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A Guide for Risk Management in Construction Projects: Present Knowledge and Future Directions

Pinar Irlayici Cakmak and Ecem Tezel

Abstract

Construction projects are well known to be prone to a high level of risk that cannot be ignored but can be managed. Researchers have studied numerous aspects of risk management including identification, analysis/assessment, response and control. Despite the fact that studies focused on risk management in construction projects have been increasing, there seems to be a limited number of published studies that summarize what has already been presented in the literature. In this regard, this chapter aims to present the existing literature on risk management from a holistic perspective and provide a guide for future directions. With this aim, a systematic literature review has been undertaken by presenting the areas focused on by researchers as well as neglected ones, by indicating the trends in research through the years and by discussing research gaps for potential studies.

Keywords: construction projects, future directions, research trends, risk management, systematic review

1. Introduction

Construction projects involve participants from different specialties working together which makes the cooperation among them designed around extensive, disparate and interrelated processes [1]. Such complexity is also increased by other external factors such as political, legal, cultural, technological and financial, which resulted in project risk. Project Management Institute (PMI) defines project risk as “an uncertain event or condition that, if it occurs, has a positive or negative effect on a project objective. ... there will be a consequence on the project cost, schedule, or quality” [2]. Due to the increasing size and complexity, a wide variety of risks impact the successful completion of the construction projects. In other words, risks are threats to project success [3]. Despite trying to eliminate all the risks in construction projects is impossible, a formal risk management process is required to manage them effectively [4].

In this regard, a systematic risk management process can help construction companies to identify not only the involved risks of projects but also to mitigate impacts of those uncertainties in different phases of projects [5]. The term “risk management” can be broadly defined as work that classifies, analyses and responds to unpredictable risks that exist in the processes of project implementation [6]. Risk management is about defining sources of uncertainty (risk identification), estimating the consequences of uncertain events/conditions (risk analysis), generating response strategies in the light of expected outcomes and, finally, based on the

feedback received on actual outcomes and risks emerged, carrying out identification, analysis and response generation steps repetitively throughout the life cycle of a project to ensure that the project objectives are met [7]. Briefly, a traditional risk management process consists of risk identification, risk analysis or assessment, risk response or mitigation and risk monitoring and control [2, 8].

The initial step of risk management is risk identification. Risk identification is the process of identifying individual project risks as well as sources of overall project risk and documenting their characteristics [2]. Although it is difficult to define and measure, it is very important to identify potential risks as early as possible. In order to manage risks properly, risk identification should be performed along with the project's initiation stage. Construction companies usually benefit from risk checklists [9, 10] and risk breakdown structures [9, 11, 12] for the identification.

Risk analysis/assessment is the process that focuses on evaluating and seeking the likelihood in which potential risks in the risk identification stage may occur [13] and it is implemented by two approaches: qualitative risk analysis and quantitative risk analysis. In qualitative risk analysis process, the main focuses are rating and prioritizing individual project risks for further analysis or action by assessing their probability of occurrence and severity of consequence/impact as well as other characteristics [2, 14]. On the other hand, quantitative risk analysis process focuses on numerically analyzing the combined effect of identified individual project risks and other sources of uncertainty on overall project objectives [2]. Researchers employed Delphi [15–17], AHP/fuzzy AHP [10, 17–23] and Monte Carlo simulation [24–26] to assess risks in their studies.

Risk response process consists of developing options, selecting strategies and agreeing on actions to address overall project risk exposure, as well as to treat individual project risks, and finally implementing agreed-upon risk response plans [2]. Dealing with negative consequences, risk response is also referred to as risk mitigation, risk elimination, risk prevention and risk reduction [8]. Appropriate risk response strategies must be selected to reduce risk exposure once the risks have been identified and analyzed [27]. Researchers widely agree that the selection of risk response strategy is an important issue in project risk management [28–30]. These strategies are avoiding, reducing or accepting project risks.

Risk monitoring and control process is the process of monitoring the implementation of agreed-upon risk response plans, tracking identified risks, identifying and analyzing new risks and evaluating risk process effectiveness throughout the project [2]. This step ensures that all information generated by risk management process is captured, used and maintained throughout the construction period [31].

The subject of risk management in construction projects has been increasingly studying since the 1980s. Most of these studies have focused on how risks are identified or analyzed/assessed in different countries such as Australia [32, 33], China [23, 34, 35], Ghana [36], Hong Kong [37, 38], India [39, 40], Indonesia [41, 42], Italy [43], Korea [44], Malaysia [31, 45], Mexico [46], New Zealand [47, 48], Nigeria [49, 50], Poland [51], Singapore [52, 53], Spain [54], Sri Lanka [55], Tanzania [56], the United Kingdom [57, 58], the United States of America [59, 60], Vietnam [61, 62] and Zambia [63]. These studies mostly used survey/interviews or case studies. Additionally, researchers proposed that various theoretical and mathematical models are also proposed for managing risks effectively and efficiently.

While literature is rich in papers addressing risk management in construction projects, few papers have researched what has already been presented. Edwards and Bowen's [64] research is one of the exceptional studies which analytically reviews the construction risk literature over the period from 1960 to 1997. Given that two decades have passed since then, it is appropriate to review the progress in risk

management research in construction. In this regard, this paper aims to analyze current literature and provide a guide for future studies on risk management in construction projects.

2. Research methodology

To review the risk management literature comprehensively, a twofold procedure was adopted in this study. At first, a systematic literature review was conducted to identify the key scientific contributions in the risk management domain. The findings of the review, then, were statistically synthesized through a meta-analytical approach which is an associated procedure of systematic literature review.

Systematic literature review adopts a replicable, scientific and transparent process that aims to minimize bias through exhaustive literature searches of published studies [65]. On the other hand, meta-analysis helps to analyse these studies by interrelating focused areas and identifying emerging or neglected themes [66].

In this regard, this study has been organized in two stages represented in **Figure 1**.

2.1 Stage 1: systematic literature review

The first stage concentrates on searching for relevant papers using scientific databases, namely, American Society of Civil Engineers (ASCE), Elsevier, Emerald and Taylor & Francis. From these databases, relevant papers were searched in the following construction and built environment-related journals: Automation in Construction (AC), International Journal of Project Management (IJPM), Journal

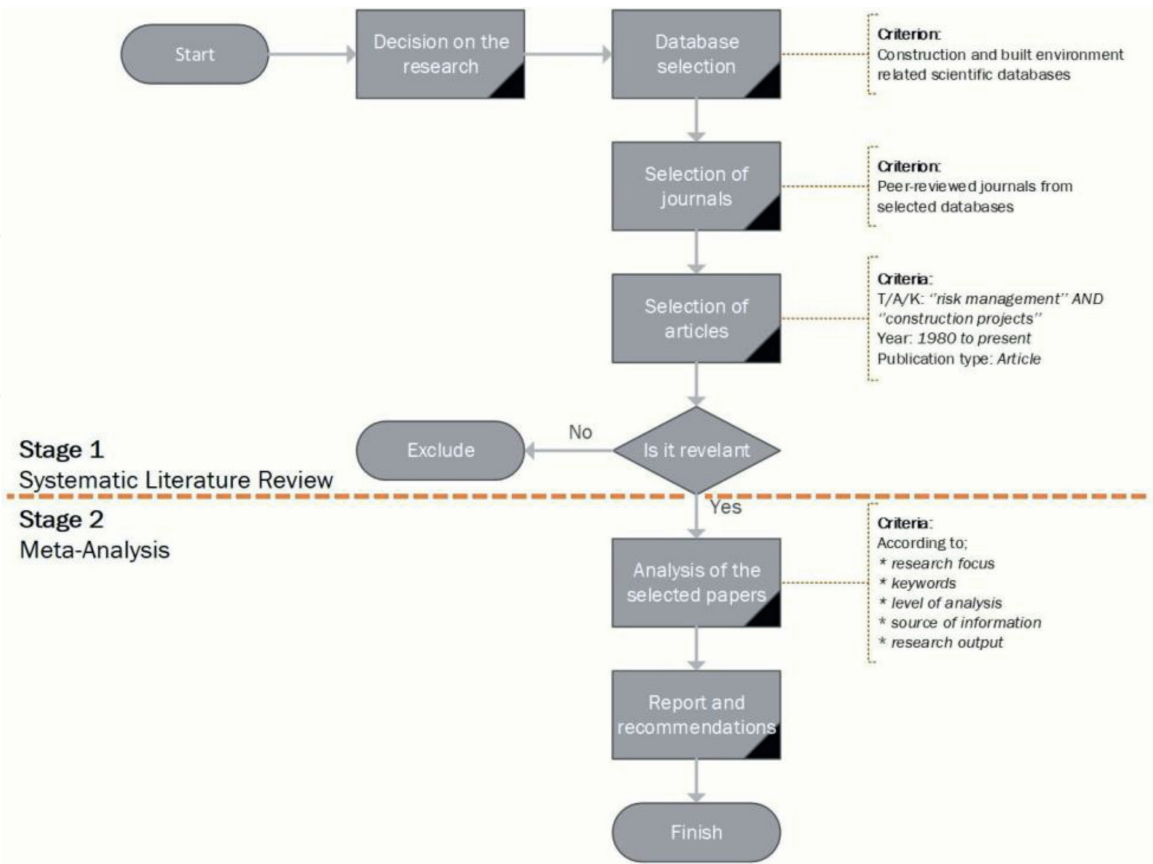


Figure 1.
Stages of the systematic literature review.

of Cleaner Production (JCP), Architectural Engineering and Design Management (AEDM), Construction Management and Economics (CME), International Journal of Construction Education and Research (JCER), International Journal of Construction Management (IJCM), Journal of Civil Engineering and Management (CEM), Journal of Construction Engineering and Management (JCEM), Journal of Management in Engineering (JME), Journal of Legal Affairs and Dispute Resolution in Engineering and Construction (LADR), Journal of Professional Issues in Engineering Education and Practice (PEEP), Journal of Architectural Engineering (JAE), Engineering Construction and Architectural Management (ECAM), Construction Innovation (CI), Journal of Financial Management of Property (JFMP), Facilities (F), Built Environment Project and Asset Management (BEPAM), Journal of Facilities Management (JFM), International Journal of Building Pathology and Adaptation (JBPA) and Management Decision (MD).

The keywords for searching were designated as “risk management” and “construction projects,” and these keywords were searched in title/abstract/keyword fields of the selected journals in the time period between 1980 and 2018. At this point, a total of 471 papers, excluding book reviews, forums and editorials, were retrieved for further analysis. Eventually, 247 papers were considered as the most relevant to the research aim and were subject to a detailed review.

2.2 Stage 2: meta-analysis

In the second stage, a meta-classification framework, adopted from Betts and Lansley [66], was designed as presented in **Table 1**. Accordingly, the framework has nine categories, such as year, scientific database, journal, keyword, research focus, level of analysis, source of information, research output and future directions with their related subcategories.

Category	Subcategory
Year	Publication date of the article
Scientific database	ASCE, Elsevier, Emerald, Taylor & Francis
Journal	Name of the journals
Keyword	“Risk management” and “construction projects”
Research focus	Risk identification Risk assessment/analysis Risk evaluation Risk response Risk monitoring and control
Level of analysis	Project level Firm level Sector level
Source of information	Review Case study Survey/interview
Research output	General insights and descriptions Statistical results Theoretical model Mathematical model Experimental/prototype model
Future directions	Future research identified in the articles

Table 1.
Research framework.

The 247 papers were analyzed according to this framework and classified by one of these subcategories. In some cases, a paper may be classified in multiple subcategories, resulting in the sum of the papers distributed among the subcategories exceeding the number of papers analyzed.

3. Data analysis and results

Risk management in construction projects was analysed according to the meta-classification framework given in **Table 1**. It is found that 247 papers have been published on “risk management” in the specified time period in the widely accepted construction and built environment-related peer-reviewed journals.

Table 2 shows the chronological distribution of the selected papers by a 5-year time period. Accordingly, risk management subject shows an increasing tendency over the years. In addition, half of these papers have been published in the ASCE’s Journal of Construction Engineering and Management.

Table 3 presents the research focus of the published papers over the years. As given in **Table 3**, research focus was classified into ten categories. These categories include four processes of risk management and their multiple combinations. It is noticeable that researchers studied the risk management subject whether discussing

Database	Journal	≤1995	1996–2000	2001–2005	2006–2010	2011–2015	>2015
Elsevier	AC				3	4	
	IJPM	1	1	2	4	4	1
	JCP						3
Taylor & Francis	AEDM				1	1	1
	CME	1	4	2	6	2	
	JCER				1	1	
	IJCM			1	1	4	5
	CEM				1	6	3
ASCE	JCEM	6	9	12	27	29	23
	JME			1	2	11	11
	LADR						2
	PEEP		2		3	2	
	JAЕ		1				
Emerald	ECAM		3	3	2	6	6
	CI						2
	JFMP				4		1
	F					1	2
	BEPAM					2	1
	JFM			1	1	4	1
	JBPA			1			
	MD			1			
Total		8	20	24	56	77	62

Table 2.
Distribution of the selected papers within the time span.

	≤1995	1996– 2000	2001– 2005	2006– 2010	2011– 2015	>2015	Total number of papers within time span
RI	1	2	3	8	10	14	38
RA	3	7	11	21	28	23	93
RR		2		4	6	4	16
RMC					3	1	4
RI+RA		3	4	6	12	9	34
RI+RR	1	1	1	3	2	1	9
RA+RR			1	1	2	3	7
RA+RMC						1	1
RI+RA+RR	1	2		5	2	3	13
RI+RA+RR+RMC	1	4	4	8	12	3	32

RI: risk identification, RA: risk analysis/assessment, RR: risk response, RMC: risk monitoring & control.

Table 3.
Analysis of selected papers according to the research focus.

one of the processes, such as risk identification, risk analysis/assessment, risk response and risk monitoring and control, or examining them through a holistic approach. Despite most of the papers focused only on risk analysis/assessment, a considerable amount of papers studied other risk management processes together with risk analysis/assessment subject. Besides, risk response and risk monitoring and control seem to be neglected processes of risk management. Recently, it is seen that these processes have started to be mentioned in risk management-related researches. Still, they do not have similar impact in the construction risk management literature compared with risk identification and risk analysis/assessment processes.

Most commonly used keywords in the analyzed papers are given in **Table 4**. It is not surprising that “risk management” keyword has the largest rate with 28.9%. The second highly rated keyword is risk (financial, political, design, economic, social, legal, safety) with the rate of 23.8%. This is followed by other keywords such as construction management/project management (11.6%), risk assessment including risk prioritization, risk score and risk rating (11.2%); risk analysis (6.0%); risk identification including checklist, risk mapping and risk breakdown structure (5.8%); cost-related issues (4.7%); risk allocation/distribution (2.0%); risk modeling (1.3%); risk response (1.1%); risk control (0.6%); risk mitigation (0.6%); risk perception/attitude (0.6%); risk strategy (0.4%); risk interruptions (0.2%); risk paths (0.2%); and risk propagation (0.2%).

The papers are analyzed according to the study levels as project level, firm level and sector level. **Figure 2** shows the distribution of these levels within the time span. As seen in **Figure 2**, the majority of the papers are studied in the project level. This is resulted from researchers mostly focused how risk is managed within a construction project rather than concentrating on the risks and their effect within a construction company or in the construction sector. Especially beginning with 2006, a huge focus has given to construction risk management studies at the project level. However, there are few studies which concentrate risk management related issues by discussing them through the firm and sector level.

Different sources of information are used in the analyzed papers which were classified as case studies, survey/interviews and reviews. As illustrated in **Figure 3**, among these, case studies and survey/interviews are the leading sources. After 2005, case studies and survey/interviews show a rapid increase. This reveals that secondary data and data collected from sector professionals are the main sources of information

Keywords	Number of papers	Frequency (%)
Risk management	129	28.99
Risk	106	23.82
Construction management/project management	52	11.68
Risk assessment	50	11.23
Risk analysis	27	6.06
Risk identification	26	5.84
Cost related issues	21	4.71
Risk allocation/distribution	9	2.02
Risk modeling	6	1.34
Risk response	5	1.12
Risk control	3	0.67
Risk mitigation	3	0.67
Risk perception/attitude	3	0.67
Risk strategy	2	0.44
Risk interruptions	1	0.22
Risk paths	1	0.22
Risk propagation	1	0.22

Table 4.
Analysis of selected papers according to the keywords.

in the analyzed papers. On the other hand, reviews are relatively less preferred information source for risk management researches.

The main outputs of the papers are shown in **Figure 4**, which were classified into five categories as general insights and descriptions, statistical results, theoretical model, mathematical model and experimental/prototype model. The main contribution is statistical results followed by mathematical model. Since most of the papers adopted a research methodology based on case studies and survey/interviews, it is reasonable that the research output shows a high tendency in statistical

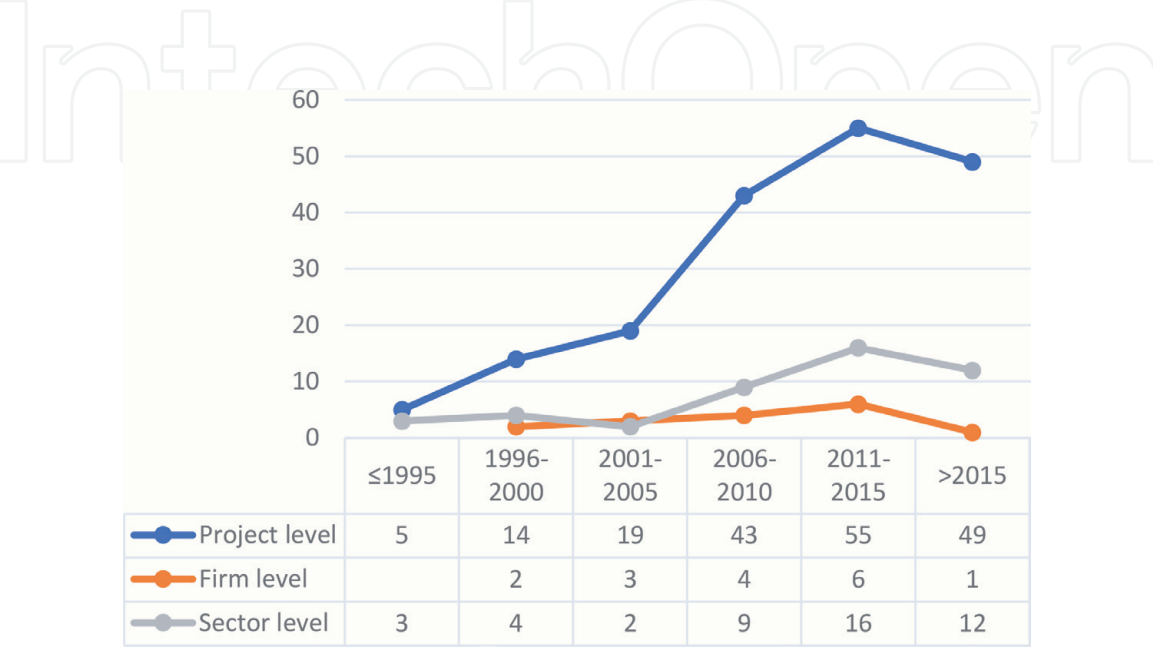


Figure 2.
Analysis of selected papers according to the level of analysis.

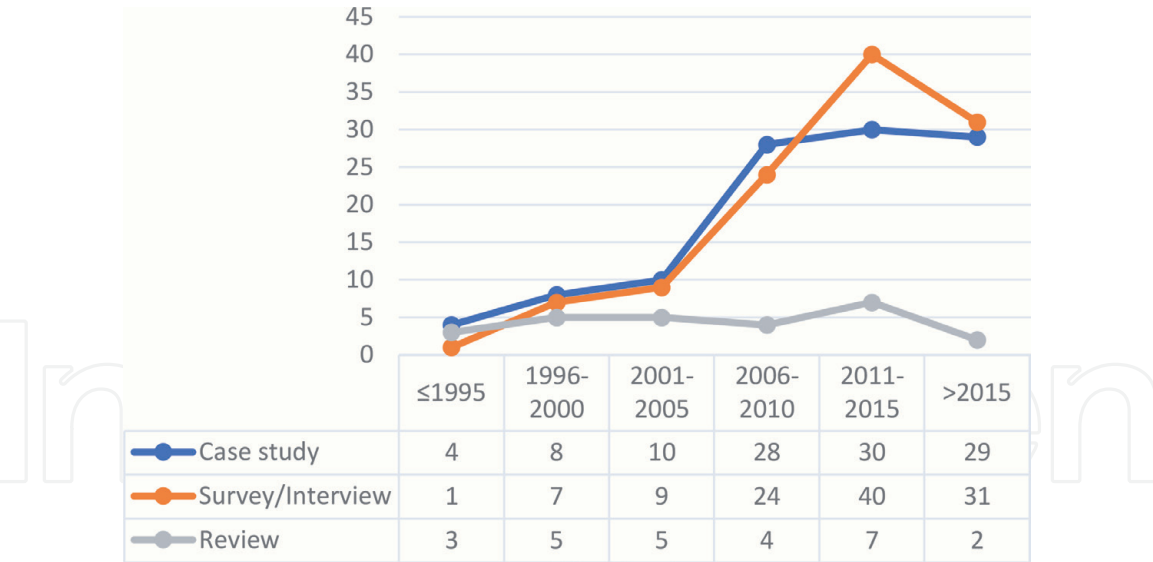


Figure 3.
Analysis of selected papers according to the sources of information.

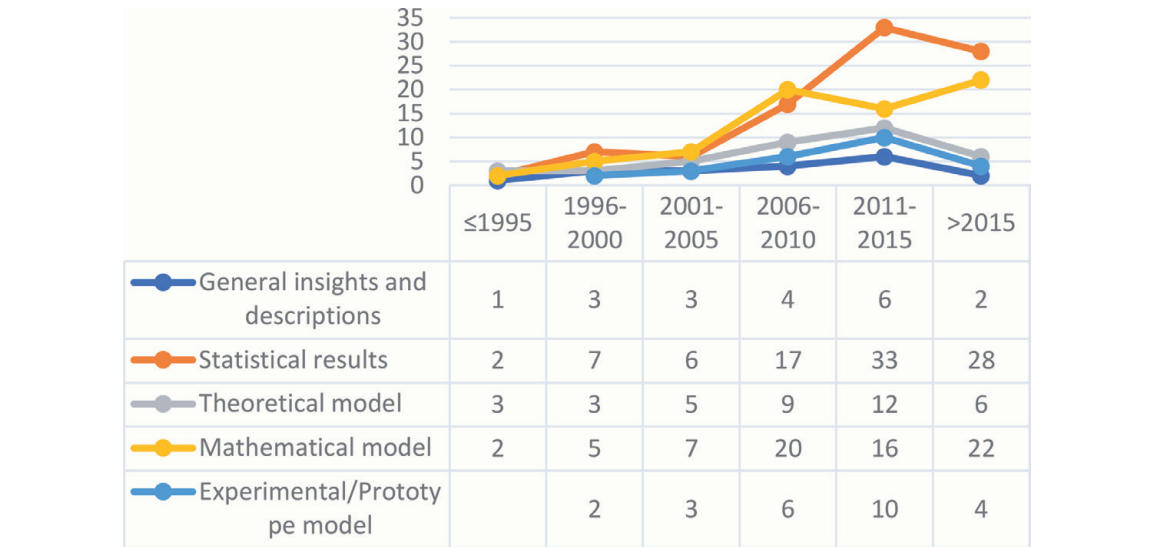


Figure 4.
Analysis of selected papers according to the research output.

results. General insights and descriptions, theoretical models and experimental/prototype models are less adopted methodologies compared with other ones.

4. Conclusion

No construction project is risk-free: risk can be managed, minimized, shared, transferred or accepted; but it cannot be ignored [67]. Construction companies should adopt an appropriate risk management approach not only to complete their projects in compliance with their project objectives but also to keep their competitiveness in the construction industry. Although researchers have drawn huge attention on every step of the risk management process, in this chapter, it is aimed to present the state-of-the-art literature by analyzing research contributions in the risk management domain.

Despite risk management subject found in the literature has reached saturation point, construction researchers have still been studying different aspects of risk management through implementing various research methodologies. A majority

of these researches concentrated on one of the risk management processes that is found in risk identification and risk analysis/assessment. On the other hand, the remaining processes of risk management, namely, risk response and risk monitoring and control, are seemed to be neglected.

In the review, highly mentioned risk-related keywords are revealed as risk management; various risk types; construction management/project management; risk assessment including prioritization, risk score and risk rating; risk analysis; risk identification and its methods such as checklist, risk mapping and risk breakdown structure; cost-related issues; risk allocation/distribution; risk modeling; risk response; risk control; and risk mitigation, respectively. As the results showed that risk response and risk monitoring and control are disregarded areas, their related keywords are less mentioned than the other ones.

Since researchers focused how risk is managed within a construction project instead of concentrating on the risks and their effect within a construction company or in the construction sector, a huge number of papers deal with risk management at the project level. Accordingly, studies on risk management at the firm level and sector level seem to be neglected. Besides, as much of the risk management researches in the past decades focused on identification and analysis/assessment of risks within a particular construction project, they mostly adopted survey/interview and case study approaches. This case has resulted in frequent appearance of statistical results as the main research outputs.

To conclude, the review has confirmed that the researchers are directed only on the first two steps of risk management process. In addition to these directions, future studies should also discuss risk response and risk monitoring and control which are the remaining ones. Besides, it is revealed that the literature lacks a comprehensive risk management process. Future studies should adopt a holistic perspective which addresses the risk management process by identifying, analyzing/assessing, responding and monitoring and control from initiation to the completion of construction projects. Similarly, future studies should be directed to risk management-related issues by discussing them at the firm and sector level as well. This systematic review is expected to contribute to the construction profession by enlightening the research gaps in the literature and by providing future directions for potential studies.

Conflict of interest

The authors of this book chapter declare no “conflict of interest.”

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