Modelling Integrated Risks of Overseas Power Construction Project: A Case Study in Uzbekistan

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Abstract

Contracting a power construction project is usually considered as a "high risk business", mostly because of a lack of adequate environmental information from other countries. Risk management has significant potential to enhance project success. However, identifying and measuring all risk factors and their relationships require a proper and systematic methodology, and more importantly, knowledge along with experience. This paper modelled integrated risks of a power construction project in Uzbekistan based on different risk perspectives from contractors and clients. Literature reviews were used to identify the risk factors which affected the power construction project. The data were collected by questionnaire and interview methods from two respondent groups during the construction process of the Ulugnal Pump Station Reconstruction Project from February 2014 to April 2014.. Shannon Entropy and statistical methods of calculating and ranking analysis were implemented for modelling integrated risks of the power construction project. Results show "Environmental Risk" and "Geological Risk" are ranked highest and belong to the high-risk category from both the perspectives of project managers and consultants in the five risk categories along with the thirteen risk factors. The findings provide decision-making support for both clients and contractors for an in-depth understanding of the risk factors that affect the power construction projects.

Keywords: Integrated risks, Power construction project, China, Uzbekistan

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1. Introduction

No power construction project is risk free. It is generally recognized that the increasing complexity and dynamism of a power construction project has substantial uncertainty and subjectivity. And power construction projects are typically influenced by multiple unknown, unexpected, and frequently undesirable variables, including numerous stakeholders, thelong production duration or entailing significant environmental challenges. Such organizational and technological complexity generates enormous risks. Therefore, currently risk management (RM) is emphasized and implemented being a critical approach for power construction project management. Risk management in power construction projects is a tedious task as the objective functions tend to be challenged during the project life cycle. Moreover, the scenarios are numerous due to the sensitivity of power construction projects to uncontrollable risks stemming from changes in the macro-environment, existence of the high number of parties involved in the project value chain, and the one-off nature of the construction process. It can be defined as 'a system which aims to identify and quantify all risks to which the power construction project is exposed so that a conscious decision can be made on how to manage the risks'. In line with these

definitions, risk management in the power construction project management context is a systematic way of identifying, analyzing and dealing with risks associated with a power construction project aiming to achieve the objectives of the project.

2. State of the art

The origins of project risk research can be traced back to the development of the Program Evaluation and Review Technique (PERT) in the 1950's in order to mitigate the uncertainty over the duration of the project. Over the past decades, risk quantification and modelling as the core of risk management, has become an increasingly important research topic [1]. These studies are generally recognized from two different perspectives. Some are focused on assessing the risk of one aspect of the project's strategies, such as cost risk [2], duration risk [3], quality risk [4], safety risk [5] and environmental risk [6]. Others are focused on assessing the risk attitude of the two main contracting parties such as the clients [7] and contractors [8]. And the research above has developed diverse methods for assessing risks. The most commonly applied methods are as follows: Shang et al. [9] used FST to assess risk probability and impact, and developed a DSS to assess the risk of construction in the design stage. Dikmen and Birgonul [10] used AHP within a MCDM framework for assessing risk and opportunity of the international construction projects. Cagno et al. [11]

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considered "risk controllability" as a ratio between the expected risk impacts before and after applying specific mitigation actions, etc.

In terms of risk assessment, little effort in both research and practice is committed to overseas construction project. And literature lacks sufficient research on systematically measuring the risk of overseas construction project, and the risk-based decision making (RBDM). Most previous studies in risk management of overseas construction project have focused on the factors contributed to the success of risk management, but little attention is given to the factors which significantly affect the decision makers' risk perspective. That plays an important role in project management. Overseas power construction projects are exposed to more uncertainties, especially in terms of external risks, mainly because of the large size of projects and the international issues involved. Particularly constructing the overseas power construction projects in Uzbekistan, which is a third world country with poverty and political unrest, is a more complex, dynamic and evolving process. Power construction projects abroad are typically influenced by multiple local uncertainty variables, such as culture, economic conditions, social and environmental injustice, technological skills, and natural hazards. Risk management for a power construction project is inherently more complicated and difficult to deal with. Hence, it is valuable to investigate an assessment methodology that can measure the integrated risks of power construction projects.

This paper aims at modelling the integrated risks of power construction projects (such as the Ulugnal Pump Station Reconstruction Project in Uzbekistan), which is pervasive for a large number of decision-making activities in the construction process of projects. The objectives of this study are: (1) to identify 13 risk factors and further categorize them into five risk categories using a literature review approach, (2) to classify risk factors and further form 4 risk levels from the questionnaires and interviews, (3) to measure and weigh risk factors, and further rank the integrated risks by Shannon Entropy. Furthermore, the paper collects and discusses the perspectives of clients and contractors to evaluate the risk factors, which supports the opinions that practitioners with different positions have different risk perceptions regarding the same project. Finally, this paper reaches a conclusion of the critical risk factors and the integrated risk categories with a high-risk level. At the same time, the paper investigates the gaps between the clients and contractors related to different risk perceptions and explores the reason for such differences. It is expected that the research findings will contribute to provide a formalized risk modelling system for researchers to use for guidance to evaluate and measure integrated risks of power construction projects. Also it will provide valuable information for clients and contractors to understand the major risk factors influencing power construction projects in the decision-making process.

3. Methodology

Risk is a multifaceted concept [12], which is defined by the Oxford Advanced Learner's Dictionary (1995) as "the chance of failure or the possibility of meeting danger or of suffering harm or loss". In the power construction projects, risk may be defined as the probability of a damaging event occurring in the project, and affecting its objectives [13]. So it emphasizes the two-edged nature of risks, such as "a threat or a challenge". Risk of power construction projects may represent opportunities, but the fact is that most of the risk usually has negative results which lead individuals to only consider its negative side [14]. And the main purpose of a power construction project's risk management plan is to identify, evaluate, and control the negative effects of risks for project success [15]. Risk is the measurement of uncertainty, and uncertainty is a risk that cannot be measured. So in this paper, risk modelling is about measuring the sources of uncertainty, and estimating the consequences of uncertain events/conditions. This study adopts the P-I risk model to define the risk of the power construction projects as the product of two risk indices: probability and consequence. Using a mathematical description, a risk can be described as follows:

$$R = P \times C \qquad (1)$$

Where R is the risk score of the power construction project within [0,1], P is the probability of the risk occurred within [0,1], and C is the degree of consequence of the risk within [0,1].

From the above risk equation, it can be seen that the degree of risk is near to 0 if a risk factor has little consequence and little probability of occurrence. In contrast, if a risk factor has a high consequence and a high probability of occurrence, the degree of risk is very high, nearing 1. This definition of risk is more realistic for power construction projects. A higher risk of project is perceived to become a problem and an obstacle to success. Then, the risk modelling process includes the following main steps: (1) risk identification, (2) risk classification, and (3) risk measurement.

3.1 Risk identification
Risk identification is the first step of the risk modelling process, in which potential risks associated with a power construction project are identified. The risk factors of power construction projects are sourced from a wide range of both literature reviews and previous works by researchers on risk assessment. Specifically those focused on Chinese projects, including Ekaterina and Per Erik [16], Alfredo et al. [17], He [18], Budi et al. [19] and Zou et al. [20]. A comparative analysis of these literature reviews are carried out in order to develop an in-depth understanding about (a) which risk factors are likely to happen within power construction projects, and (b) how can power construction projects be influenced by these risk factors. So the risk system of the power construction project includes 5 risk categories and 13 risk factors (seen in Fig. 2), which is believed to represent most risks of power construction projects in Uzbekistan and elsewhere. A list of the risk factors of the Ulugnal Pump Station Reconstruction Project are identified and described as shown in Table 1.
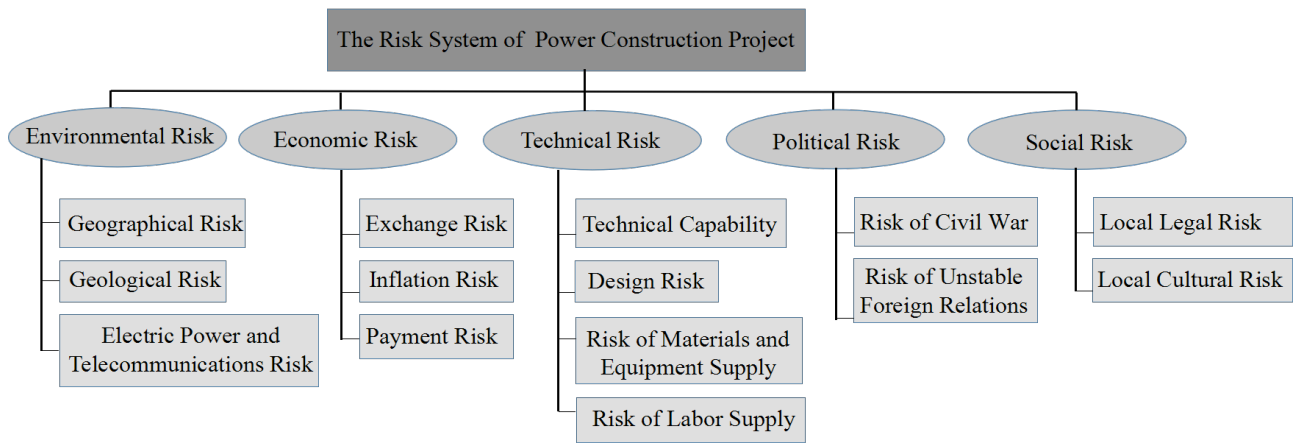
Fig. 1. The risk system of power construction project

Table 1. Description of risk factors of power construction project

Risk Factors		Description
Environmental Risk	Geographical Risk	The power construction project is located in the wilderness. The roads from the site to other cities are mostly winding and narrow, and transportation is extremely inconvenient.
	Geological Risk	The power construction project has a lack of complete and objective geological data, and many drill holes do not reach the rock layer. This increases the risk of the design and construction of the foundation.
	Electric Power and Telecommunications Risk	Since Uzbekistan frequently lacks power resources, a normal power supply can not be guaranteed. In addition, local telecommunications are also underdeveloped, which affects the organization and management during the major phases of construction.
Economic Risk	Exchange Risk	The currency of Uzbekistan is the Uzbekistan Som (UZS). Most power construction projects invested in and constructed by Chinese companies are payed in US dollars. The fluctuation of the US Dollar(USD) to the Chinese Renminbi (CNY) exchange rate creates the risk of the changes in real income for Chinese enterprises.
	Inflation Risk	The business finance market of Uzbekistan is small and closed. But the independent business finance market makes the assets more stable and less affected by international financial crisis. Additionally, the government adopts a series of measures to alleviate the impact of financial crisis, and curbs inflation, such as lowering corporate taxes, recapitalizing state-owned commercial banks, introducing policies to support export-oriented enterprises, and raising the price of natural gas for exports.
	Payment Risk	The contractors only have preliminary designs at the bidding stage. The power construction project budget is expected to increase dramatically when the detailed design is completed. Within the limits of the loan and payment terms agreement, government budget is inevitably tight, which affects normal payment, and is not conducive to pursue claims for additional expenses.
Technical Risk	Risk of Technical Capability	Power construction project construction is a complex and cumbersome process, such as the preparation of mortar and concrete, pouring of concrete, welding and banding of steel, the installation of templates, etc. Each process has high operational requirements and specifications. But there are many differences between Uzbekistan and China in the process of power project construction. Such differences or contradictions increase the risk of the project's construction. Local construction teams pay less attention to construction safety, and the quality inspection system of the project's construction in Uzbekistan is inadequate. Most of the projects do not have supervision or on-site engineers, and the contractors controlling the quality of the construction project are control by themselves without oversight.
	Risk of Materials and Equipment Supply	Industrial raw materials in Uzbekistan are extremely scarce, such as cement, brick, steel, cables, etc. And most of the equipments (such as excavators, bulldozers, cranes, etc.) were made by the Soviet Union, or have been imported from China, Japan, Korea and other places. Some of these equipments are second-hand, some have been scrapped, while the remaining have been in use for more than 20 years. So both the supply of materials and equipments can not meet the requirements of the project's construction. In addition, the supply is susceptible to the fluctuation of the price of materials and equipments, and the interaction of supply and demand of the international market. Therefore, the construction of the power project is also influenced by market fluctuations.
	Risk of Labor Supply	The low technical capacity of local labor increases the risk of the construction, such as improper command, incorrect operation, equipment damage, and injured personnel. So the contractors need to send a group of domestic workers to organize, manage and train the local labor force, which reduces the efficiency and increases the cost of the project.
Political Risk	Risk of Civil War	Numerous military coups have occurred since independence, and assassinations and attacks have occurred frequently due to the conflict between political parties. Regarding Chinese people in Uzbekistan, criminal acts have increased. Chinese companies implementing power projects in Uzbekistan still face the risk of terrorism and crimes based on national sentiment.
	Risk of Unstable Foreign Relations	Uzbekistan has tense relations with neighboring countries. Wars and riots continue to occur in surrounding countries, such as the ongoing war in Afghanistan, the riots of the Kyrgyz in 2010, and some terrorists of Taliban which makes the situation in this region tense.
Social Risk	Local Legal Risk	Uzbekistan has implemented a number of policies and regulations to attract investment since 1999, such as reducing or waiving taxes for foreign companies. But in the actual implementation process, the relevant preferential policies can not be honored, and fines, breaches of contracts and other events often occur. In addition, the legal system of Uzbekistan belongs to the Anglo-American law system, and despite being an Islamic nation. So the legal system of Uzbekistan is

Local Cultural Risk	very complicated, and with religious overtones. The legal system of China differs materially from Uzbekistan, which impacts the engineering disputes and claims. Uzbekistan is a multinational country. There are now more than 100 nationalities living in Uzbekistan. And most inhabitants in Uzbekistan believe in Islam, which has very strict rules. Chinese companies should respect for the habits of nationality and religious beliefs in the process of power project construction.	

3.2 Risk classification

As an integrative part of risk identification, risk classification attempts to structure the diverse risk which affects the power construction project. In order to collect quantitative data of risk classification, this study has adopted an anonymous self-administrated questionnaire and a semi-structured interview over a three-month period. The entire data collection process is mainly comprised of two steps. First, the questionnaire feedbacks the data of risk classification, just as the probability of the occurrence of each risk factor and its magnitude of consequence. In the questionnaire, a consultation is conducted with the experts of project management in China to verify the risk factors. Among the 40 respondents, consultants and professors represent 45% and 55%, respectively. Of the respondents, 80% of them have had more than 10 years of experience in the field of project management, which affirms the reliability and quality of the data. Depending on the suggestion by the respondents, the five-point scales for probability (impossible, seldom, occasional, probable, often)

and consequence (catastrophic impact, huge impact, large impact, small impact, no impact) need to be converted into numerical scales. So the scale point of 0, 0.2, 0.4, 0.6, 0.8 and 1 are used to quantify the probability and consequence. According to the different values of the probability and the consequence, the risk classification can be assigned to four different risk levels, which are extremely high-risk, high-risk, medium-risk, and low-risk. These risk levels correspondingly represent that attitudes of the experts, and the matrix is presented in Table. 2. Secondly, the data of the risk factors is collected from two respondent groups by the semi-structured, in-depth, face-to-face interview method during the construction process of the Ulugnal Pump Station Reconstruction Project from February 2014 to April 2014.. The ten respondents, including five project managers from the China National Electric Engineering Corporation and five consultants from the clients all have more than 20 years of experience in power construction projects. This is in the effort to ensure the data collected is accurate and reliable.

Table 2. The risk classification matrix

	Impossible [0,0.2)	Seldom [0.2,0.4)	Occasional [0.4,0.6)	Probable [0.6,0.8)	Often [0.8,1]
Catastrophic impact on project [0.8,1.0]				**Extremely High-Risk**	
Huge impact on project [0.6,0.8)			**High-Risk**		
Large impact on project [0.4,0.6)		**Medium-Risk**			
Small impact on the project [0.2,0.4)	**Low-Risk**				
No impact on the project [0,0.2)					

3.3 Risk measurement

Risk modelling is an integral part and key process of project risk management. One of the most difficult activities is to determine what the risk factors are and how should they be prioritized.

First, in order to make the data of the risk factors consistent and clear, and to eliminate the impact of the different units of each risk factor, the data of risk factors is globally standardized (by dimensional analysis).

Let $X_{ij} = (x_{ij})_{m \times n}$ which denotes the original risk factor matrix over the scores evaluated by the experts. Let $R_{ij} = (r_{ij})_{m \times n}$ defines the matrix as the standardized risk factor matrix. That

$$r_{ij} = \frac{x_{ij} - \min_j x_{ij}}{\max_j x_{ij} - \min_j x_{ij}} \qquad (2)$$

Where x_{ij} is the original risk score of the i risk factor which is evaluated by the j expert, r_{ij} is the standardized risk score of the i risk factor which is evaluated by the j expert, $\min_j x_{ij}$ is the minimum risk score of the i risk factor which is evaluated by all experts, and $\max_j x_{ij}$ is the maximum risk score of the i risk factor which is evaluated by all experts.

Secondly, in order to model the integrated risks, the weight of each risk factor needs to be determined. So in this paper, Shannon Entropy is used to calculate the weight, which is capable of avoiding subjectivity. Shannon entropy is one of the most important metrics in information theory. Entropy measures the uncertainty associated with a random variable. The concept was first introduced by Claude E. Shannon in the paper "A Mathematical Theory of Communication". Shannon entropy provides an absolute limit on the best possible average length of lossless encoding

or compression of an information source. It allows for the estimation of the average minimum number of bits needed to encode a string of symbols based on the alphabet size and the frequency of the symbols. Shannon defines entropy H as follows:

$$H_i = -k \sum_{j=1}^{n} f_{ij} \ln f_{ij} \tag{3}$$

Where H_i is the entropy of the i risk factor, n is the number of experts, f_{ij} is the probability mass function as:

$$f_{ij} = \frac{r_{ij}}{\sum_{j=1}^{n} r_{ij}} \tag{4}$$

.

And k is the expected value operator as

$$k = \frac{1}{\ln n} \tag{5}$$

Suppose when $f_{ij} = 0$, then $f_{ij} \ln f_{ij} = 0$

So the entropy weight ω can be explicitly written as

$$\omega_i = \frac{1 - H_i}{m - \sum_{i=1}^{m} H_i} \qquad 0 \le \omega_i \le 1, \sum_{i=1}^{m} \omega_i = 1 \tag{6}$$

Where ω_i is the weight of the i risk factor, and m is the number of the risk factors.

The integrated risks can be written as

$$R = \sum_{i=1}^{m} \omega_i R_i \qquad i = 1,2,\cdots,m \tag{7}$$

Where R is the risk score of the integrated risks.

4. Result analysis and discussion

4.1 Case study

Uzbekistan is a predominantly agricultural country, which was an important cotton production base for the Soviet Union. Thus, the Soviet Union built a large number of pumping stations in Uzbekistan, and there are currently more than 400 large pumping stations now running. When the Republic of Uzbekistan gained independence in 1991, the economics of the country gradually increased with economic reforms. For promoting domestic industry and opening the international construction market, the government of Uzbekistan initiated numerous projects to attract advanced foreign contractors to participate in its domestic construction projects. The Ulugnal Pump Station Reconstruction Project as one of these projects, is constructed by China National Electric Engineering Corporation. This project (seen in Fig. 2) is located in the northeast of Andijan State and the Kara Daria River Basin. The Ulugnal Pump Station was built in 1980, and is now mainly used for agricultural irrigation with an irrigated area of 5500 km^2. The water pumped by the Ulugnal Pump Station contains about 3 kg/m^3 of sediment despite the original pumps being designed for simply pumping water. Thus, the pumps have been seriously damaged after many years of use. The Ulugnal Pump Station can not meet the requirement of water supply even with repairs being made two to three times a year. The efficiency of the long-term extended service pumps have decreased significantly due to the aging equipment. Therefor the Ulugnal Pump Station is unable to guarantee normal water supply for agricultural production in the Andijan State. The Ulugnal Pump Station Reconstruction Project was approved by the Cabinet of Uzbekistan to improve the reliability of the water supply. This project was used Chinese government loans, and the China National Electric Engineering Corporation (CNEEC) supplied all electrical/mechanical equipment along with technical training, including the designing, manufacturing, pre-assembling, testing, packaging, and transportation. The Ulugnal Pump Station Reconstruction Project was completed and put into operation in May 2014, which improved the efficiency of irrigation in the Andijan State.

Fig.2. The location of Ulugnal Pump Station in Andijan State

4.2 Analysis of integrated risks

The ten respondents were asked to provide their perception on measuring the probability and consequence of each risk factor. The results are summarized in Fig. 3. The figure provides the information of the risk factors which can be considered to potentially affect the construction process of the Ulugnal Pump Station Reconstruction Project. The results of the probability and consequence scores performed by both project managers and consultants are quite similar, and can be classified into 5 categories, where: (1) "Geological Risk" and "Payment Risk" can be seen as a high-probability with medium-consequences, (2) "Electric

Power and Telecommunications Risk", "Risk of Technical Capability" and "Inflation Risk" are considered as a high-probability with low-consequences, (3) "Geographical Risk", "Risk of Civil War" and "Risk of Unstable Foreign Relations" can be seen as a low-probability with high-consequences, (4) "Risk of Materials and Equipment Supply", "Risk of Labor Supply", "Local Legal Risk" and "Local Cultural Risk" are considered as a medium-probability with medium-consequences, and (5) "Exchange Risk" can be seen as a low-probability with low-consequences.
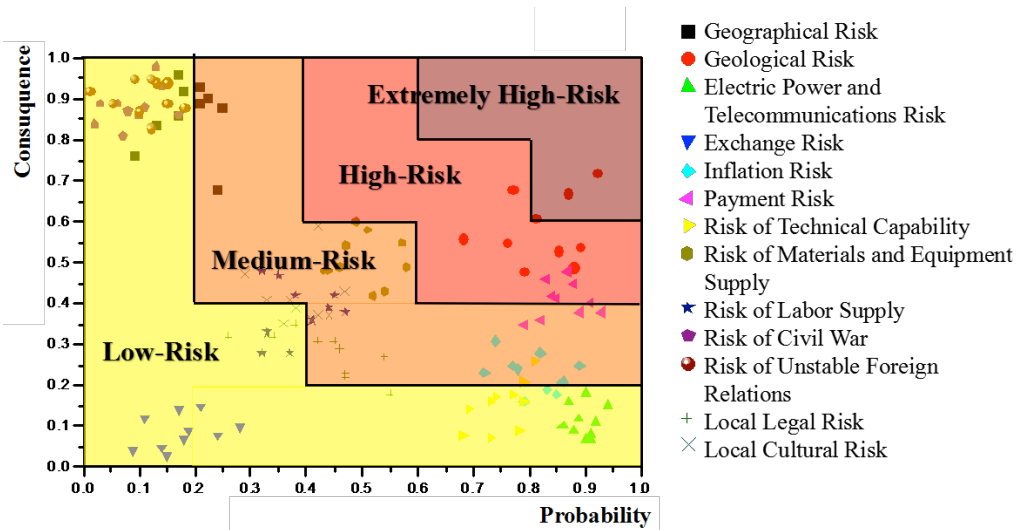

Fig.3. Description of the statistics from the perception of the respondents regarding the probability and consequence score of each risk factor

To analyze the scores of risk factors with relatively mean values, maximum values and minimum values, a criterion is set in this paper for identifying those critical risk factors. And the analysis of the results are shown in Table 3, Fig. 4 and Fig. 5. The overall risk factors are measured on a 0-1

scale, where 0 represents a low-risk level and 1 represents an extremely high-risk level.

Table 3. Description of the statistics from the perception of the respondents regarding the risk score of each risk factor

Risk Score of Risk Factors		Project Managers				Consultants			
		Mean	Max	Min	S.D	Mean	Max	Min	S.D
Environmental risk	Geographical Risk	0.185	0.187	0.068	0.049	0.139	0.220	0.146	0.029
	Geological Risk	0.489	0.583	0.379	0.090	0.472	0.662	0.418	0.100
	Electric Power and Telecommunications Risk	0.103	0.141	0.073	0.027	0.100	0.162	0.063	0.045
Economic risk	Exchange Risk	0.015	0.032	0.007	0.009	0.017	0.028	0.004	0.011
	Inflation Risk	0.170	0.230	0.126	0.044	0.199	0.193	0.153	0.016
	Payment Risk	0.380	0.364	0.277	0.038	0.365	0.418	0.349	0.029
Technical risk	Risk of Technical Capability	0.136	0.139	0.054	0.034	0.095	0.211	0.051	0.059
	Risk of Materials and Equipment Supply	0.240	0.314	0.201	0.048	0.267	0.284	0.211	0.030
	Risk of Labor Supply	0.171	0.160	0.090	0.030	0.122	0.179	0.154	0.013
Political risk	Risk of Civil War	0.066	0.130	0.057	0.033	0.096	0.146	0.017	0.052
	Risk of Unstable Foreign Relations	0.126	0.141	0.009	0.050	0.073	0.158	0.097	0.022
Social risk	Local Legal Risk	0.117	0.146	0.099	0.021	0.120	0.133	0.083	0.023
	Local Cultural Risk	0.143	0.248	0.136	0.045	0.180	0.155	0.126	0.012

From the perception of all respondents, "Geological Risk" with the mean values of 0.489 (project managers) and 0.472 (consultants) is greater than other risk factors, which belongs to the high-risk level. This risk is classified to be the most significantly important factor to affect the construction process of Ulugnal Pump Station Reconstruction Project. But for some other risk factors, the project managers and

consultants hold a different view on classifying the risk levels. It should be noted that "Payment Risk" with the mean values of 0.380 (project managers) and 0.365 (consultants) belongs to the high-risk in the perception of the project managers, while belongs to the medium-risk in the perception of the consultants. "Risk of Labor Supply" with the mean values of 0.380 (project managers) and 0.365

(consultants) and "Geographical Risk" with the mean values of 0.185 (project managers) and 0.139 (consultants) belong to the medium-risk in the perception of the project managers, while belong to the low-risk in the perception of the consultants. "Local Cultural Risk" with the mean values of 0.143 (project managers) and 0.180 (consultants) belongs to the low-risk in the perception of the project managers, while belongs to the medium-risk in the perception of the consultants. And the other 8 risk factors which belong to the medium- or low-risk are quite similar in the perception of all respondents. Furthermore, the scores of risk factors measured by the project managers are mostly higher than that measured by the consultants. The results tend to suggest that the project managers, compared with the consultants, are more aware of risk analysis and management techniques. Different positions of the project managers and the consultants create a significant disagreement on the ratings of risk factors. The project managers on the side contracting,

might consider a trade-off between consequences and benefits. For them risks are harmful to construction projects by causing failure or loss. However, it should be noted that contractors also suffer from uncertainties, particularly ones that have dramatic impacts on their own benefits. So they exaggerate the scores of risk factors, and the higher risk of the project can cause and increase in the client's investment into the project. In contrast, the consultants with richer engineering experience, would be more familiar with and more skillful at addressing the potential risks that might block the successful implementation of the project. They believe high-quality risk management has been widely investigated in the process of the construction to reduce the risk of the project, which can also reduce the cost of the project for the clients. So the project managers and consultants can not have an absolutely fair perception of a project's risks. Thus, this paper uses the perception of both of them to generate more accurate estimates.
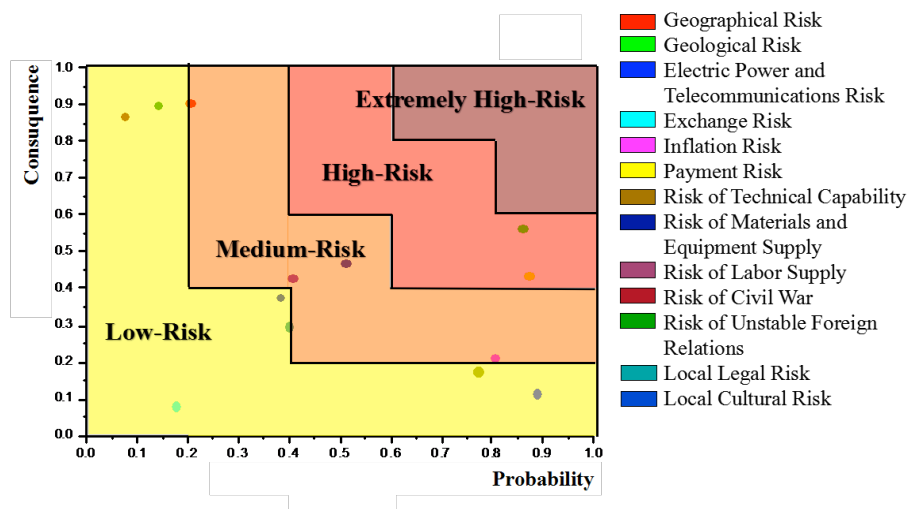

Fig.4. Description statistics of the project managers' perception on the risk levels of each risk factor
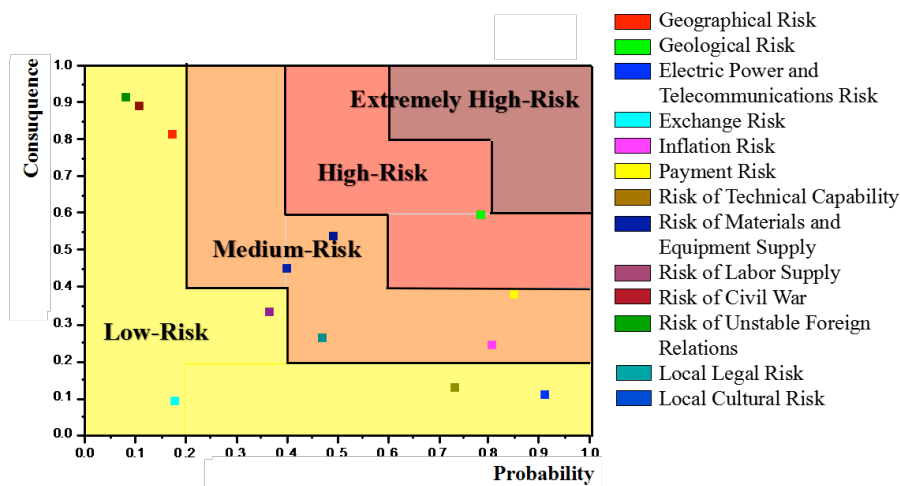

Fig. 5. Description statistics of the project consultants' perception on the risk levels of each risk factor

Finally, the independent 2-sample t-test is used to examine whether there is a significant difference in the mean values between project managers and consultants. Among the t-test results, 4 risk factors (which are marked in gray in Table 3) are above the significance level of 0.05. "Geological Risk" obtains significantly different mean values for both the project managers and consultants

(S.D=0.090 and 0.100, respectively), which is the highest risk factor. Moreover, the mean values of the remaining three risk factors, for example, "Risk of Unstable Foreign Relations" (S.D=0.050) is significantly different only from the project managers' perception, "Risk of Technical Capability" (S.D=0.059) and "Risk of Civil War" (S.D=0.052) are significantly different only from the

consultants' point of view. This yet again reinforces the previous assertion that the extent of high disagreement is found to be valid between the project managers and the consultants, due to "different positions and different perceptions".

Then, in order to model the integrated risks, a total of 13 risk factors which belong to 5 risk categories are weighted by Shannon Entropy. The scores of theintegrated risks are then calculated and ranked. The ranking results of these risk factors are shown in Table 4 and Fig. 6.

Table 4. Description statistics of the score and rank of the integrated risk

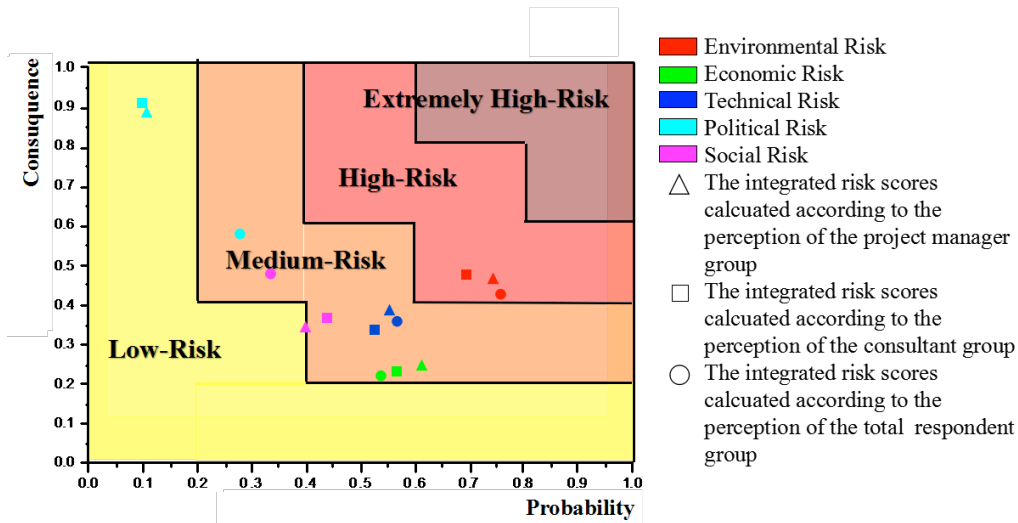| Risk Factors		Project Managers			Consultants			Total		
		Weight (ω)	Integrated Risk Score	Rank	Weight (ω)	Integrated Risk Score	Rank	Weight (ω)	Integrated Risk Score	Rank
Environm-ental Risk	Geographical Risk	0.196			0.227			0.158		
	Geological Risk	0.426	0.266	1	0.416	0.262	1	0.404	0.263	1
	Electric Power and Telecommunications Risk	0.378			0.357			0.438		
Economic Risk	Exchange Risk	0.348			0.412			0.452		
	Inflation Risk	0.325	0.177	3	0.248	0.167	2	0.283	0.171	3
	Payment Risk	0.327			0.340			0.265		
Technical Risk	Risk of Technical Capability	0.261			0.320			0.353		
	Risk of Materials and Equipment Supply	0.449	0.180	2	0.312	0.159	3	0.409	0.179	2
	Risk of Labor Supply	0.290			0.369			0.239		
Political Risk	Risk of Civil War	0.588			0.540			0.618		
	Risk of Unstable Foreign Relations	0.412	0.088	5	0.460	0.086	5	0.382	0.087	5
Social Risk	Local Legal Risk	0.486	0.153	4	0.493	0.149	4	0.317	0.150	4
	Local Cultural Risk	0.514			0.507			0.683		

Fig. 6. Description statistics of the risk levels of the 5 integrated risk categories

It can be clearly seen that "Environmental Risk" among the initial 5 integrated risks is ranked first based on the calculated results (the mean value: 0.266 by the project managers group, 0.262 by the consultants group, and 0.263 by the total group), which belongs to the high-risk level. So "Environmental Risk" is therefore determined as critical and with the highest risk which influenced the construction process of the Ulugnal Pump Station Reconstruction Project. These results provide support for the conclusion that external environment plays a dominant role regarding power construction projects. Due to the nature of political unrest and environmental complexity of Uzbekistan, all respondents emphasize the importance of controlling the environmental risk of the Ulugnal Pump Station Reconstruction Project. The "Economic Risk" (the mean value: 0.177 by the project managers group, 0.167 by the consultants group, and 0.171 by the total group), "Technical

risk" (the mean value: 0.180 by the project managers group, 0.159 by the consultants group, and 0.179 by the total group) and "Social Risk" (the mean value: 0.153 by the project managers group, 0.149 by the consultants group, and 0.150 by the total group) are ranked as second through fourth, respectively, as the critical integrated risks which affect the Ulugnal Pump Station Reconstruction Project. They belong to the medium-risk level. The two risk factors "Economic Risk" and "Technical Risk" obtain significantly different ranks in the different respondent's groups, which highly depends on respondents' perspective, experience and personal characteristics. The project managers on the side of the contractors, as the actual implementer of the construction of Ulugnal Pump Station Reconstruction Project, pay more attention to the technical risks. The consultants from the side of the clients, as the investors of the project, emphasize the investment risk. "Political Risk" (the mean value: 0.088 by

the project managers group, 0.086 by the consultants group, and 0.087 by the total group) is ranked as fifth, which belongs to the low-risk level.

5 Conclusions

Power construction projects involve significant inherent uncertainty which often implies risk. Risk management is recognized as a very necessary and important process for the project team to achieve project success. This paper presents a supportive framework for the risk modelling of the overseas power construction project constructed by the China National Electric Engineering Corporation (CNEEC) in the developing country of Uzbekistan. The conclusions obtained are shown as follows:

(1) The 4 risk levels (extremely high-risk, high-risk, medium-risk, and low-risk) are formed and obtained through the questionnaire and interview of two respondent groups (a project manager group from the side of contractors and a consultant group from the side of clients). It has been demonstrated that all respondents exhibit similar views that the mean value of "Geological Risk" is greater than other risk factors and belongs to the high-risk level. Other risk factors, namely "Payment Risk", "Risk of Labor Supply", and "Local Cultural Risk" are deemed to be of different risk levels based on the different perspectives of these two respondent groups. Respondents' risk attitudes may be influenced and determined by their different standings in the construction project.

(2) The "Environmental Risk" is ranked first and belongs to the high-risk level from both the perspectives of project managers and consultants, which illustrates that the external environment plays a dominant role in power construction projects. For other integrated risk categories, the project managers pay more attention to "Technical Risk", because the contractors are the actual implementers of construction. However, the consultants view "Economic Risk" as the more important integrated risk category, because the clients are the investors of the project.

The findings from this study provide more systematic and formal decision-making support for clients and contractors to understand the critical risk factors that affect power construction projects. Meanwhile, the results are a useful reference for them to make use of their own knowledge and experience as well as international practices to best avoid and control risks before and during the construction process of power construction projects.

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