Risk Definition for Construction: Risk, Uncertainty, Hazard, Opportunity

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Abstract

Risk in construction processes results in deviation from a project's objectives, causing time and cost overruns, safety issues, quality deficiencies, technical problems and a lack of client satisfaction. To solve these problems, this paper reviews the current definition of risk, uncertainty, hazard, and opportunity through a literature review. Flowcharts for risk identification are developed in the construction project process. This research also indicates that opportunities come from uncertainty, which could be transferred to risk. These findings provide a valuable reference for the construction manager to understand the major differences between risk, uncertainty, hazards, and opportunities. These findings could help the main author develop PhD research in offsite construction risk management methodologies, especially those parts related to the identification of risk.

Keywords: construction process, risk, uncertainty, hazard, opportunity.

1. Introduction

During the construction process, any small decision for change may cause risk. As wrong assessments and misjudgements may cause the process to pause or fail, it is necessary to continuously manage and monitor risk.

During the last five years, UK construction has seen a stable increase (see Figure 1). The increasing demands of construction have promoted the demand for construction risk management. Due to the increasing complexity and interrelation of construction methods, current construction risk is very hard to eliminate, and it may transfer or be shared from one party to another through contractual clauses (Andi, 2006).

Figure 1: UK construction output (tradingeconomics, 2018)

In 2017 in England, the Grenfell Tower fire caused 71 deaths and over 70 injuries due to the type of cladding that had been applied during refurbishment of the building; thus, a lack of construction risk management contributed to the tragedy (Madden, 2017).

Offsite construction has been proved to have benefits in terms of reducing risks for construction projects (Venables *et al.*, 2004). It provides an effective alternative to traditional construction that improves benefits for all stakeholders in the construction process (Pan *et al.*, 2012). However, many articles report that time overruns (Arashpour & Arashpour, 2015), cost overruns (Nasirzadeh *et al.*, 2014), safety issues (Wang & Yuan, 2011) and quality problems (Zeng *et al.*, 2007) still occur in offsite construction processes. Little research has been done into the difference between risk and uncertainty in offsite construction processes.

As construction projects have become more uncertain and complex, the demand for risk management methodologies has increased (Kangari & Riggs, 1989). Despite the high demand for construction risk management, the definition of construction risk remains unclear and is easy to confuse with uncertainty. In the current situation, the construction industry may have worse risk management than other industries (Laryea & Hughes, 2008). Taroun (2014) identified that definitions are needed, not only for the risk management process, but also for construction risk in general.

This research fills the gap in the literature regarding the lack of a clear definition of risk within the context of construction risk management. In order to provide a complete understanding of the basis of construction risk, conceptual and empirical papers that define construction risk, but and also those that deal with synonyms and antonyms of risk (unreality, hazard and opportunity) are classified. However, the main analysis of this research is focused on the risk definition, and highlights the uniqueness of risk.

To reach the goal of this research, a variety of literature has been reviewed. This research focuses on literature that explicitly classifies and defines construction risk, uncertainty, hazards, and opportunities. Each section includes the history, definition and features of each phase, and several frameworks are developed for their comparison. This argument provides effective solutions for risk identification. As the author's thesis focuses on offsite construction risk management methodology definition and analysis, and risk must be identified and classified before risk management can be applied, this solution could help the author to define the risks of offsite construction and prepare for risk management methodology development.

2. Risk

After the Second World War, risk management underwent a significant improvement (Chapman & Ward, 2003). Many project management textbooks now contain definitions of project risk. A consensus of opinion of risk can be taken from the *Guide to the Project Management Body of Knowledge* (PMBOK), which defines risk as 'an uncertain event or condition that, if it occurs, has a positive or negative effect on a project objective' (PMI, 2017). In UK, a similar official risk management book called the *Project Risk Analysis and Management Guide*, developed by the Association for Project Management (APM), defines risk as 'an uncertain event or set of circumstances which, should it occur, will have an effect on achievement of the project's objectives'(Bartlett, 2004).

2.1 Risk is occurrence- or event-based

Jablonowski (2006) defined risk as the chance or likelihood of events with negative consequences, such as injury or loss. Busby and Zhang (2008) agreed with this opinion, and emphasised project risk as the statistical concept of the probabilities and consequences of threatening conditions and events, bases on the project event and having either positive or negative influence. Construction risk could be

financial, technical, political or organisational, and may have internal, external or project influence for construction projects (Zhang *et al.*, 2017). All risks must have at least one source and one subsequent event which may occur as a result of that underlying state of affairs (Winch, 2010).

2.2 Risk is quantifiable and solvable.

Cervone (2006) defined risk through a simple and understandable question: 'What are the problems I might encounter while performing this project and how do I avoid them?' This means that risk must be quantifiable and solvable. Many risk identification tools have been developed based on this assumption: for example, brainstorming, interviews, checklists, scenario analysis, and fault tree analysis. However, most risks that have caused serious consequences have not been found before the project process (Dziadosz & Rejment, 2015). Edwards and Bowen (2013) emphasised that, if the risk could be found by risk manager, the consequences of uncertainty could be avoided.

2.3 Risk is the consequence of uncertainty

Dziadosz and Rejment (2015) treat risk as a measurable part of uncertainty, so that the occurrence probability and the size of damage can be estimated. This view is shared in turn by Aven (2016) and Cleden (2017) who contend that risk is uncertainty about and severity of the consequences of an activity with respect to something that humans value. The probability of the future event occurring must be greater than 0% but less than 100%, while the impact or consequence of the future event is unexpected or unplanned for (Chia, 2006).

3. Uncertainty

In social science, uncertainty has most commonly been paired with risk. Beck (2014) pointed out that uncertainty has a strong relationship with risk. The Oxford Dictionary (2017) defined uncertainty as 'The state of being not able to be relied on or not known or definite.'

Compared with risk, uncertainty has fewer relevant literature definitions. Most of literature conflates the definitions of risk and uncertainty. However, some sources point out the difference between them. Jaafari (2001) defined uncertainty as the probability that an objective function will not reach its planned target value, or as an unknown probability of occurrence of an event. Winch (2010) pointed out the 'Uncertainty in the plain English sense of "lack of certainty" is in part about "variability" in relation to performance measures like cost, duration, or "quality". It is also about "ambiguity"…'. Perminova *et al.* (2008) explored the differences between risk and uncertainty (see Figure 2).

Risk and uncertainty as defined in different disciplines

	Risk	Uncertainty
Economics	Risk refers to events subject to known or knowable probability distribution [23]	Uncertainty is a situation for which it is not possible to specify numerical probabilities [23] Uncertainty is a state in which individual actors find it impossible to attribute a reasonably definite probability to the expected outcome of their choice (Keynes, 1937)
Psychology	Risk is the fact that the decision is made under conditions of known probabilities [39]	Uncertainty is a state of mind characterized by a conscious lack of knowledge about the outcomes of an event [19]
Philosophy		Doubt presupposes certainty [44]
Org. theory		Uncertainty emanates from a set of objective but largely unmeasured environmental characteristics [22]
Dictionary	The possibility of something bad happening at some time in the future; the situation that could be dangerous or have a bad result (Oxford Dictionary of Current English, 2005)	Uncertainty is the state of being uncertain; something you can not be sure about (Oxford Dictionary of Current English, 2005)
Project management	Risk is an uncertain event or condition that, if it occurs, has a positive or negative effect on at least one project objective, such as time, cost, scope or quality [36]	

Figure 2: Risk and uncertainty difference (Perminova et al., 2008)

3.1 Uncertainty is a state of unknowing

Morris (2013) emphasised that 'uncertainty really reflects unknowns'. Uncertainty is the state of mind of someone deciding on a course of action without a clear outcome (Wakeham, 2015). As argued by Howell *et al.* (2010), the core concept of uncertainty is a lack of certainty over the parameters, the

context or the possible outcomes of a particular set of circumstances. Therefore, the project is unknown due to this uncertainty, and the project managers do not know that they do not know (NicholasTaleb, 2015).

3.2 Uncertainty is a lack of information

Frank (1999) divided uncertainty into either aleatory or epistemic uncertainty. Aleatory uncertainty is uncertainty that cannot be foreseen in advance, and epistemic uncertainty is described as uncertainty deriving from a lack of knowledge. Either lack information of judgment or lack information of knowledge will cause uncertainty (Grote, 2015).

3.3 Uncertainty cannot be measured

Unlike risk, uncertainty cannot be measured (Serpella *et al.*, 2014). Knight (2012) stated that risk is events subject to known or knowable probability, whereas uncertainty refers to events for which it is impossible to specify numerical probabilities. Uncertainty always comes from some set of objective environmental characteristics, and most of them are unmeasured (Jauch & Kraft, 1986). This feature of uncertainty causes the manager to be unable to control it, and they have to ignore it (Ford & Hegarty, 1984; Nowotny *et al.*, 2001).

3.4 Uncertainty is the context for risk

Uncertainty should be treated as a context for risks, as events have a negative impact on the project's outcomes (Perminova *et al.*, 2008). Saunders (2016) presented the relationship between uncertainty and risk (see Figure 3).

Uncertainty	**Risk**
We do not know how many engineering resources will be made available to the project.	We may not have sufficient resources to deliver the project to plan.
We do not know what changes the industry regulator may require to our proposed product design.	We may need to do significant product redesign, delaying the project delivery.
We do not know what the impact of an external industry report into a previous industrial accident on our project may be.	We may need to incorporate new safety features into our project, again delaying the project delivery and increasing project cost.
We do not know what the end point of our project is.	We may not be able to deliver on time and to budget if the scope is not clearly defined.

Figure 3:risk is kind of uncertainty (Saunders, 2016)

3.5 Uncertainty can be positive and negative

Hillson (2002) divided uncertainty into two varieties: 'risk' referring exclusively to a threat, and 'opportunity' which is an uncertainty with positive effects. Perminova *et al.* (2008) explained that uncertainty is when the established facts are questioned, and thereby the basis for calculating risks or opportunities is questioned. Similar ideas can be found in several different sources (Ward & Chapman, 2003; Morris, 2013; Cleden, 2017).

4. Hazard

In the Oxford English Dictionary, a hazard is defined as 'A danger or risk.' (2017). However, some sources pointed out that the distinction between risk and hazard is clear (Lofstedt, 2011). Hazard is associated with the intrinsic ability of an agent or situation to cause adverse effects to a target (Renn, 2008).

4.1 Hazard is a potential event of risk

Renn (2008) suggested that if a project is not exposed to hazards or has the solution for the corresponding risk, the condition of hazard may never materialise. The German Federal Institute for Risk Assessment (BfR), meanwhile, described hazard as the potential of a substance in toxicology to cause an adverse effect, while risk is the product of the scale and probable occurrence of damage (Spielmann *et al.*, 2008).

4.2 Hazard is negative

Hazard is always negative. It is a potentially damaging physical event, phenomenon, or human activity, which may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation (Nations, 2004). A paper from the International Risk Governance Council (IRGC) provided a similar idea that hazard is the potential for harm or other consequences of interest (IRGC, 2005). The most authoritative view may come from the International Organisation for Standardization (ISO), which provide the simplest and clearest idea of hazard as a 'source of potential harm' (ISO, 2018).

4.3 Hazard is associated with intrinsic abilities

Although hazard is always negative, it would not transfer to risk if there were no sensitive targets (Andretta, 2014). For example, there is a poisonous mushroom, and if somebody eats it, there will be a risk of him/her becoming poisoned. If nobody eats it, it will not be a risk (no sensitive targets), but it is still a hazard. Hazard is associated only with the intrinsic ability of an agent, stressor, or situation to cause adverse effects to a target population or receptor (Asante-Duah, 2017).

5. Opportunity

In general, opportunity is defined as 'A time or set of circumstances that makes it possible to do something' (Oxford-Dictionary, 2017). Opportunity and threat are always considered as elements of the relative possibility of risk (Hillson, 2002). However, the inner feature of opportunity is still unclear.

5.1 Opportunity is a dual risk

As risk exposure could be defined as Probability (loss) multiplied by Impact (loss), opportunity exposure could be treated as Probability (gain) multiplied by Impact (gain). Opportunity could thus be treated as a dual risk. If seized, it can have positive impact on a project, but otherwise it will have a negative influence (Boehm, 2014).

5.2 Opportunities have positive influences on the project

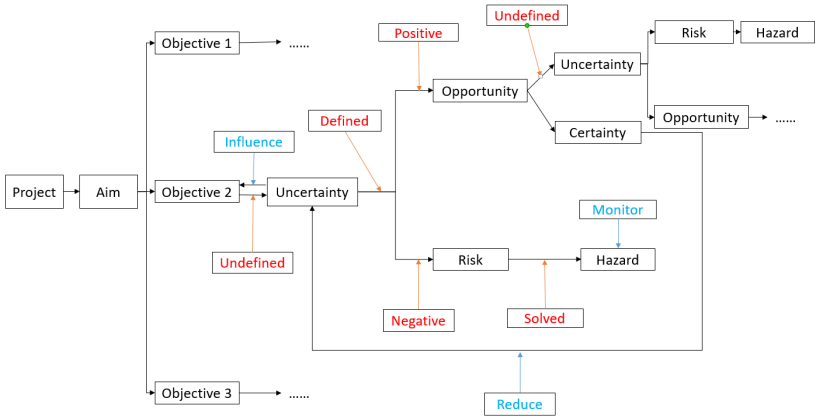
As with threats, opportunities also can involve uncertainty, which has the potential to affect project objectives (Hillson, 2002). Chapman and Ward (2011) provided a similar idea to support the idea that opportunities have a positive influence for the project.

5.3 Opportunity may increase risk

Kendrick (2015) divided opportunities into three types: those related to project specifications, those related to planning decisions, and those related to beneficial uncertainties. Although some of the opportunities may reduce overall project risk, most actually increase overall project risk and serve as sources of potential project problems. This is because the positive utility magnitude of improving an expected outcome is generally less than the negative utility magnitude of failing to meet an expected outcome (Pyster *et al.*, 2012).

6. Analysis

From the literature review above, a flowchart can be developed to explain the relationship between risk, uncertainty, hazard, and opportunity:

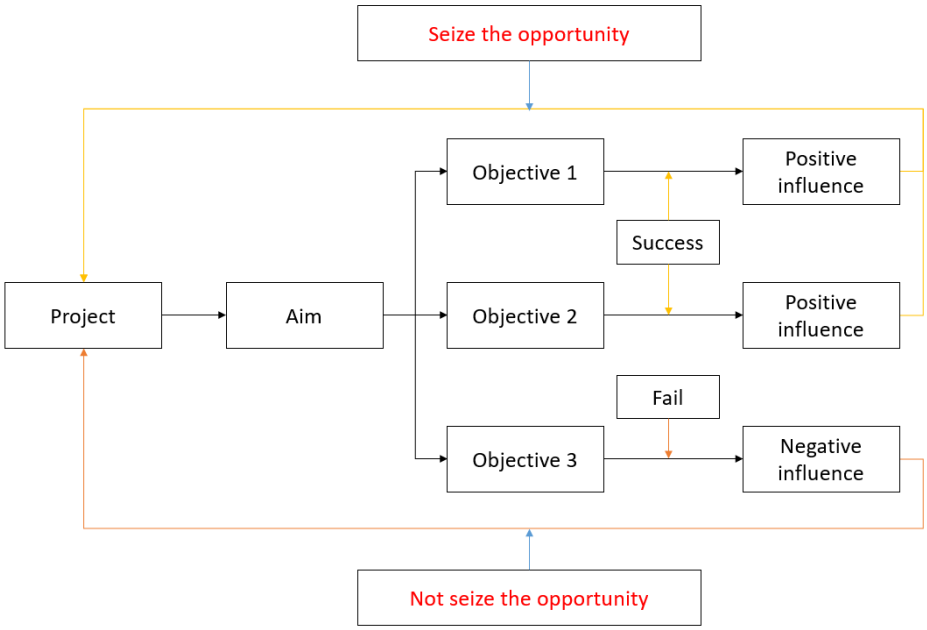


Graph 1: uncertainty, risk, hazard, opportunity flow chart

In order to understand the process for Graph 1, the project manager could follow seven steps to divide the project:

1. A project begins, and the project manager defines the project aim and objective.
2. Each objective has its uncertainty; at this time, the project manager knows the uncertainty could influence the project, but they do not know when, where, why, to whom, and how the uncertainty may happen.
3. The project manager needs to use risk identification and risk assessment to know how the uncertainty influences the project. Negative uncertainty transfers to risk, and positive uncertainty transfers to opportunity.
4. For risks, project manager needs to use risk analysis and risk response to understand how to manage the risk and how to respond to it. After this, the risk transfers to hazard, and the project manager needs to monitor the hazard, but does not need further action.
5. For opportunities, the project manager needs to divide each opportunity into two parts: uncertainty and certainty. Uncertainty from the opportunity may bring new risks or opportunities, and certainty can reduce the uncertainty of this objective.
6. All the objectives can be broken down using a similar structure through steps 1–5.
7. After all objectives are finished, the aim can be achieved, and the project can be completed.

This graph provides the interesting idea that each project could be treated as an opportunity. As each project has its own aim and several objectives, each objective could be treated as a smaller project. If the objective is seized, it could be treated as 'the positive influence of the aim'. Due to knowing that an opportunity has a positive influence on the project if seized, the relationship between objective, aim and project could treated as in *Graph 2*.



Graph 2: Opportunity flowchart

These two flowcharts provide the link between risk, uncertainty, hazard and opportunity. As presented, most construction project uncertainty could be divided into risks and opportunities. Those risks which has been solved will become hazards. Opportunities have uncertainty as a part, and could influence the construction project.

7. Conclusion

In the UK, current construction risk management methods need significant improvement. This paper has presented a review of the construction risk identification literature. It focused on the differences between risks, uncertainties, hazards, and opportunities. It has also presented flowcharts to help the construction risk manager to identify the process for the construction risk. This paper will become a part of the main author's PhD thesis, which will introduce ways to analyse offsite constriction risk and then manage those risks. This paper will contribute to the risk definition part of the thesis, and future work will discuss different types of risk: internal risks, external risks, and project risks.

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