
Multilevel project-oriented risk-mining approach for overseas construction project's preemptive action

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Abstract

As international construction market increases, the importance of risk management in international construction project is emphasized. Unfortunately, current risk management practice does not sufficiently deal with project risks. Although a lot of risk analysis techniques have been introduced, most of them focus on project's external unexpected risks such as country conditions and owner's financial standing. However, because those external risks are difficult to control and take preemptive action, we need to concentrate on project inherent risks. Based on this premise, this paper proposes a project-oriented risk mining approach which could detect and extract project risk factors automatically before they are materialized. This study presents a methodology regarding how to extract potential risks which exist in owner's project requirements and project tender documents using state of the art data analysis method such as text mining. The project-oriented risk mining approach is expected to effectively reflect project characteristics to the project risk management and could provide construction firms with valuable business intelligence.

Keywords: Overseas risk management, Project-oriented management, Text mining

1 Introduction

Construction project is a progressive work for materializing uncertain owner's requirements. Owners typically provide contractors with a set of tender documents for a bid proposal upon which a contract may be let and executed (Murdoch & Hughes 2008). Since contractors can understand project objectives and owner's design intent from the tender documents, analysis of tender documents is a very important and primary work in the project initial phase. It is extremely important to both the owner and the contractor that the requirements for quality be clearly communicated in the RFP (tender document), so that the resultant proposals will be as responsive to the owner's needs as the cost, technical, and time constraints of the project allow (Gransberg & Molenaar 2004). However, the quality of tender documents is subjected to be poor and unclear depending on owner's specialty in construction project and the project's delivery system. Therefore, tender documents analysis should be managed from a risk management aspect because the tender documents have many potential project risks.

In the life cycle risk management view, the effect of risk management in the early stage is much greater than the late risk management because early risk management can take preemptive action. However, information uncertainty and the amount of available information is poor at a beginning step (Figure 1). Since available information in the early stages is not enough and clear, initial risk management is important to find risk factors. This also explains unclear information should be detailed and take anticipative response to maximize initial risk management effects.

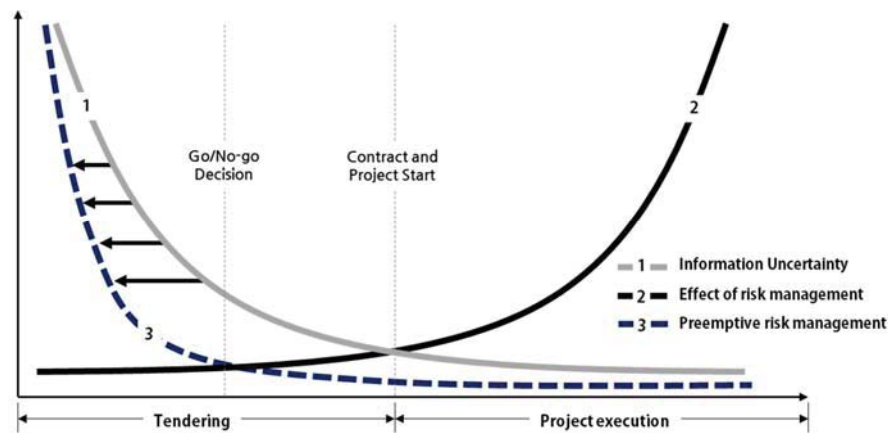


Figure 1 Life cycle risk management

Although the importance of initial risk management has been emphasized, however, current risk management practice in the early stages does not sufficiently deal with project risks. Most of risk analysis techniques focus project's external unexpected risks on such as country conditions and owner's financial standing. However, because those external risks are difficult to control and take preemptive action, we need to concentrate on project inherent risks. Project extraneous risks could be controlled by mining and managing project intrinsic potential risks. In other words, project-oriented risk management should be performed to give concrete shape to document based on potential multi-level risks.

This study presents a methodology how to extract potential risks which exist in owner's project requirements based on the analysis of construction tender documents especially in international projects. Since international projects are inherently exposed to unpredictable and complicated risk scenarios (Han, S. H. et al. 2007), this study selected overseas projects as research object and analysis overseas project's tender documents and risk factors using state of the art data analysis method such as text mining.

2 Current State of Risk Management

International construction projects require high level of risk management skill. There are many potential risk factors in overseas project such as project risk, country risk and owner's risk, etc. In this section literature review on risk management and construction tender documents are performed and research questions are derived.

2.1 An overview of current research

Risk management researches have been performed in several aspects: 1) definition of risk factors, 2) building a risk response framework or system and 3) risk quantification for risk evaluation. Zhi, H. (1995) have described the risk factors classified as nation/region risk (political situation, economical and financial situation, social environment), construction industry risk (market fluctuations, law and regulations, standards and codes, contract system), company risk (employer/owner, architect, labor and sub-contractors, materials and equipment, internal) and project risk (defective physical works, schedule delay, cost overrun). Al-Bahar & Crandall (1990) introduced a risk model entitled construction risk management system (CRMS) to help contractors identify project risks and systematically to analyze and manage them. Sonmez et al. (2007) presents a quantitative methodology to determine financial impacts of the risk factors during the bidding stages of international construction projects.

However, the risk factors analyzed at the previous studies were weighted toward high-level of risks, such as country risk or company risk, not project-oriented (low-level) risks. Moreover, most existing risk management system and framework are based on quantitative techniques which require numerical data. However, much of the information related to risk analysis is not numerical. Rather, this information is expressed as words or sentences in a natural language (Kangari & Riggs 1989).

That is the reason current risk management practice does not sufficiently deal with project risks in the real construction world. Besides, since majority of risk quantification studies relies on survey based statistical analysis which deals with generalized risk, the result from the analysis is difficult to reflect each project's characteristic.

Therefore, this study proposes project-oriented risk management methodology so that text-based tender documents could be analyzed and detected. Figure 2 shows the differences between current risk management studies and this study in terms of the level of risk factors and risk management method.

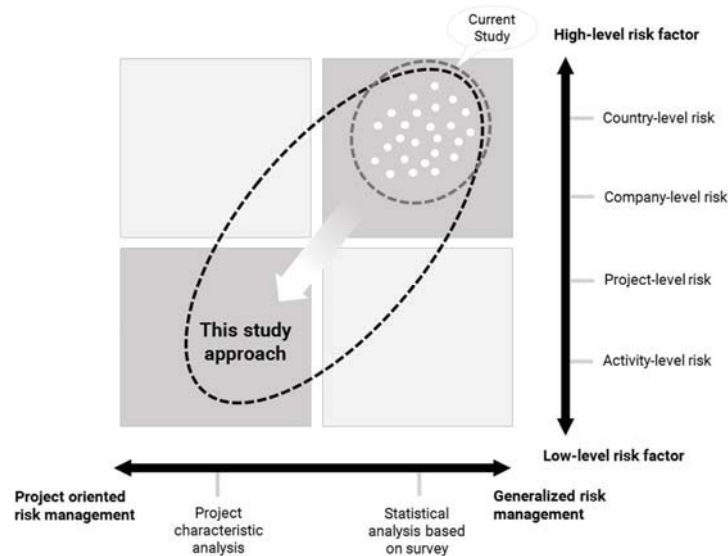


Figure 2 Differences between current risk management studies and this study

2.2 Construction tender documents

Tendering is one of the stages in a construction project that requires extensive information and documents exchange. Such tender documents often contain the information about a client's project plans so that a contractor can price it (Laryea 2011).

Tender documents may include (Designing Buildings Wiki 2015):

- A letter of invitation to tender
- The form of tender
- Preliminaries : including pre-construction information and site waste management plan
- The form of contract, contract conditions and amendments. This might include a model enabling amendment for building information modelling (BIM), making a BIM protocol a contractual document
- A tender pricing document (or contract sum analysis on design and build projects)
- Employer's information requirements for BIM
- Design drawings, and perhaps an existing building information model
- Specifications

Close analysis on huge amounts of tender documents is always a challenging task since the tender period is not enough. Furthermore, tender documents might not always be clear, consistent and adequate. Brook (2004) indicated that major problems associated with quality of tender document's information in drawings, specifications and bills of quantities included missing information, late information, wrong information, insufficient detail, impracticable designs, inappropriate information, unclear information, provisional information, poorly arranged information, uncoordinated information and conflicting information. Because poor quality of tender documents has strong influence on project success (such as construction delay and cost increases) close analysis and review on tender documents should be implemented.

2.3 Research questions

From the previous literature review, not only project external risk (high-level risk) factors but also project-oriented risk factors should be managed in the early stage of construction project. Because construction tender documents contain what the owner wants to build it, it could be a base information which make project forward. Based on this premise, the paper suggests a methodology regarding how to extract project-oriented risk factors from the tender documents and how to assess various types of risk factors. In order to proceed the study the following questions should be addressed:

- (1) What type of risks should/could be solved?
- (2) What kinds of project-oriented risks are existed in tender documents?
- (3) How to identify project-oriented risks?
- (4) How to extract/mine text-based risk factors?
- (5) What are the proper evaluation method for various types of risks?

3 Multilevel Project-Oriented Risk-Mining Methodology

In this section, multi-level project-oriented risk mining methodology is presented. Since every risk exists from bottom (project inside) to the top (project outside), multilevel project-oriented risk mining approach would be necessary to predict risk level accurately.

3.1 Project-oriented risk

Construction tender documents contain many potential project-oriented risks because tender documents may not clear, consistent and adequate. Poor quality tender documents can lead to inaccurate estimates, higher margin in bids, claims and disputes (Laryea 2011).

In order to draw project-oriented risks, this study suggests two different ways: 1) a close analysis of previously performed project's tender documents and 2) review on construction claims/disputes cases. From the study of previous projects, especially which experienced losses due to a poor review of tender documents, we could figure out what issues written on tender documents influenced the project's success and fail. Besides, analysis of construction claims and disputes could give some types of project risk which may exist behind the documents.



Figure 3 Risk identification and risk mining

Figure 3 shows how project-oriented risks are identified. After some of risk factors are derived from the analysis of tender documents and claim/dispute cases, risk vocabulary dictionary would be defined. The defined risk vocabulary dictionary can make text-based documents possibly examined by risk mining methodology. The illustrative example for drawing project-oriented risks is presented in the following section.

3.2 Risk mining process

Risk mining is defined as a methodology in this study which extract text-based risk factors, classify risk type and assess them based on the data type. In other words, project-oriented risk-mining could be defined as an automatic risk extraction method based on the analysis of tender documents. In order to perform the risk mining process data analysis method such as data mining, text mining and information visualization would be applied.

3.2.1 Step 1: Text mining

The first step of risk mining process is text mining which extract internal potential project risks behind the tender documents existed in text data form. Because the examination of tender documents has been conducted by some of experts so far, the quality of review was subject to be varied. Moreover, the analysis on tender documents has not been perfectly carried out due to the short tendering period and huge amounts of documents. Thus, text mining could be a helpful method to analysis risks on documents and discover meaningful information. In order to mining text-based risk factors, definition of project-oriented risk factors should be performed in advance (Figure 3). Since text data is unstructured data, some of text-processing methods which transfer unstructured data into structured data should be conducted.

3.2.2 Step 2: Risk classification

Second step is risk classification which classify previously mined risks according to the risk type. In this step risk type is defined using prior performed project-oriented risk factors. The risk type could be defined by risk predictability, risk controllability and level of risk, etc.

3.2.3 Step 3: Risk assessment

Final step is risk assessment which evaluate classified risk types in accordance with appropriate risk assessment method by risk type. Since the assessment method could be different by risk type which could be unstructured data or structured data, various data analysis method would be applied. In this step, the assessed risk type could be not only project-inside but also project-outside risk type. In other words, the initial analysis object is focused on project-oriented risks, which exist in tender documents, but the evaluated risk type from the risk mining process covers multi-level risk factors.

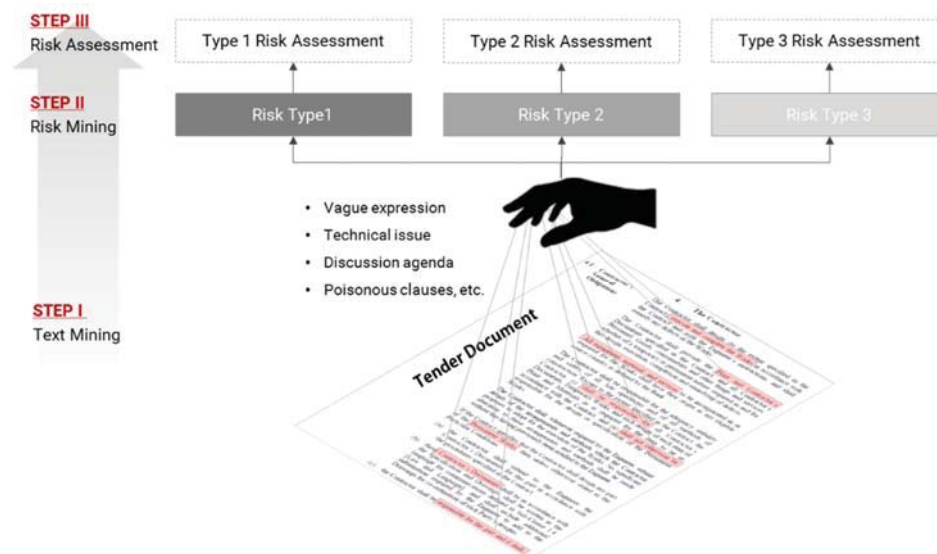


Figure 4 Risk mining process

3.3 Multilevel project-oriented risk mining methodology

According to the risk mining process above the multilevel project-oriented risk mining methodology could be illustrated as Figure 5. Previously identified risk factor and types are stored in project-oriented risk DB, and the DB is used when the risk mining is in the process. In other words, the data stored in the DB is applied to the risk mining process as a mining subject. Thus, if newly incoming tender documents have similar words or phrases compared to the risk DB (risk vocabulary dictionary), the words or phrases are detected, classified and assessed them by risk mining process.

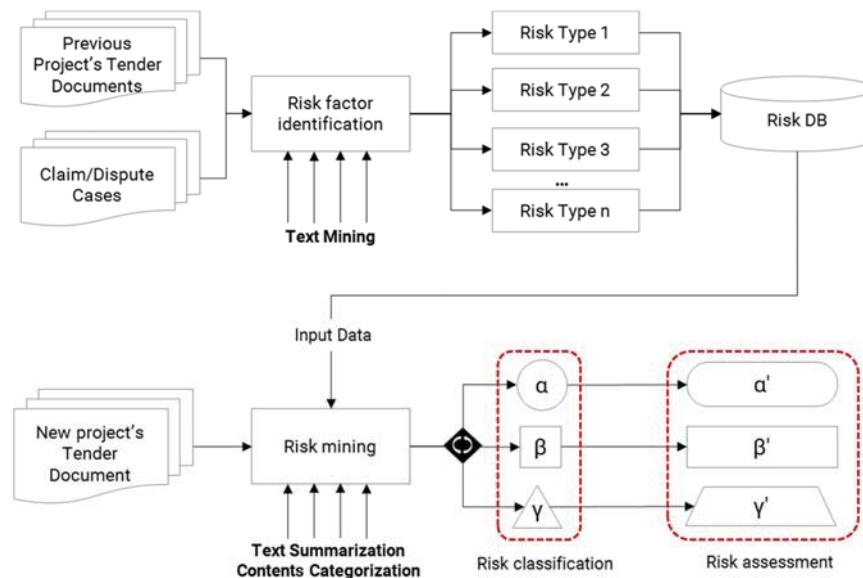


Figure 5 Project-oriented risk mining methodology

4 Illustrative Example: Text Mining of Risk Factors

To illustrate the proposed approach, analysis on construction law cases using text mining tool is performed on a trial basis to draw project-oriented risk factors which are related to construction claims and disputes. For the text mining analysis a total of 73 international construction law cases were collected, and NVivo 10 which is specialized for qualitative research was used for technical text processing.

4.1 Frequency Analysis

In order to derive risk-related words from the construction law cases, frequency analysis was conducted as a part of text mining. Since some words occurred most frequently, such as 'the', 'a', 'contract' and 'owner', etc., are not meaningful itself, these words were excluded on this frequency analysis. Table 1 shows the top 30 frequent words appeared in the law cases. There are some words related to cause of dispute such as 'payment', 'subcontract', 'breach', 'site', 'delay' and 'language'. These words also means risk-related words which should be examined during the tendering process. Although the frequency rate is not much high, however, important risk-related words could be placed low ranking. In other words, high frequency rate dose not stand for the importance. Therefore, it is necessary to search word relationship which shows the way how word appears with other words in the text-based documents. The following section (word tree analysis) gives some idea for understanding word relationship.

Table 1 Frequency analysis result

No.	Word	Frequency	Weighted Percentage (%)	No.	Word	Frequency	Weighted Percentage (%)
1	Court	88	2.4	16	Argued	20	0.5
2	Ruled	52	1.4	17	Breach	20	0.5
3	Appeal	44	1.2	18	Entitled	20	0.5
4	Payment	34	0.9	19	Completion	19	0.5
5	Awarded	32	0.9	20	Site	19	0.5
6	Conditions	30	0.8	21	Stated	19	0.5
7	Subcontract	30	0.8	22	Delay	18	0.5
8	Sued	29	0.8	23	Price	18	0.5
9	Claim	28	0.7	24	Prime	18	0.5
10	Arbitration	26	0.7	25	Required	18	0.5
11	Failed	24	0.7	26	Supreme	18	0.5
12	Final	23	0.6	27	Recover	17	0.5

13	Agreement	22	0.6	28	Clause	16	0.4
14	Low	21	0.6	29	Pay	16	0.4
15	Refused	21	0.6	30	Language	15	0.4

4.2 Word tree analysis

Word tree analysis displays the results as a tree with branches representing the various contexts in which the word or phrase occurs. Some words which are related to tendering terms (clause, agreement, failed etc.) were selected to make word tree in order to know the relations among words in a sentence. Figure 6 shows the word tree of 'clause' and 'failed'. According to the 'clause' word tree, 'no damage for delay' clause and 'order of precedence' clause are related to construction dispute, that is, these terms should be examined in advance for preventing risk arising. The word tree of 'failed' represents what types of dispute factors are existed in construction law cases. It could be possible to understand that 'giving timely notice' is also connected to the construction risk issue and should be managed at the tendering process. Using the word tree analysis more practical risk words and phrases could be derived, and based on the risk-related terms risk vocabulary dictionary could be defined.

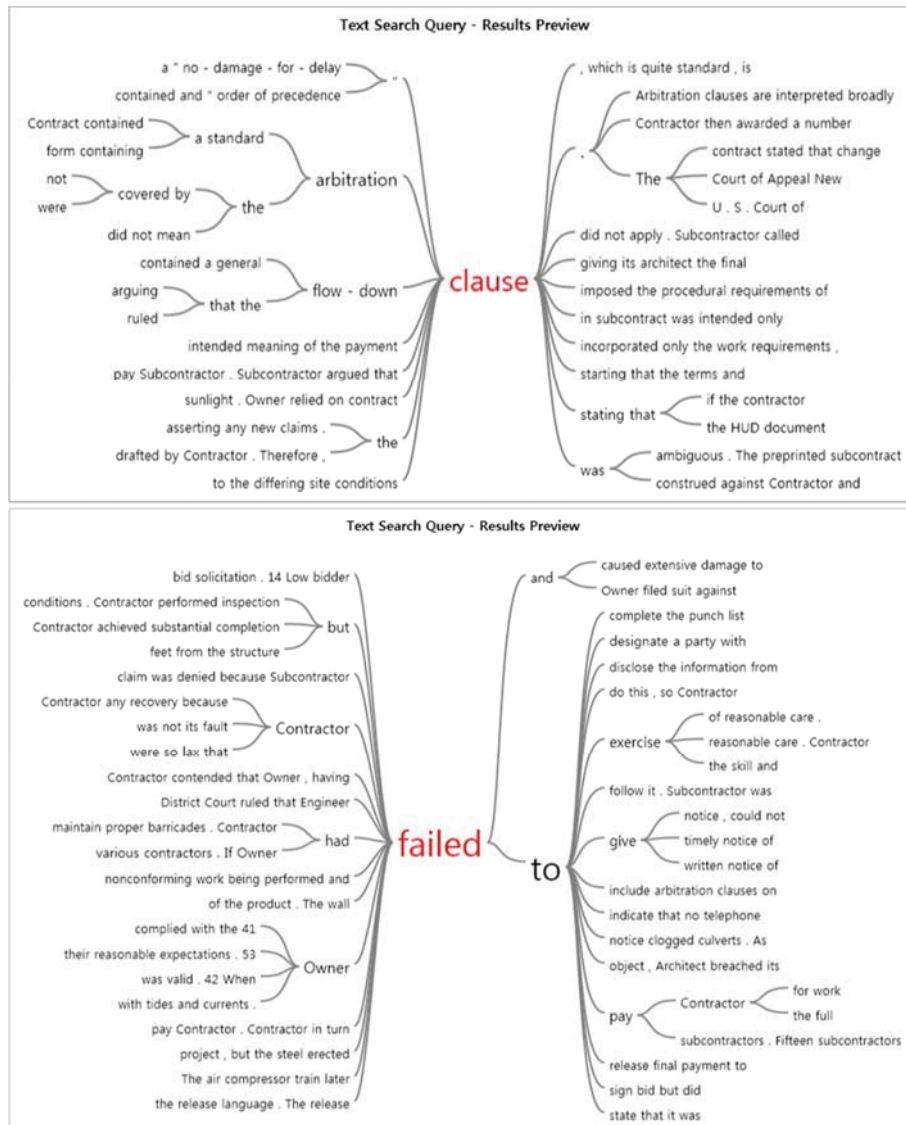


Figure 6 Word tree analysis

5 Conclusion and Future Study

The purpose of this paper is to propose a new approach for managing text-based project-oriented risks. Since available information in the early stages is not enough and clear, identifying owner's design intent written in tender documents is crucial for proceeding construction project. However, current risk management practice in the early stages does not sufficiently deal with project risks. In this paper, multilevel project-oriented risk mining methodology is presented based on investigation of current state of risk management. Moreover, to illustrate the proposed approach, mining risk factors from the construction law cases was performed. Because the illustrative example was only a part of drawing project-oriented risk factors, the text mining results are not enough to make project-oriented risk vocabulary dictionary and risk DB. However, if the study of previously performed project's tender documents will be conducted later, more practical risk factors could be derived. Using the risk factors risk mining process could be processing with computer-aided skills in the future study.

Acknowledgements

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