

# Towards a better modelling and assessment of construction risk: Insights from a literature review

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## Abstract

This paper reviews the literature of construction risk modelling and assessment. It also reviews the real practice of risk assessment. The review resulted in significant results, summarised as follows. There has been a major shift in risk perception from an estimation variance into a project attribute. Although the Probability–Impact risk model is prevailing, substantial efforts are being put to improving it reflecting the increasing complexity of construction projects. The literature lacks a comprehensive assessment approach capable of capturing risk impact on different project objectives. Obtaining a realistic project risk level demands an effective mechanism for aggregating individual risk assessments. The various assessment tools suffer from low take-up; professionals typically rely on their experience. It is concluded that a simple analytical tool that uses risk cost as a common scale and utilises professional experience could be a viable option to facilitate closing the gap between theory and practice of risk assessment.

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*Keywords:* Construction; Literature review; Project management; Risk assessment; Risk assessment practice; Risk cost; Risk modelling

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## 1. Introduction

“No construction project is risk free. Risk can be managed, minimized, shared, transferred or accepted. It cannot be ignored” (Latham, 1994, p.14). The construction industry is often considered as a risky business due to its complexity and the strategic nature of its products. It involves numerous stakeholders, long production duration and an open production system, entailing significant interaction between internal and external environments (BSI-6079-4, 2006). Such organisational and technological complexity generates enormous risks (Zou et al., 2007). Unfortunately, the construction industry has a poor reputation in risk analysis when compared with other industries such as finance or insurance (Laryea, 2008). Although every step of a risk management process has received huge attention from researchers, it seems that risk assessment is a controversial issue (Baloi and

Price, 2003). Traditionally the focus has been on quantitative risk assessment (Tah and Carr, 2001) despite the difficulties encountered in obtaining objective probabilities, and frequencies, in the construction industry. This difficulty stems from the fact that construction projects are very often one-off enterprises (Flanagan and Norman, 1993). This reality is a key driver behind the obligation of project managers being to rely on subjective probabilities as Winch (2003) concluded. In fact, risk in many cases is subjectively dealt with through adding an approximate contingency sum (Kangari and Riggs, 1989). Therefore, individual knowledge, experience, intuitive judgement and rules of thumb should be structured to facilitate risk assessment (Dikmen et al., 2007b).

Risk assessment is inherently related to risk modelling. The Probability–Impact (P–I) risk model is prevailing and risk is usually assessed through assessing its probability of occurrence and impact. However, the P–I risk model was subject to criticism from researchers who discussed potential improvements in it. Moreover, researchers have investigated different theories, tools

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and techniques for aiding risk assessment. Unfortunately, there is a clear gap between the theory and practice of risk modelling and assessment. Hence, it is of crucial importance to understand the actual practice of risk analysis and review the development of construction risk modelling and assessment in an attempt to research viable alternatives that may contribute to closing this gap. This paper presents the result of an extensive review of the published literature of construction project risk modelling and assessment in English. The research focused mainly on peer-reviewed articles published in academic journals specialised in construction management, project management, risk analysis, and management science. The following databases were utilised for researching relevant papers: Science Direct, Web of Science, ABI-Inform (Proquest), Business Source Premier (EBSCO), Emerald, and Sage Management & Organization Studies. To further support reviewing the published literature, the Google Scholar search engine was deployed. The following key words were used in the search: project risk, construction risk, risk analysis, risk assessment, risk modelling, and risk management. These words were used after discussing them with research colleagues. However, different combinations of them were used to validate the extensiveness of the search results. Moreover, other key words were tried to investigate any differences in the search results such as: risk model, risk modelling, uncertainty analysis, and project uncertainty. Besides computerised search, manual bibliographic search was also used. In many cases, reviewing the papers helped in identifying related papers. The review process took place between October 2008 and August 2009. However, regular search activities have been conducted since then to keep the review results updated. The search targeted all of the available articles in the databases in order to review the historical development of risk modelling and assessment. Hence, there was no time restriction when searching the databases. As a result, around 400 articles were reviewed. Eventually, 68 ones were considered as most relevant to the research aim and were subject to a detailed review. These papers, detailed in [Appendix \(A\)](#), cover the last three decades of project risk modelling and assessment history. To be included in the final list, papers had to meet the following criteria: 1) provide a methodology for assessing project risk; 2) use specific theory or technique for assessing risk; 3) present an attempt to improve project risk modelling; and 4) relate to construction or project management domain. In the next section of the paper, a chronological review of these 68 papers is provided. Later, the paper analyses and the results of the literature review will be discussed to enable eliciting the main themes and developmental trends. After that, a review of the actual practice of risk analysis is displayed in order to complement the review results and to enable defining the characteristics of practical alternatives. The paper ends with a summary of the key findings and conclusions.

## 2. Literature review

Risk analysis in construction industry is not new. It has its roots since the development of the Program Evaluation and Review Technique (PERT) in the 1950s for tackling uncertainty in project duration. Conventionally, risk has been dealt with as an

estimation variance benefiting from the dominance of Probability Theory (PT). In the 1980s, however, risk began to be perceived as a project attribute and Risk Management (RM) became a well-established project management function. During the 1990s researchers investigated different theories to account for the special nature of construction risk, and after the beginning of the new millennium risk assessment flourished as a hot research topic.

### 2.1. Before the 1980s

Although the origins of risk analysis can be traced back to as far as 3200 BC ([Baker et al., 1999b](#)), risk had not appeared in construction literature until 1960s ([Edwards and Bowen, 1998](#)). [Baker et al. \(1999b\)](#) argued that the term “risk analysis” was used for the first time by [Hertz \(1964\)](#) who utilised the computer for generating probability distributions of investment projects rates of return. Reviewing literature reveals that risk analysis publications started in the USA where risk was considered implicitly when researching other problems like bidding and cost and duration estimation. Risk was modelled as an estimation variance and RM was perceived as a way of reaching more accurate estimates during the tendering stage. According to [Edwards and Bowen \(1998\)](#), statistical methods were initially used before employing Monte-Carlo Simulation (MCS) during the 1970s. Despite the dominance of the probabilistic methods and MCS, the dearth in risk analysis publication is very evident in that era; very few articles about risk analysis can be referred to like [Carr \(1977\)](#), [Friedman \(1956\)](#), [Gates \(1960, 1967, 1971\)](#), [Gates and Scarpa \(1974\)](#), [Morin and Clough \(1969\)](#), and [Spooner \(1974\)](#). Regarding risk management, it was the end of the 1970s when project RM started to become an essential component of project management ([Merna and Al-Thani, 2008](#)). Actually, reviewing the literature reveals that the beginning of the 1980s is the actual start of perceiving RM as an independent project management function and research domain.

### 2.2. The 1980s

In the 1980s PT-based tools and MCS continued to dominate risk assessment. However, Fuzzy Sets Theory (FST) was introduced at the end of this decade as a viable alternative for tackling subjectivity in construction risk assessment. [Chapman and Cooper \(1983\)](#) presented one of the earliest attempts to structure project risks and, systematically, identify their sources. They introduced the “risk engineering” approach, which integrated different tools and techniques like PERT and decision trees, for combining risk events and producing probability distributions of activities and project durations. Hence, risk was modelled as a distribution variance of an activity or project duration. [Diekmann \(1983\)](#), however, modelled risk as a variation of cost estimation. He reviewed different tools used for producing a probabilistic estimate of project cost and used MCS for such a purpose. Contrary to the previous two papers, [Barnes \(1983\)](#) modelled risk as probability and impact (P-I) with risk impact defined as a variance in cost estimate. In a subsequent paper, [Cooper et al. \(1985\)](#) presented a method for assessing project cost risk. A hierarchical risk breakdown structure was

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