

According to the above method, after eliminating weight dispersed points, the rest expert weight evaluation value can be used to calculate the index weight of each layer.

Case Study based on Jili Water Plant Project in the Republic of Congo

This paper chooses Jili Water Plant Project as the turnkey project of overall contract for this company. The working scope mainly includes design, construction, equipment manufacture supply, equipment installation, debug, personnel training, 1 year warranty, 3 years of spare part and others. Total contracting construction periods are 36 months. When implementing Jili Water Plant Project, during this project's risk identification period, risk identification method introduced in above chapter is utilized according to project department existed knowledge accumulation and experience summary, in order to identify the potential risk factors for Jili Water Plant Project. See figure 2, 9 major categories with 27 risk factors of Jili Water Plant Project are identified.

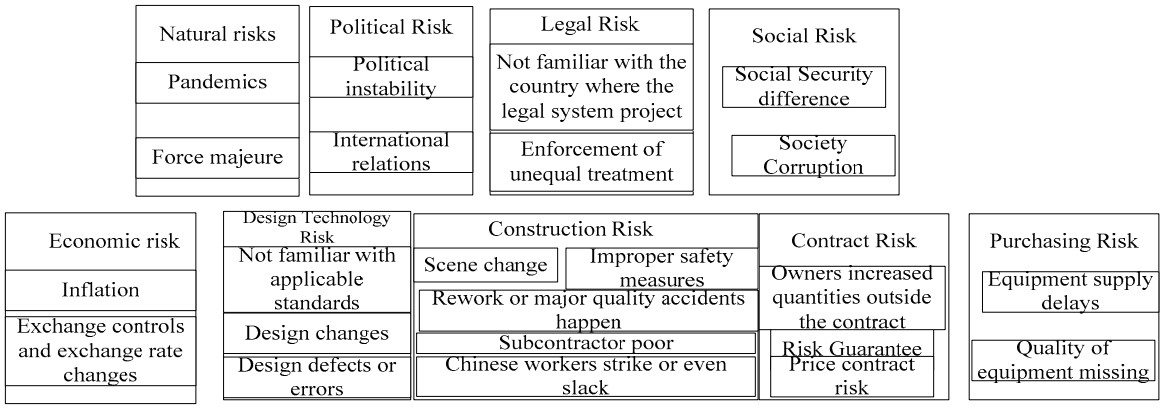

Figure 2 Risk identification list of Jili Water Plant Project

Firstly, establish the hierarchical structure of the issue which is going to be studied namely the index system of risk factor in table 2. Then compare and judge the relative materiality of any two factors to quantify. In order to insure the truth and realibility of the inputing comparison value, brainstorming method, delphi method and other methods are commonly used to assign the values. Lastly, for the weight between each factors in each judging matrix, integrate all the calculation results and calculate combination weight.

Use yaahp calculation software, yaahp software is one assistatn software of analytic hierarchy process, which provides the help of model construction, calculation, analysis and others for decision-making process of analytic hierarchy process. It can improve calculation efficiency and accuracy. Analytic hierarchy process finally output the important rank corresponding to the overall target for various plans. Use software to analyze consistency for all the judges of each expert, which makes all the judged matrix's consistency proportion less than 0.1, so as to conform with the requirements of results consistency of single hierarchical arrangement of analytic hierarchy process. For the obtained final weight and rank of each risk factor, see the bellow table 2 and figure 2,

Table 2 Weigh rank of risk factor for Jili Water Plant Project

No.	Alternative offer	Weight
1	Turbulent political scence	0.1616
2	Poor security of society	0.0859
3	Not familiar with applicable standard	0.0742
4	Force majeure	0.073
5	Poor transportation condition	0.0625
6	Rework or accident due to poor quality	0.0591
7	Contract scope incease by owner	0.0569
9	Internation relation	0.0539
10	Fixed lump sum risk	0.0433
11	Unequal treatmetn of law enforcement	0.041
12	Exchange control and exchange rate changes	0.0355
13	Design change	0.0305
14	Improper safety precautions	0.03
15	Chinese worker slow down, even strike events	0.0258
16	Poor owner's ability to pay	0.0219
17	Deffect equipment	0.0152
18	Design deffect or error	0.0124
19	Poor sub-contractor ability	0.0123
20	Inflation	0.0118
22	Familiar with the law system of the project in that country	0.0103
23	On-site situation change	0.0084

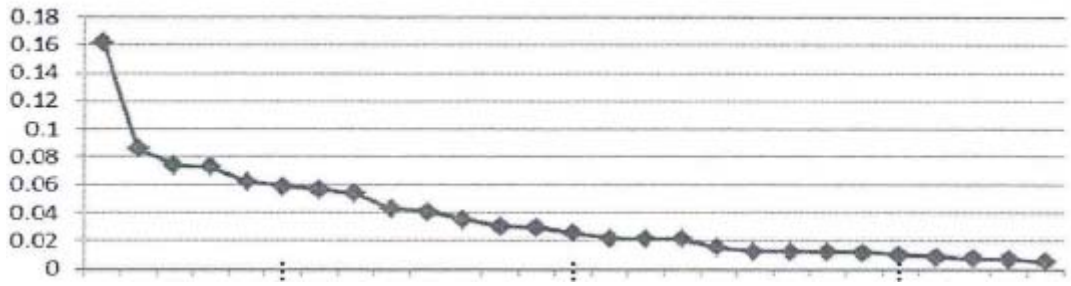

Figure 3 Weigh rank

The 5 risk factors of turbulent political scence, not familiar with applicable standard, poor transportation condition, fixed lump sum risk and rework or accident due to poor quality rank the top, this indeed objectively reflects risk condition of the international engineering overall contracting project in current phase of African area. The above risk factors are always discussed in most of the projects. Firstly, in recent years, the turbulence of Libya, Egypt, Syria and other countries also verify this result, especially the loss of Chinese company in Libya, which represents the political situation of the project in that country having important effects to international engineering overall contracting project. On another hand, standard issue is the common issue met in international engineering projects. In Africa, this risk is also big. More and more projects use the standard of the project existed country or European and American standards, however, Chinese enterprises are lack of the ability to connect with European and American standards. As the standard differences, owners and consulting engineers will have different opinions in the process of approving drawings or construction plans, resulting in project delay. Our country requires "Step Out", that means enterprise needs to improve self-ability, "Step Out" from the low side of labor export and product export to management output and technology output. Especially in technology output, that means in the finaly analysis of "Standard" output. To improve international recognization and acceptance degree of Chinese standard is the approach to efficiently avoid "Standard Risk" and improve enterprise income. Third, poor transportation ability. This is the common phenomenon in African countries, which is also the overall photo of poor infrastructure commonly occured in African countries. "Poor transportation ability" also reflects not developed logistics service market, big logistics cost variation and other aspects. Fourth, "Firm lump sum" is "Characteristics", but also a common "Risk", which is an indisputable truth for international engineering overall contracting project. Firm lump sum contract makes the whole contractor do not have the space to adjust price, which requries the whole contractor having enough consideration on the technical issues, environmental issues, owner contract increase in scope, bestowal of the project existed country potentially meet in implementing these projects in project initiation period. Fifth, rework or accident due to poor quality, which is the direct risk related to construction and the subjective ability of the whole contractor is more related to this risk. The position rank, on one hand, it shows engineering quality have very big restriction to the sucessful or failed project. The overall contractor shall grasp from the quality of design source, insure design, construction as well as purchase. On another hand, it shows quality risk does not like previous stated various risks, which are easy to control. As the quality management ability of the overall contractor is strethening, the rank of such risk will keep decreasing on the basis of stability.Sixth, "Poor owner's ability to pay". Most of the African countries belong to under developed or not developed countries, such countries have the characteristics of big debt burden, low self-international credit and not complete industry structures. However, the needs in development of one country's infrastructure are extremely urgent, which is a contradiction. When representing Chinese enterprises "Step Out" to Africa, most of them utilize good loan terms from Chinese government to get the project. While, from another angle, it is also the chacracteristics including Chinese overall contractor is lack of market competition ability especially with the rapid development in domestic economic recently, our labor price advantage is not significant, not deeply understand of market as well as lack of core competition. Seventh, "Equipment quality deffect". This mainly represents the gap between the process level of domestic equipment suppliers and that of international level or main requirements, in addition, international logistic insurance's influence to this risk factor.

Summary

This paper is based on the summary of the projects implemented in Africa, utilizes the combination approach of quantification and qualification to analyze and evaluate, so as to strengthen communication and knowledge share, moreover, it also analyzes and studies the collected history data and information to further establish a set of scientific and systematic evaluation index system, whch makes project risk management become more process oriented and standarization. Last, it utilzies analytic hierarchy process in combination with engineering example to construct risk evaluation index system and analyzes the importance degree of index weight.

References

[1] Project Management Institute. *A guide to the Project Management Body of Knowledge* (PMBOK Guide) 2000 Edition. Newtown Square Pennylvania USA.

[2] Zong Yan. *Contracting Engineering Development Overview of China to Overseas in the Year of 2008*.International engineerign and labor,2009, 35(3):，p59-66.

[3] Wu Wuqing. *Engineering Construction Project Risk and Countermeasures. Electricity construction*,2007,(1),p60-61.

[4] Feng Yajuan. *Engineering Overall Contracting Risk*. Liaoning Enginering and Technology University journal(Social science version) 2005, 5(1):13-14

[5] Selcuk Karabat. *Sixth International Workshop On Project Managementand Scheduling* [J]. European Journal of Operational Researchl27(2001):217-219

[6] Jing Nan. *Risk Analysis and Countermeasures of China Railway "Step Out"*. Shannxi construction.2011,Vol34,p 245-247.

[7] Li Baoren. *Several Questions and Thinkings on China Railway "Step Out"*[J]China railway.2010,Vol (1),p15-25 .

[8] Guo Jie. *Project Risk Management*. National defense and industry press.2007:12.

[9] Sun Jiatian, Wu Jingtai. *The Application of WBS-RBS Approach in Overseas Engineering Project Risk Identification*. Shenyang Aerospace University journal.2009 ,vol(2) ,p65-69..

[10] China's foreign contracted projects chamber of Commerce.*Contracting Engineering Development Report of China to Overseas*.2011-2012.