Journal of Civil Engineering and Management
ISSN 1392-3730 / eISSN 1822-3605
2022 Volume 28 Issue 6: 457–468
https://doi.org/10.3846/jcem.2022.16925

RISK CAUSATION MODEL TO CAPTURE AND TRANSFER KNOWLEDGE IN INTERNATIONAL CONSTRUCTION PROJECTS

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Received 29 April 2020; accepted 28 February 2022

Abstract. International construction projects are facing various severe risks from country, partner, company, and project. Global contractors have suffered heavy losses. Previous researches have proved that an available organizational risk repository is a reliable knowledge source that can be used to introduce experience-based solutions of how specific risks can be managed in international construction projects. The construction of the organizational risk repository calls for an effective feedback mechanism that dispels the organizational culture of unwillingness to disclose management failure and encourages proactive creation and retention of data and information on historical projects and risk-related knowledge. Hence, this paper proposes a risk causation model for international construction projects (RCM_ICP) to support such a mechanism. RCM_ICP links response measures to the chain of risks to identify management failures and conduct modifications, thereby promoting thinking on the part of the management and capturing key risk management experiences. It includes a category component for the efficient retrieval of relevant knowledge based on country-related factors. Besides, this paper proposes the risk review procedures as the instruction of RCM_ICP. Hence, this research breaks the barriers of sharing information between project and organization levels in a project-based industry.

Keywords: risk management, accident causation model, international construction projects, knowledge management, organizational learning.

Introduction

International construction projects kept on an increase and became an important market for global contractors. However, international construction projects manifest more complex web of project systems given the multinationalization of participants, diversity of currency and payment, internationalization of technical specifications, and standardization of contract performance procedures. Thus, contracting international construction projects is universally considered "high-risk business" (Akgul et al., 2017; Bu-Qammaz et al., 2009; Chang et al., 2018a; Hastak & Shaked, 2000; Isaka et al., 2017; Lee et al., 2016; Zhu et al., 2019). It is reported that global contractors have suffered heavy losses in the international market due to poor risk management (Lee & Han, 2017).

Although each project is unique, certain knowledge gained in previous projects may offer valuable suggestions to risk management activities for future projects (Tserng et al., 2009). The identified risks, the occurred risk events, and their consequences within each project constitute the tacit knowledge kept by individuals. However, given the high staff turnover in the construction industry, critical knowledge for risk management rooted in individuals' minds and experiences may be lost (Coners & Matthies, 2018). To solve the problem, all this risk-related knowledge needs to be captured and then retained in the organizational risk repository so that it can be transferred to organizational knowledge (Eken et al., 2020). It implies that the retention of documented information on historical projects with their risks is capable of disseminating lessons learned and the best practice from completed projects and thus avoiding the repetition of errors and extra work in future projects.

Recent literature has highlighted the benefits of organizational risk repositories on risk management in international construction projects. For example, Dikmen et al. (2008) developed a tool to facilitate the construction of a lessons-learned database that contains the information related to risk assessment throughout the life cycle

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of a project. Yildiz et al. (2014) incorporated the lessons learned database into a risk mapping tool so that decision-makers may refer to risk event histories of previous projects to make estimations about forthcoming projects. Okudan et al. (2021) suggested that decision-makers can retrieve similar projects in the corporate risk memory (i.e., a database) and use their risk-related knowledge as a starting point for the risk management of current projects. In addition, various organizations, such as Project Management Institute (2017), International Organization for Standardization (2018), also pointed out the necessity of constructing organizational risk repositories.

Although the organizational risk repositories proposed in the aforementioned literature did provide physical structures to store risk-related knowledge, their application is limited in practice due to some deficiencies. For example, most of these structures focused on the data and information related to risk assessment for better quantification of risk impacts and likelihood of risk occurrence. They ignored capturing the knowledge for risk response and risk monitoring (such as the selected response measures and their effectiveness). Moreover, the lack of a component that makes the risk-related knowledge easy to retrieve and identify is another challenge (Okudan et al., 2021). This is particularly important for overseas projects because overseas projects are usually conducted in an unacquainted environment, and it is difficult to find comparable cases. Most importantly, people are usually unwilling to talk about problems occurred in a project, especially wrong strategies and managerial decisions (Dikmen et al., 2008). The lack of an effective feedback mechanism may cause the repository to stop accumulating new experiences and eventually be out of date. That is to say, the organizational risk repository should be well structured to facilitate feedback of risk-related knowledge, with the aim of promoting continuous improvement of risk management. However, such a structure is still lacking in the literature.

Hence, this paper proposes a risk causation model for international construction projects (RCM_ICP) to provide such a structure. The accident causation model is a widely adopted structure to investigate sources of safety accidents and capture knowledge for safety management. Although it has not been extended to investigate risk events in international construction projects, it provides inspiration. In the proposed model, RCM_ICP links response measures to the chain of risks intending to examine the effectiveness of the response measures. Moreover, it includes a category component for the effective identification and efficient retrieval of relevant knowledge based on country-related factors. Lastly, it encourages thinking from the perspective of management, which in turn facilitates feedback of knowledge for risk management and promotes continuous improvement of risk management at both project level and organization level.

The remainder of this paper is organized as follows. Section 1 reviews the literature on organization risk repositories for international construction projects and accident causation models. Section 2 demonstrates the construction and instruction of the proposed model. Section 3 illustrates its application at both project and organization levels. Final section summarizes the contributions of this research and provides suggestions for future researches.

1. Literature review

1.1. Organization risk repositories for international construction projects

Recent literature in overseas construction management has widely discussed the application of organizational risk repositories in risk management. These researches can be divided into two types according to the research methods.

The first type of researches utilized a collection of statistical techniques such as structural equation modeling (Niu et al., 2019; Viswanathan et al., 2020), factor analysis (Chang et al., 2018b; Li et al., 2020), and network analysis (Chen et al., 2019), with the aim of identifying the major risks and their propagation mode in international construction projects. For example, Chen et al. (2019) extracted 52 cost overrun risks and 158 risk paths from the repository with 156 engineering cases and established a cost overrun risk propagation network. Chang et al. (2018b) noted 14 significant political risk paths using the repository with 264 valid cases conducted by Chinese contractors. Viswanathan et al. (2020) analyzed the collected data from 105 questionnaires to identify risk mitigation measures and test their influence on the success criteria of international construction projects. Notably, given the "project-based" nature of the construction industry, there is no standard set of major risk factors or risk paths applicable to all projects. Besides, the performance of such statistical techniques significantly relies on the quality of the repositories, which was not analyzed in these researches.

Hence, the other type of researches applied the method of analogical reasoning such as case-based reasoning. They suggested the decision-makers retrieve similar projects in the organizational risk repository and use their risk-related knowledge as a starting point for the risk management of current projects. For example, after constructing a case library to store the cost performance of historical projects, Zhu et al. (2021) proposed a case-based method to predict the impact of country-related risk on cost overrun for overseas infrastructure projects. After developing a relational database to store historical risks, Okudan et al. (2021) presented a case-based tool to create, update, and check risk registers for forthcoming construction projects. In summary, case-based reasoning is a potential way, but these studies remain some limitations. Most of them ignored the risk response process because these repositories failed to store the selected response measures and their effectiveness in previous projects, leading to a loss of knowledge for risk response. In addition, although the aforementioned repositories are standardized, the review and record processes are generally independent of risk management processes and lack formalized procedures.

This may cause the repository to stop accumulating new experiences and eventually be out of date.

Consequently, the organizational risk repository should be well structured to improve its quality, thus enhancing its practicability. Although several authors have devoted efforts to developing knowledge management tools in the construction management literature (Eken et al., 2020; Kivrak et al., 2008), most studies are generic repositories that embody all types of knowledge. As a result, the knowledge for risk management tends to be fragmentary and hard to be retrieved in extensive repositories. There are only a few researches conducted from the perspective of developing a repository that specific to risk-related knowledge, as listed in Table 1. According to the practical needs, the organizational risk repository should possess several characteristics. Firstly, the repository should capture and store all the risk management processes and their outcomes. Therefore, the information and data of risk response and risk monitoring activities and their outcomes should be included (A in Table 1). Next, international construction projects usually involve risks specific to international transactions, which vary significantly according to different host countries. A category component should be included for the efficient retrieval of similar projects and relevant knowledge based on country-related factors or other project features (B in Table 1). Furthermore, the structure of the repository should support an effective feedback mechanism that is coupled with risk management processes (C in Table 1). In this way, it can promote continual improvement of risk management by facilitating feedback of risk-related knowledge. Obviously, the existing organizational risk repositories are unable to meet al. needs and remain some limitations.

1.2. Accident causation model

To make up for the above limitations, this paper introduces the theory of the accident causation model (also called the incident causation model). In the field of health and safety management, the accident causation model is extensively adopted to investigate safety accidents and capture knowledge for managing accidents. It was first proposed by Heinrich (1941) to explain the relationship between safety accidents and the causes that lead to them.

Over the years, system models have replaced the initial isolated event model and have been popular for close to two decades (Hulme et al., 2019). Numerous famous accident causation models have abounded in literature, including the Swiss Cheese Model, AcciMap, the Human Factors Analysis and Classification System (HFACS), the Systems Theoretic Accident Model and Processes (STAMP), and the Functional Resonance Analysis Method (FRAM). To date, several studies have revised these models to support thorough accident analysis for specific industries. For example, Chen et al. (2021) developed an Accident-causing Model to predict and prevent human accidents in electrical fires. Lam and Tai (2020) proposed a network analytical framework to investigate the factors and effects of railway incidents. Woolley et al. (2020) applied and extended the STAMP method to present a control structure model of construction in Australia.

This paper adopts the theory of system model to improve the structure of organizational risk repository for international construction projects for two reasons. First, system models reinforce the concept of multiple-causation, where the cause of an incident does not lie in one line of causation (Chua & Goh, 2004). This provides a theoretical basis for connecting the response measures to the chain of risks as long as considering the effectiveness of response measures as one of the causes of the risk events or consequences. Then, system models highlighted the role of the organization. They held that the latent factors causing the accidents reside in the organization. These factors should be identified and improved during the accident investigations. Otherwise, the accidents already occurred in previous projects would reoccur in a new one. This idea provides a reference for promoting improvement of risk management on the organization level through an effective feedback mechanism.

Table 1. A review of the existing organizational risk repositories

Authors	Year	Brief description	A	B	C
Tah and Carr	2001	A common language for describing supply chain risks based on a hierarchical-risk breakdown structure	☒	☒	☒
Dikmen et al.	2008	A relational database to store and update risk-related information	☑	☒	☒
Fidan et al.	2011	An ontology for relating risk and vulnerability to cost overrun in international projects	☒	☒	☒
Yildiz et al.	2014	A database system that represents risk event histories of international construction projects based on an ontology	☒	☒	☒
Ding et al.	2016	An ontology-based semantic network that links risk knowledge to specific objects in the BIM environment.	☑	☒	☒
Zhu et al.	2021	A case library to code and store historical risks in international construction projects	☒	☑	☒
Okudan et al.	2021	A database that includes risk-related knowledge about past projects	☑	☑	☒

2. Risk causation model for international construction projects

This paper proposes a risk causation model for international construction projects (RCM_ICP) to provide a structure to capture and transfer knowledge for risk management. The structure of RCM_ICP is initially developed based on an extensive literature review. Then, this research conducted a series of group discussions with experienced professionals to examine the applicability of RCM_ICP. These professionals included five staff members of the China International Contractors Association and seven members from two Chinese construction companies. All experts have over six years of managerial positions and have been involved in more than three international construction projects. In each group discussion, the authors firstly introduced the construction and usage of the proposed model to ensure consistent understanding. Then the experts were invited to review the major risks that occurred in their last project according to the introduced model to test whether the risk-related knowledge they obtained from the risks was explicitly captured and retained in the structure of the model. After that, the authors conducted exploratory discussions with the experts to find out the model's problem when applied to practice. After all group discussions, the authors improved the model and tested it in five major risk events in different overseas projects. The risk reports were submitted to the experts for their approval. One of them will be described in detail in the next section of this paper. Finally, a general structure is identified to form the RCM_ICP, as depicted in Figure 1.

2.1. Structure of RCM_ICP

The first two components are "International Construction Project" and "Situational Variables". They label the critical characteristics of the project system in which the risk occurred. Hence, decision-makers can retrieve similar projects or situations in the extensive repository according to these two components. "International construction project" is designed for primary retrieval of similar projects. It is divided into four parts and records the basic information of the host country, partners, contractor, and construction project. "Situational Variables" is a set of quantitative indicators designed for further retrieval of similar situations. The selection of the situational variables is based on the retrieval algorithm proposed by Zhu et al. (2021). The variables related to the host country is quantified according to the various global index. For example, "Government stability" refers to the "Political Stability Index: from Global Economy. More information on the data source can be seen in the research by Zhu et al. (2021).

The third component "Risk Path" is cited from related literature (Chang et al., 2018b; Charkhakan & Heravi, 2018; Chen et al., 2019; Eybpoosh et al., 2011; Liu et al., 2016) to illustrate the propagation chain of potential risks.

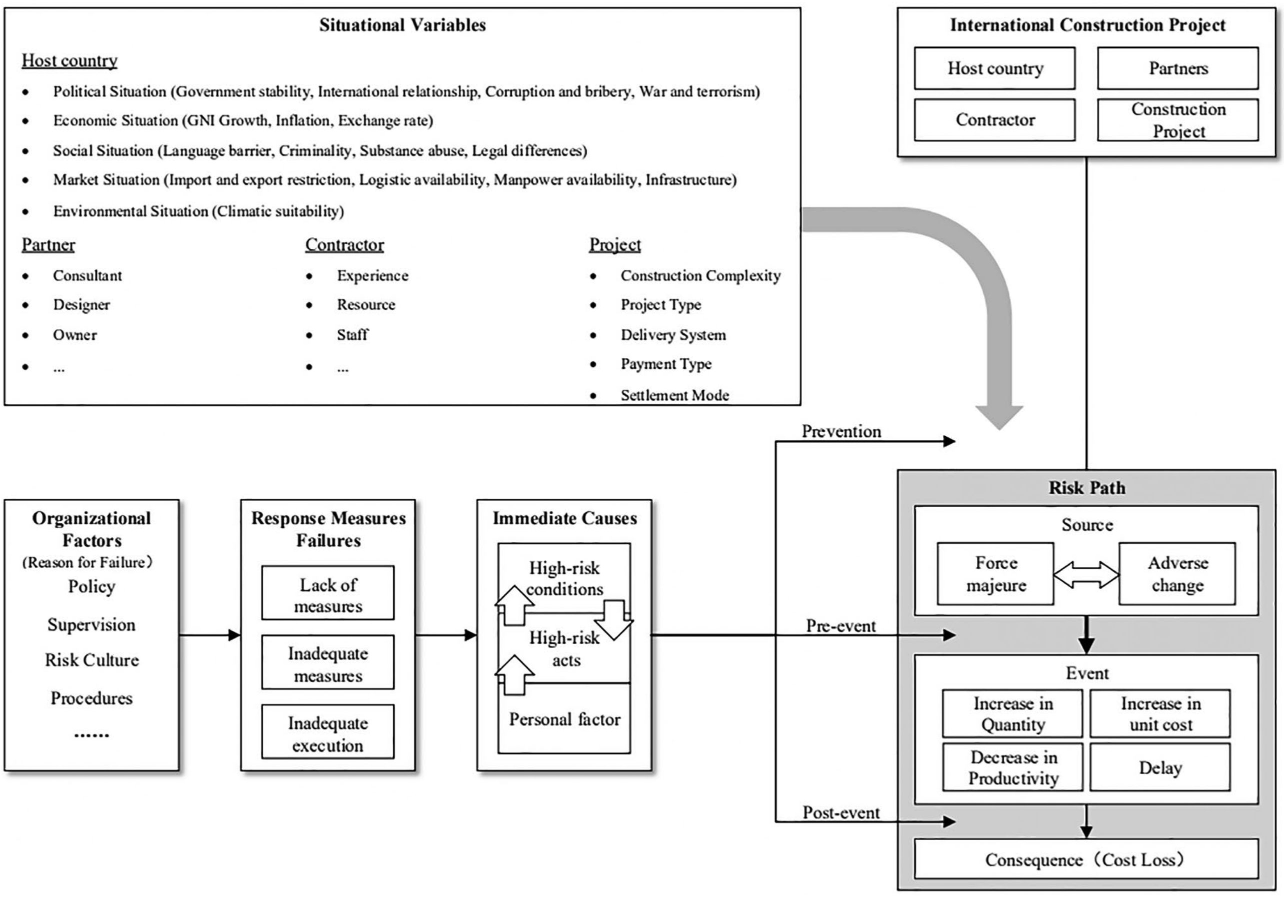

Figure 1. Risk causation model for international construction projects

Risk path consists of sources, events, and consequences, indicating three stages of risk occurrence, such as "design problems – increase in work quantity – cost overrun". "Source" refers to the starting point of the occurrence of the risk path. It affects the probability of event occurrence through adverse change and force majeure. Adverse change implies a negative change from the initial conditions of the project system, such as "adverse change in restrictions for foreign companies". Force majeure is the occurrence of a sudden unexpected event that causes problems in a project, such as a pandemic, an earthquake. Events can be described as increases or decreases in performance indicators, such as quantity, productivity, quality, and time. Figure 1 shows the top 4 events that frequently occurred in the international projects carried out by Chinese contractors. The event will have impacts on the outcomes of the project and cause cost loss. In this paper, cost loss is discussed as a typical consequence. In general, the occurrence of a risk event is inevitably caused by one or more risk sources, and one risk source may lead to the occurrence of one or more risk events. Each risk event has a consequence.

The components "Immediate Causes", "Response Measures Failures", and "Organizational factor" are designed to investigate the risk occurrence scenarios from the perspective of management. They are used to determine the effectiveness of response measures to the occurred risks at three stages of the risk path (respectively prevent, pre-event, and post-event stage). "Immediate Causes" answer to these questions: Why the risk source occurred, why the source led to the event, and why the event led to the consequence. That is to say, immediate causes refer to the high-risk acts or conditions that let the risks develop from source to event and then to consequence. For example, for the risk path "design problems – increase in work amount – cost overrun", the immediate causes at prevention, pre-event, and post-event level are, respectively, "the lack of communication with the designer", "defects in detailed construction drawings" and "the lump sum payment contract & low contingency reserve". High-risk acts can be influenced by high-risk conditions. Vice versa. Personal factors also may cause high-risk acts. "Response Measures Failure" is the reason why response measures failed to prevent the immediate causes, namely, the identified failure that causes high-risk acts or situations. The risk response measures are divided into three categories. Prevention measures decrease the probability of occurrence of the source, pre-event measures respond to the source to lower the severity of the events, and post-event measures reduce the impact of the event on the project cost. When a risk occurs, the response measures will be systematically reviewed to determine whether measures were lacking, whether the selected measures were sufficient to control the risk, or whether the selected measures were inadequately executed. In this way, appropriate recommendations can be made to improve the risk response measures. "Organizational Factors" can be understood as the latent factors that lead to the failure, such as poor risk culture and informal procedures to conduct risk response activity. This component encourages the organization to accept the responsibility to implement self-changes to respond to the risks rather than lay the blame upon personal factors or coincidence.

The proposed RCM_ICP has several useful characteristics. First, it inherits the concept of multiple-causation and links the response measures to the risk path by considering the failure of response measures as another cause of risk propagation. Each time a risk occurs, decision-makers are encouraged to review the selected response measures, determine the failure, and conduct modifications to prevent similar risks. In this way, the selected response measures and their effectiveness can be captured and stored in the model, hence avoiding the loss of knowledge for risk response. Second, the situational variable component is included as a category for the effective retrieval of similar projects and situations. It makes it easier to transfer risk-related knowledge from one project to others since decision-makers can identify potentially relevant content through similarity between projects or situations. Furthermore, RCM_ICP emphasizes the impact of the incompetence of the organization on the propagation of risk path and promotes further self-examination on organizational factors. This is conducive to a summary of key risk experiences from the perspective of organizational learning. In general, the usage of RCM-ICP is able to facilitate feedback of risk-related knowledge and promote continuous improvement of risk management at both project and organization levels, as shown in the following section.

2.2. Usage of the RCM_ICP

Essentially, RCM_ICP can couple the organizational risk repository with the risk management process by providing a structure for the risk review activity, as shown in Figure 2.

This paper defines risk review as "the formal review when risks occur that captures key risk experiences for improving risk management for the current and future projects". Risk review aims to facilitate feedback of risk-related knowledge at two levels. Generally, the risk manager will monitor the occurrence of risks, namely whether there is an occurrence or change of a particular set of circumstances during the life cycle of a construction project. Given the nature of the "high level of uncertainty" in international construction projects, the likelihood of risk occurrence is considerably higher than in domestic projects. When a certain risk occurs, risk review procedures should be activated to collect relevant information on the risk occurrence scenarios, examine the effectiveness of response measures, and make changes to the failure measures, hence achieving improvement of risk management at the project level. Meanwhile, it encourages further summarization of key risk experiences that have a certain general relevance for future projects and identification of the organizational factors. It improves risk management at the organization level by transferring such knowledge to the organizational risk repository.

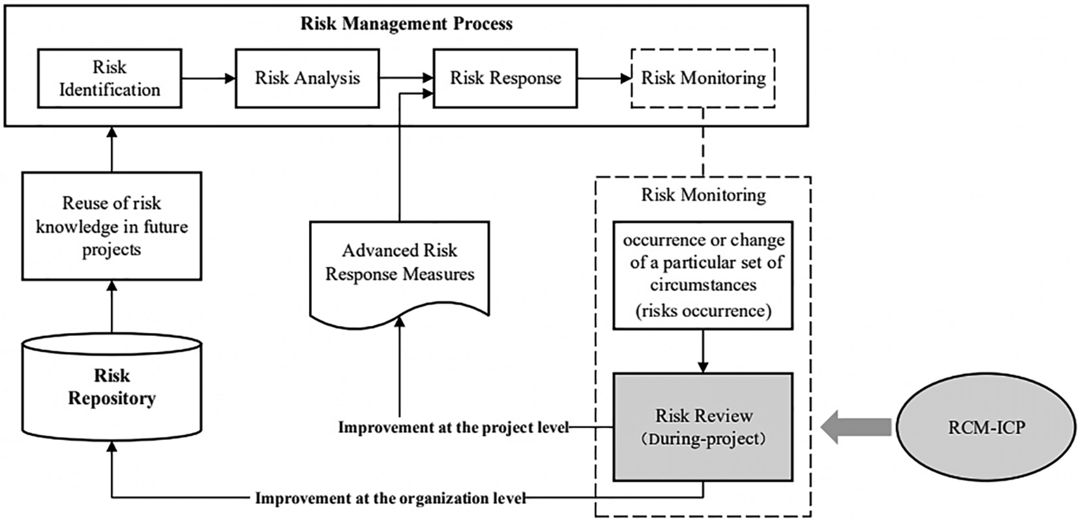

Figure 2. Risk management process

From the aspect of the project level, RCM_ICP ensures systemic and thorough review on the occurred risks to improve response measures for the current project. This paper proposes the formal procedures to review risks based on the RCM_ICP, as depicted in Figure 3.

The first step is to identify situational variables. Essential information about the host country, the partners, the contractor, and the project must be collected. The second step is to describe the risk path. The next step is to analyze the immediate causes at three stages. Subsequently, the relevant measures to deal with such immediate causes are listed, and the failure of the selected measures can be respectively identified through the following issues. The existence of selected measures and the execution of these measures must be checked to determine why the prevention measures failed to prevent the occurrence of the source, pre-event measures failed to intervene in the event, and post-event measures failed to decrease the impact of the event. Moreover, whether the deviations contribute to the occurrence of the risk path must be ascertained. If no relevant measures are existing in the response measures, then “lack of measure” failure is presented. If relevant measures exist, then the deviations between the selected measures and actual measures will be evaluated. If actual measures are the same as selected measures and the risk path still occurred, then there is “inadequate measures” failure. In case of execution deviations, the adequacy of the selected measures is evaluated subsequently. If the deviations between the selected measures and actual measures contributed to the risk path, then there is an “inadequate execution” failure. When the deviations did not contribute to the risk path, there remains “inadequate measures” failure. Finally, the investigation will focus on making changes to the failure measures to avoid the recurrence of the risks in the same project. If necessary, it should also determine the organizational factors. In summary, the risk reviewing procedures based on the RCM_ICP are capable of identifying the failure of response measures and making recommendations to compensate for it, hence improving the risk response measures at the project level in a reactive way.

From the aspect of the organization level, RCM_ICP contributes to the construction and evolvement of the organizational risk repository. Because RCM_ICP provides a common structure to record all the risk management process and their outcomes and divides a long risk report into short phrases. This shows the potential to develop a database that allows knowledge transferring to the risk management process of a new project. Decision-makers can retrieve similar projects and identify relevant knowledge according to the situational variables. Thus, decision-makers needn’t develop the risk register and response measures from scratch. Furthermore, RCM_ICP can further facilitate organizational improvement by encouraging in-depth investigation of organizational factors. The determination of organizational factors is difficult, but this process is necessary to facilitate self-examinations of the organization. In this context, the reviewing procedures could provide more information for the organization to achieve self-changes in policy, culture, or procedures, not just documented data and information of historical projects and their risks.

3. Application

The application of RCM_ICP is tested in an international construction project executed by a leading construction company in China. The sample project is a railway construction project in Saudi Arabia. The project experienced a serious delay in the work process. The contractor had to pay a large number of liquidated damages due to failure to complete contracted construction content before a certain key date. The purpose of risk review is to identify the failure of the response measures, propose appropriate measures to compensate for it. Although the risk review cannot mitigate the damage of the occurred risk events, the

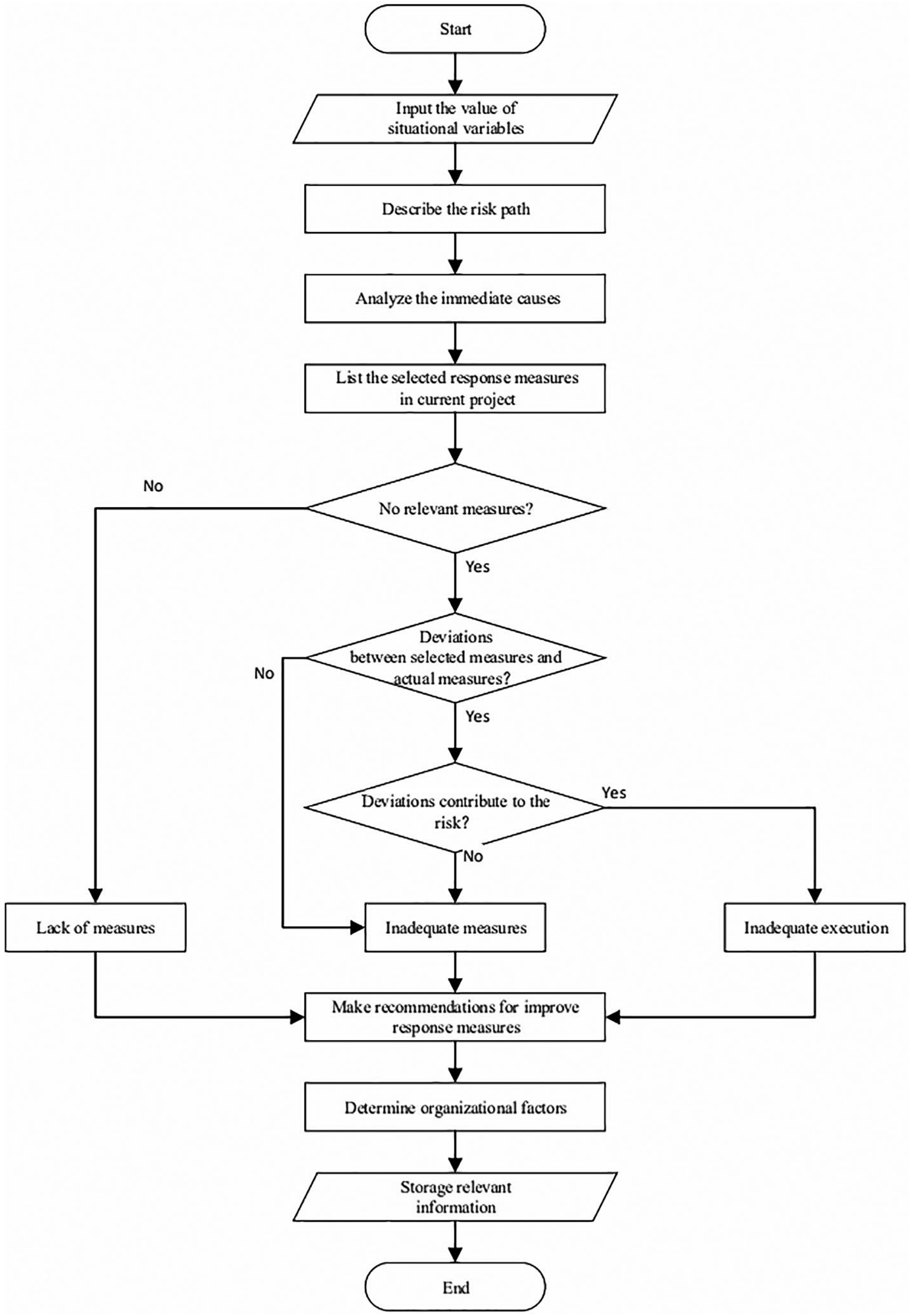

Figure 3. Formal procedures to review risks based on the RCM_ICP

improved measures can prevent the recurrence of similar risks in this project and the future ones to some extent. After the risk review, the relevant risk knowledge can be structured based on RCM_ICP, as shown in Figure 4.

The first two steps of the reviewing procedures are to record the situational variables and to describe the risk path. The variables of the "host country" category can be determined according to the aforementioned global index. The contractor and partners are anonymous as required. More information is detailed presented in Figure 4, as well as a brief introduction to the developing process of the risk event. The consequences are cost overrun ($2 million). A "delay in Work Process" event has directly caused the consequence. The starting point is the source "adverse change in labor availability" and "adverse change in working days".

The risk review then analyzed the immediate causes and identified response measures failures at the prevention, pre-event, and post-event level. Taking the prevention level as an example, one of the immediate causes is that the contractor underestimated the impact of religious differences, hence leading to labor issues. First, only local believers were allowed to enter the construction site in Mecca, which caused the adverse change in labor availability. Then, the local believers did not participate in the construction during Hajj and Ramadan, which caused the adverse change in working days. Hence the immediate causes are determined. There is only one relevant measure in the selected measures of this project. That is "a certain proportion of local workers". The contractor did recruit some local workers before commencing the work. Although the number had reached the required proportion but was still not enough for this project. It denotes that the selected measure is insufficient to prevent the immediate causes. Therefore, the investigation revealed an "inadequate prevention measure" failure.

The last step is to determine the underlying reasons for failure and make recommendations to improve the response measures. According to the immediate causes, the recommendations for prevention measures are to adopt a higher proportion of local workers according to total man-hours and available working days. So that similar events will not occur in the same project and future ones. The organizational factors for inadequate prevention measures are determined as lack of in-depth market research and lack of experience in a religious country. Based on the preceding case study, the organization should take action to compensate for the gap, such as setting up strict market research procedures. The reviewed information at the other two stages is also presented in Figure 4.

This case study confirmed that the application of the RCM_ICP in risk review could capture risk-related knowledge to improve risk management at the project level because the measures that could have prevented the occurrence of the risks are recommended. If every occurred risk event can be reviewed based on RCM_ICP, the accumulated risk records would capture more relevant knowledge including the likelihood of risk occurrence, the impact of risk events, and the effectiveness of response measures. Otherwise, such knowledge often remains in the individual experience of the project participants implicitly instead of being retained in the organizational risk repository explicitly. In addition, this section also determines the organizational factors. It would help the organization to improve its culture and procedures.

In order to further test whether the application of RCM_ICP could facilitate the construction and evolvement of the organizational risk repository, this research has been applied in a Chinese construction company that remains active in the international contracting market. RCM_ICP was embedded in the structure of the company's risk repository for ease of use, as shown in Figure 5. In addition, the risk management process was coupled with the organizational risk repository, as illustrated in Figure 6.

In general, the company staff needs to activate the risk management process by inputting basic information of the project and the initial value of situational variables. After retrieval, they can refer to the risk sources and events that have occurred in similar projects to identify potential risks. Next, the staff can analyze the likelihood and impact of a certain risk by calculating the ratio of occurrence number and the total number of similar projects as well as the ratio of cost loss and project budget. Then, they can generate a set of response measures by referring to the selected measures and the recommendations for measures in similar projects. These measures would usually be practical and effective since they had been implemented and reviewed before (Chua & Goh, 2004). Finally, the RCM_ICP facilitates the improvement of response measures for

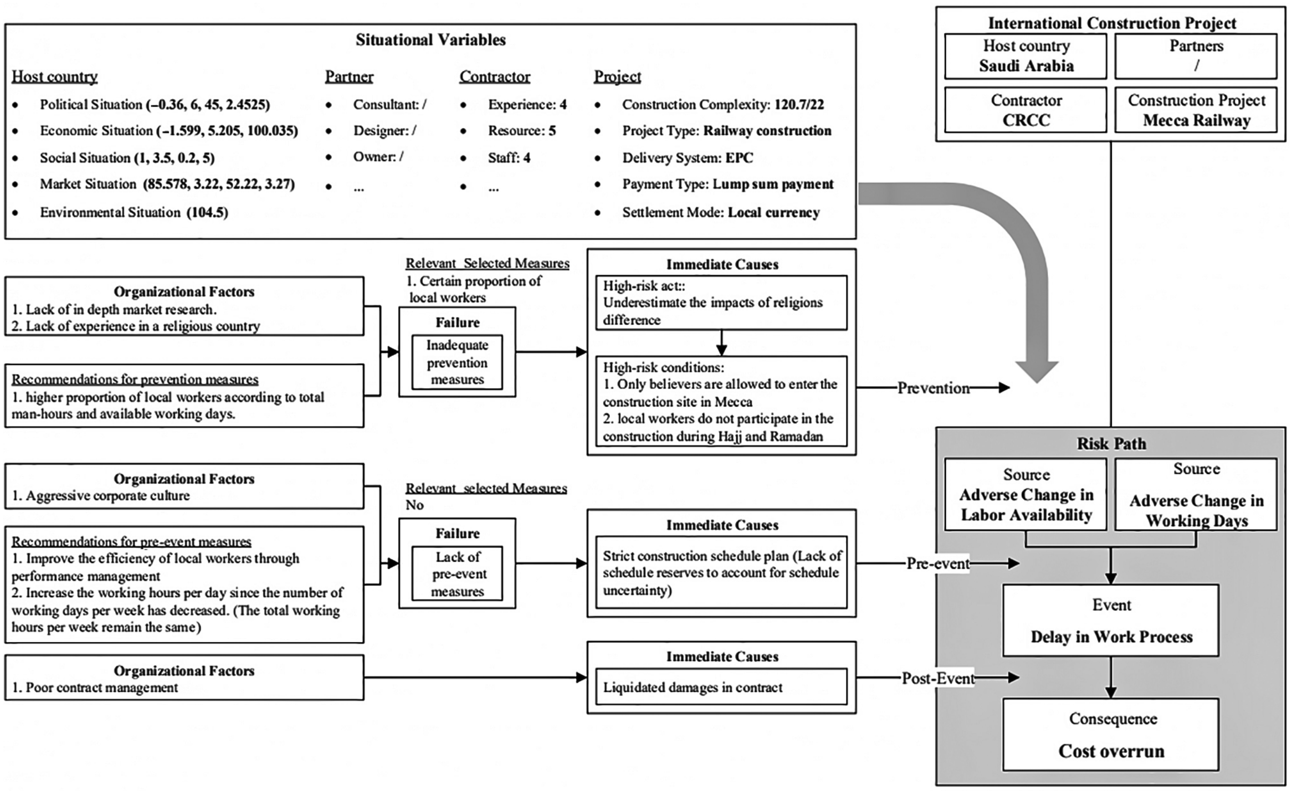

Figure 4. Application of the RCM_ICP

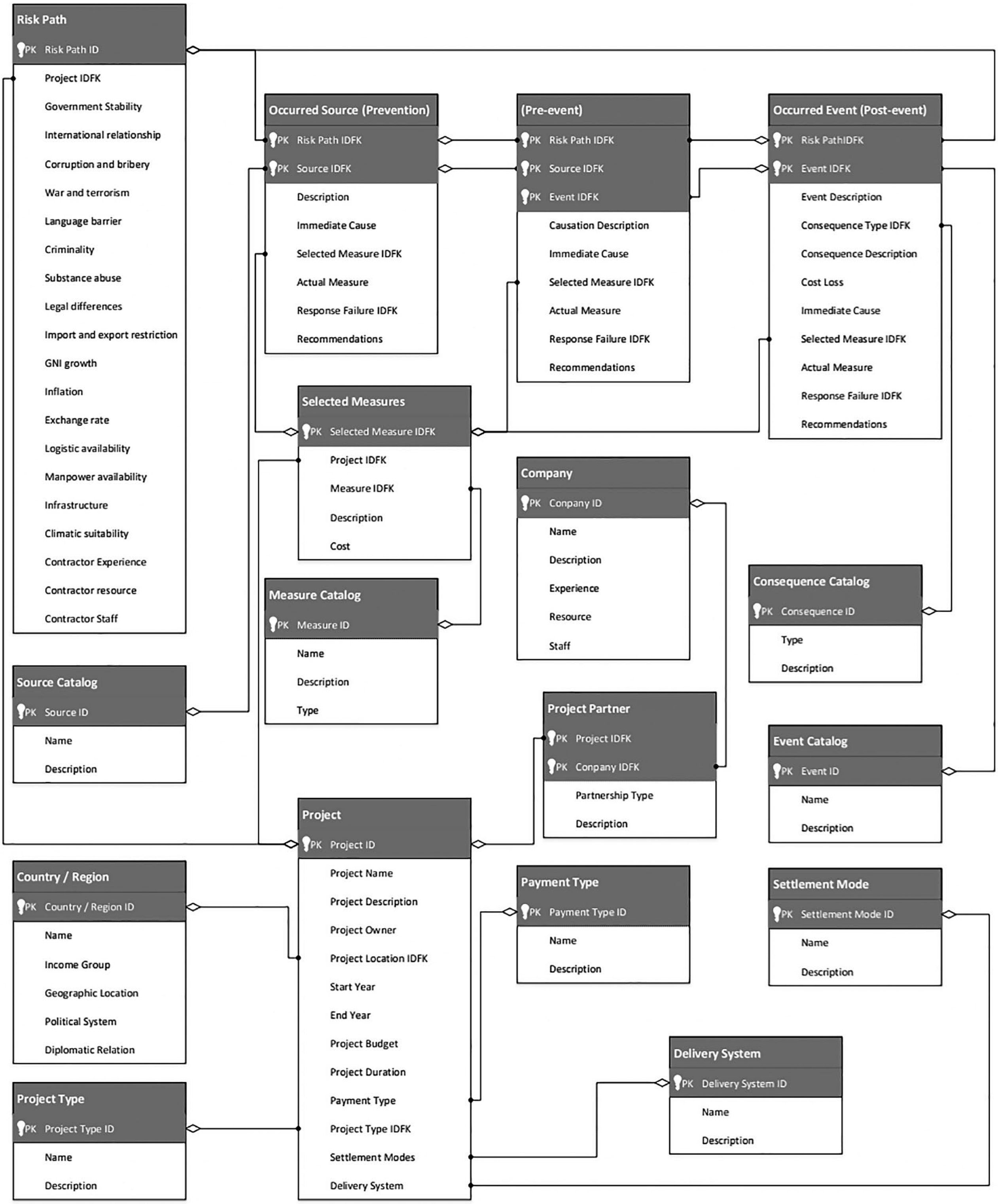

Figure 5. Embedded RCM_ICP in the structure of the company's risk repository

the current project during risk monitoring once again. In this way, the risk repository will continuously accumulate new experiences and facilitate the improvement of risk management at the organization level.

The senior management of the company is satisfied with the improved risk repository and the risk management process. They mention that the project managers used to blame the occurred risk events and their consequences on the nation differences or incompetent local workers. RCM_ICP identifies "failure of response measures" as the fundamental cause of risk propagation, The project managers have to end each risk review with an examination of the response measures that were formulated by themselves. This promotes proactive thinking on the part of the management, which in turn contributes to capturing knowledge. Besides, RCM_ICP facilitates feedback of risk-related knowledge through the improved risk management process. The project manager can obtain a reference for the risk management process by creating new projects and retrieving similar projects in the repository. In exchange, they are relatively more willing to record the risk management process and its outcomes in the repository. This case study confirmed that the application of RCM_ICP can facilitate knowledge feedback and improve the quality of the organizational risk repository.

Conclusions

This research proposes a risk causation model for international construction projects (RCM_ICP) to capture and transfer risk knowledge, aiming at improving risk management at both the project level and the organization level. The proposed model links the response measures to the risk path by considering the failure of response measures as the cause of the risk propagation. Hence, each time a risk event occurs, the effectiveness of response measures

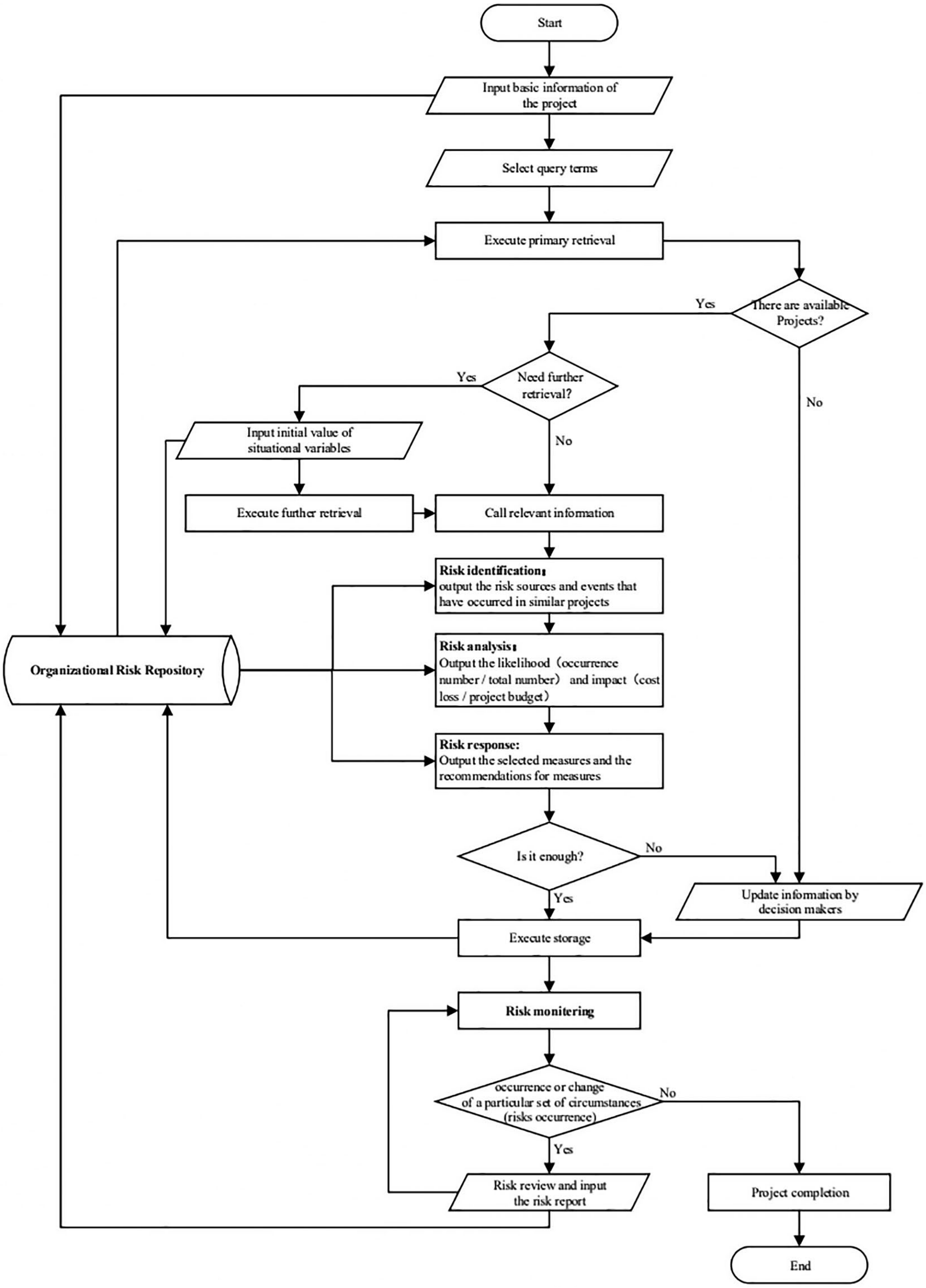

Figure 6. Risk management process coupled with the organizational risk repository

will be examined and improved. In this case, it contributes to dispelling the organizational culture of unwillingness to disclose management failure and capturing key experiences on how specific risks can be managed. The component "situational variables" is included as a catalog for effective identification and efficient retrieval, which is quite valuable for reusing relevant knowledge. Furthermore, RCM_ICP emphasizes the impact of the incompetence of the organization and promotes the identification of organizational factors to enhance organizational learning. This paper also proposed the risk review procedures to illustrate the usage of RCM_ICP. Therefore, this research breaks the barriers of sharing information between project and organization levels in a project-based industry, thereby improving the quality of the organizational risk repositories and enhancing its practicability.

It is noted that risk review should be used as a reactive method because the occurrence of risks might result in highly undesirable losses or damage. The limitation of this research is that it failed to provide a proactive way to capture risk-related knowledge. In addition, the further work of this research is to optimize the data model of the organizational risk repository. Considering the complex relations among risk-related concepts, a graph database like Neo4j might be a better choice than a relational database.

Acknowledgements

The authors express their sincere gratitude to China International Contractors Association (CHINCA) for assistance in conducting group discussions. They also appreciate the project managers of the anonymous construction companies for valuable and useful information.

Disclosure statement

The authors do not have any competing financial, professional, or personal interests from other parties.

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