Investigating Risk Management Capability of Construction Firms in the Gulf Cooperation Council (GCC) Countries

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy (PhD)

College of Engineering, Design and Physical Sciences
Brunel University

United Kingdom

By

Ghadeer R. Alfandi

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② Abstract

Implementing risk management (RM) effectively in construction projects and organisations has long been recognised as key to ensuring successful project performance. Therefore, it has become increasingly vital for construction organisations to have RM as an integral part of their project management practice. Such necessity has driven significant increase in research on RM practice in the construction industry. However, little research has been conducted to systematically investigate the RM implementation in the Gulf Cooperation Council (GCC)'s construction industry. Therefore, this research study was aimed at thoroughly investigating RM implementation in this industry toward developing an appropriate framework for improving existing practice. Specifically, this research study has developed a RM framework for enhancing RM implementation practice in construction firms and an informed list of best practice recommendations, all of which aid as a road map for implementing an effective RM system, thereby contributing to the enhancement of practice. In addition, the research has developed a RM maturity model purposely for measuring firms' existing RM maturity level and identifying key areas for further improvement.

Mixed method approach was chosen for the purpose of addressing the research aim and objectives. The first stage of the approach involved a comprehensive review of relevant literature. Then, a pilot study and two questionnaire surveys were designed and distributed to professionals from construction organisations in the GCC countries. Moreover, six case studies from real-life projects were conducted. The RM framework was validated through a series of experts' interviews. This research has identified and ranked 62 key risk factors affecting construction project performance, and were categorised under four levels, namely: country level, industry and market level, firm capability level, and project implementation level. Also, this research study has identified 28 RM maturity criteria and 15 critical barriers to RM implementation. These were used to develop a comprehensive RM maturity system, which can serve as a guide for determining the RM capability of construction organisations to enable them decide on the most appropriate implementation strategies.

Moreover, the case studies provide rich in-depth qualitative data that explains, among others, the status of RM implementation in practice and the level of maturity displayed by GCC construction organisations on this subject. The cross–case comparison results substantiated the survey findings, and highlighted the influence of the firms' characteristics on the RM implementation. Also, the findings serve as a case-study from GCC countries from which other countries in the Middle East and developing world can benefit immensely from the lessons learnt, since these countries share a lot in common as far as RM practices are concerned. The empirical results and outcomes of this research are arguably the first to be presented for the GCC construction industry, and therefore have a high potential of contributing significantly to the existing body of knowledge and understanding in RM. The results of this research do not only fill a major gap in the literature on the subject of RM practice in this industry, but also offer greater awareness and understanding of RM implementation in construction firms. Future studies would be conducted to assess the RM maturity in other projects or in other countries and to investigate the relationship between the RM maturity and improvement in project performance. For instance, the case studies would be performed to uncover RM implementation and the associated managerial implications which will allow practitioners to understand the real implementation issues in practice and the experience of firms that is worth learning from.

Keywords: Risk management, construction projects, GCC region, risk capability and maturity.

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Declaration

It is hereby declared that the thesis in focus is the author's own work and is submitted for the first time to the Post-Graduate Research Office. The study was originated, composed and reviewed by the mentioned author and supervisors in the department of Civil Engineering, College of Engineering, Design and Physical Sciences, Brunel University London, UK. All the information derived from another works has been properly referenced and acknowledged.

Ghadeer Alfandi

London-UK

Dedication

To the memory of my father

Rashed Alfandi

Acknowledgment

Alhamdulillah, all praises to Allah for the strengths and His blessing in completing this thesis.

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List of abbreviations

APM	Association for Project Management
CIM	Controlled Interval and Memory Modelling
CWG	Civil Work Group
ENR	Engineering News Record
EPC	Engineering Procurement Consultant
EWG	Electromechanical and System Work Group
GCC	Gulf Cooperation Council
JVs	Joint Ventures
KCI	Kuwaiti Construction Industry
KPI	Key Performance Indicator
LV	Low Voltage
MV	Medium Voltage
OCCs	Overseas Construction Companies
OPM	Overall Project Management
PERT	Project Evaluation and Review Techniques
P-I	Probability - Impact
P-I-V	Probability – Impact - Velocity
PMBoK	Guide to the Project Management Body of Knowledge
PMI	Project Management Institue
PMO	Project Management Office
PRAM	Project Risk Analysis and Management Methodology
PRM	Project Risk Management
QC	Quality Control
RAMP	Risk Analysis and Management for Projects Methodology
RM	Risk Management
RMII	Risk Management Implementation Index
RSIS	Risk Significance Index Score
SMEs	Small – Medium Enterprises
TBM	Tunnel Boring Machine
TTP	Temporary Traffic Plans
WBT	Web – Based Tool

Chapter One
General Introduction

1.1 Background

The construction industry in the Gulf Cooperation Council (GCC) countries (namely, Saudi Arabia, the United Arab Emirates (UAE), Kuwait, Oman, Bahrain, and Qatar) is generally considered as economic barometer of these nations (Deloitte, 2015). This industry is worth US$ 2.01 trillion, which is roughly two-third of the entire annual gross domestic product (GDP) of these countries (Middle East Economic Digest, 2015). The growing economies in the GCC, along with the economic diversification in the non-oil sector, has resulted in increased demand for infrastructure and building development (Loo et al., 2013). The drivers for this growth are high oil revenue, high population growth, economic diversification, the need to create jobs, and the political necessity of investing in social infrastructure following the recent regional unrest of the Arab uprising (MARKAZ, 2011; Kilani, 2014).

As a result, the GCC construction industry has been experiencing significant boom in construction undertakings over the past decade (Al-Sabah et al., 2014). Latest forecast on planned projects in the GCC countries and those currently underway have a total value of US$172 billion, the highest on record to date (MEED, 2015). Notable among these projects include (Lowe and Altrairi, 2013): the 2,177 km-long GCC rail network aimed at linking all six countries for the first time; Riyadh East Sub Centre Project in Saudi Arabia; Al-Maktoum International Airport expansion in the UAE; Oman National Railway project budgeted; Qatar 2022 FIFA World Cup infrastructure developments and Qatar’s Passenger & Freight Rail project. The scale of such mammoth infrastructure developments strongly highlights the great importance, than ever before, of ensuring successful execution of GCC construction projects.

However, many construction projects in the GCC region have long been bedevilled with numerous difficulties that have resulted in frequent instances of severe overruns in project budget and schedule (Al-Sabah et al., 2014). A critical review of the relevant literature have identified the main sources of the difficulties responsible as including: war threats, political instability, and price inflations (El-Sayegh, 2008; Al-Sabah et al., 2014); poor planning, site management and supervision by contractors, problems with subcontractors, and owners' unreasonably imposed tight schedule (El-Sayegh, 2008; Ruqaishi and Bashir, 2014); permits and regulations hurdles, unclear scope definition, site access, and lack of adequate, material, equipment and qualified labour (Al-Kharashi and Skitmore, 2009; Kartam and Kartam, 2001).

As can be seen, the success of GCC projects are (and continue to be) hampered by wide-range and multiple risk issues from multifarious sources. The reason for this is attributable to the fundamental nature of construction projects and what their execution entails, as characterised by the inherit uncertainties associated with construction operations, and the political, commercial, market/business, and physical environment under which project delivery take place (Andi, 2006; Bryde and Volm, 2009; Kuo and Lu, 2013). As various research shows, failure to adequately deal with construction project risks contributes to significant project cost and time overruns (Thompson and Perry, 1992; Kartam and Kartam, 2001; Wang and Chou, 2003).

Surprisingly, the GCC industry's quest for solutions to its poor performance track record have so far received very little governmental initiatives and research attention directed at ensuring better awareness, adoption and promotion of effective Risk Management (RM) practice in the GCC region (Kartam and Kartam, 2001; Ruqaishi and Bashir, 2014). Stimulated by this gap, coupled with the urgent need for the industry to cope better with project delivery challenges, the research reported in this thesis was undertaken to explore current RM practices among contracting organisations in this region, towards the development of a framework for enhancing the process.

1.2 An overview on GCC countries and risk implications

The Gulf Cooperation Council (GCC) countries occupy most of the Arabian Peninsula; an area of huge reserves of crude oil and gas. Figure 1 presents the geographical location of these countries. These six countries, along with Iran and Iraq, hold 56 and 40% of the world's proven reserves of conventional oil and gas (IEA, 2013). Also, all six countries share the similarities of being a resource rich and labour importing region (The World Bank, 2007). The construction boom, fuelled by rapid economic and population growth, has attracted foreign contractors to export their services to the Gulf.

Oil production constitutes the cornerstone for the economic strength of this region. The GCC economies are a combination of high oil prices, expanded oil production, expansionary fiscal policies, and low interest rates in support of buoyant economic activity (GCC Research Division, 2013; Khamis, Rasmussen, and Westelius, 2012). The living standard in the GCC countries is relatively high. In addition to sharing common borders, the GCC countries have relatively similar political systems and share a common language, religion, and social values (Ruqaishi and Bashir, 2013).

Political stability is one of the major factors associated with the GCC region since 1990, and considered the second key risk in construction projects by (Al-Sabah et al., 2014). The region witnessed unrest starting with the First Persian war in 1980-1988, followed by the First Gulf war in 1990, and then continued to the Second Gulf war in 2003. In early 2011, the Middle East, witnessed the Arab Spring, a wave of democracy movements, which was started particularly in Tunisia and spread to Egypt and other GCC countries such as the Kingdom of Bahrain and the Republic of Yemen. These political movements have been contributing to the disruption and suspension of some ongoing construction projects (Engineering News Record, 2011).

Figure 1 Geographical location of the GCC countries

1.3 Statement of the Problem

Arguably, modern construction projects are exposed to more risk and uncertainties than perhaps any other industry (Kuo and Lu, 2013). There are generally three main reasons that explain this characteristic. First, construction processes have become much more complex undertakings as revealed by the nonlinear and dynamic nature of the project activities (Zou et al., 2010; Zhao et al., 2014). Second, construction projects involve the participation of multiple parties each working to their individual contractual terms and having special interest to protect their business, resulting in an interwoven intricate network of great dynamics and complications (Thompson and Perry, 1992; Wang and Chou, 2003). Thirdly, construction projects are often executed in a highly unpredictable physical, financial and economic environment, making the process quite difficult to track and control the inherit uncertainties (Hatush and Skitmore, 1997; Ruqaishi and Bashir, 2014). These reasons have given rise to increased concerns about risk in construction project. Consequently, RM continues to not only attract a great deal of research but also remains an important subject often called upon when seeking solutions to poor project performance (Al-Sabah et al., 2014).

A significant part of the encyclopaedic amount of RM research concerns the development of effective RM methodologies based on standard processes of managing risk. The most noteworthy attempts in this regard are: the Risk Analysis and Management of Projects (RAMP) method produced by the Institution of Civil Engineers (ICE et al., 1998); Project Risk Analysis and Management Guide (PRAM) (Simon et al. 1997; Chapman and Ward 1997); and similar methodological processes proposed by: Project management Institute (PMI, 2008), The International Organisation for Standardization (ISO, 2009) and the Institute of Risk Management (RMS, 2002).

Although the subject of RM continues to increasingly attract attention from researchers and practitioners alike, very limited efforts have been expended by the GCC construction industry toward understanding their peculiar risk issues and ways of dealing with them effectively. RM studies undertaken in this region have so far largely been limited to the identification, assessment, and allocation of projects risk factors encountered in practice (Kartam and Kartam, 2001; El-Sayegh, 2008; Al-Sabah et al., 2014; Ruqaishi and Bashir, 2014). A common thread running through these studies' findings is that RM is hardly implemented effectively by construction organisations in the GCC region. Whilst the studies are helpful in some respect, they have shortcomings as far as their contribution to addressing the RM issues within this region is concerned. For instance, the studies focussed on risks either at the project or organisational level and were based on the perspective of a specific project stakeholder (e.g. either the employer or contractor). There is therefore a lack of comprehensive examination of project risks unravelled from all the key relevant sources and across all the main stakeholders in the GCC area. Also, the studies did not thoroughly investigate the practical applications of RM processes and the capacity of relevant organisations to ensuring their effective implementation. Such limitation makes it difficult to determine the suitability of employing and promoting any of the existing RM methodologies in the GCC region or otherwise (Hopkinson

2000, Zhao et al., 2014). Furthermore, it keeps the industry in the dark as to where priority or the weakest areas of RM lie, and hence needing improvements and best actions to take to increase performance (Hopkinson 2000; Anagnostopoulos et al. 2005).

In addition to these shortcomings in past GCC research efforts, the effective implementation of RM in organisations and on projects has long been seen to be impeded by the fragmented nature of the construction industry in general (Chapman, 2001; Zou et al., 2010). For instance, the absence of a common view on project risks amongst contracting parties, combined with parties' differing objectives and their common adverse relationships, mean that coordinating RM in a systematic and effective manner is, at best, an extremely difficult undertaking. Understandably, RM practices are often regarded as highly variable, intuitive, subjective and unsophisticated (Loosemore et al., 2006), contributing to the inability of the industry to traditionally formalise a common RM approach recommended across board. So, in spite of the attempt made to develop methodologies for enhancing effective RM practice the value of such outputs is little (or not fully recognised) outside of the context upon which they were based and developed. Therefore, an important consideration in any attempt or initiative aimed at developing a RM framework for improving practice in the GCC construction industry should include, *inter alia*, an empirical investigation into current RM practices and the capabilities of the organisations involved.

1.4 Research Aim and Objectives

In view of the foregoing, the aim of the research reported in this thesis is therefore to investigate RM implementation practice in the GCC construction industry toward developing an appropriate framework for improving practice. In pursuit of this aim, the main research objectives embraced the following:

- To review the literature on risk and RM in construction management journals;

This objective demands a comprehensive review of relevant literature in the top high rank journals in construction management.

- To identify, assess, and understand the most common risks which may cause delay in the construction projects.
  This objective will be accomplished through reviewing relevant literature about the identification and assessment of construction risks in developed and developing countries.

- To investigate the existing implementation of RM systems in construction firms and assess the level of maturity of these systems;
  This objective will be accomplished through reviewing current RM maturity models in literature, identify main attributes of a mature RM system, and investigate RM systems in GCC's construction firms.

- To investigate the application of RM tools and techniques in practice;
  This objective demands a review of literature on common RM tools and techniques used in practice and investigate the level of implementation of these tools and techniques in construction firms

- Explore the barriers of effective RM implementation in construction firms while undertaking projects in the GCC.
  To understand the barriers to RM, the possible factors that may affect RM implementation will be uncovered, and the interrelationships among these critical barriers will be investigated.

- Propose a RM framework that facilitates effective RM implementation in these firms;

- To validate the proposed framework and present recommendations;

This objective will be accomplished through a series of interviews with experts in the GCC construction industry.

1.5 Research questions

This research aims to answer the following research questions:

1. What are the critical risk factors that affect the performance of construction projects in GCC region?
2. To what extent do GCC construction organisations implement RM systems properly?
3. What are the barriers to effective RM practice faced by GCC organisation?
4. How best can current RM practice be improved for the GCC construction industry?

1.6 Research Methodology

Research methodology is the means by which a researcher can answer research questions. In order to achieve the objectives outlined above, the researcher used different tools and techniques for data collection and analysis. Their application and the justification for choosing such methods are detailed in Chapter 2. An overview of the methodology used is described below.

As with most research undertakings, this research study started with critically reviewing the relevant literature published in high ranked journals from construction management domain. The literature review provides the theoretical background and the context of the issues under investigation. The review covered risk and RM in the construction industry, with regard to the applications, barriers, tools and techniques used by this branch of management discipline.

Through the review the major risk factors affecting project performance were identified and assessed. After this, an initial survey was initiated to solicit the opinions of Kuwaiti clients and contractors on risk and RM in the construction industry. This investigation was followed by a large scale regional-wide questionnaire survey of construction firms operating in the GCC countries on their RM implementation practices. The result of this survey and the review pointed to the need for a further in-depth investigation into the issues of RM implementation in construction organisations. This investigation was carried out through the use of case-studies from six real life projects in the region.

The data collected from questionnaire surveys were analysed using statistical techniques including descriptive statistics, ranking index, correlation analysis, Chi-square tests, and ANOVA test. Also, the case studies data were analysed through cross-case comparisons. Finally, the findings were used to present best practice recommendations and to develop the RM frameworks, which were then validated by a number of experts using questionnaire survey.

1.7 Thesis structure

The structure of the thesis can be visually followed using the schematic in Figure 2. In total, the thesis is composed of ten chapters. The chapters are grouped in four main parts namely; establishing the context, theoretical part, empirical part, and the research findings. Having set out the aim and objectives of the study, the research questions which have to be answered in order to meet these are identified in **Chapter one**. Thereafter, details were provided of the scope of the study, how it is to be carried out, and what the following chapters contain.

Chapter two discusses the research design and processes followed, the sampling associated with the empirical work, the data collection techniques and data analysis methods used. Two rounds of questionnaire surveys and six case studies were performed. The data were collected through literature review, questionnaire surveys, and semi-structured interviews. Several statistical analysis methods were selected to analyse the data. Issues concerning the validity and reliability of the study are also discussed. **Chapter three** presents a desk study investigation based on critical review on risk and RM from construction management journals. It presents the definitions of risk and uncertainty and highlights the distinction between them. Also, it presents the early efforts in RM, and the development of RM in the international guidelines and standards. Moreover, it discusses the different processes of RM, such as risk identification, risk assessment, risk response, and risk monitoring, and highlights its importance.

Chapter four presents further in-depth literature review covering RM implementation in construction firms over the period of 1985-2013. It also highlights the barriers to successful implementation of RM, RM tools and techniques used in practice, and presents RM capability models of construction firms reported in the literature. **Chapter five and six** present the data collection and analyses of the results obtained. The analysis covered the data collected from the questionnaires and the case studies from six real life projects in the GCC countries.

Chapter seven presents the proposed RM framework for improving practice, developed based on the analysed results and findings. **Chapter eight** presents the feedback obtained from participants in the validation questionnaire survey, and analyses them in attempt to validate the framework.

Finally, **Chapter nine** critically discusses the research results and investigates their relationships to research questions and the literature. Also, it summaries the key findings and conclusions, highlights the research contributions made, discusses the limitations of the research and then, presents recommendations and future research directions.

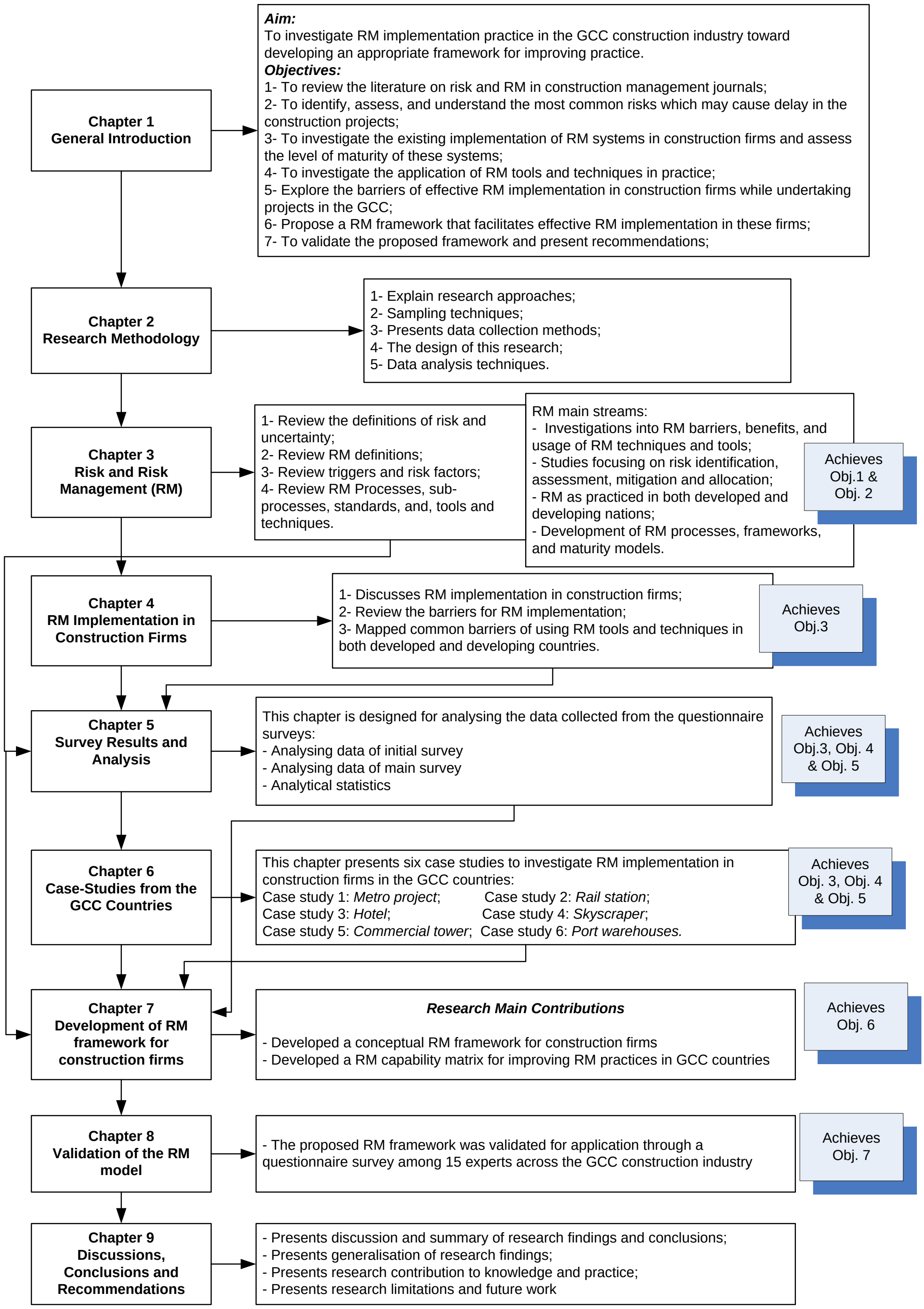

Figure 2 Thesis structure

1.8 Summary of this chapter

This chapter establishes the context and reasoning behind the research. It introduces the research objectives, research problem, scope, questions and outlies the research methodology. It also presents the importance of RM, provides a summary of the literature gaps, and demonstrates the structure of the thesis. In the next chapter, the literature pertaining to the study is critically reviewed.

Chapter Two
Research Methodology

2.1 Introduction

In the introduction chapter there was a brief explanation about the research methodology. In this chapter, a detailed account is delivered regarding the research design and data collection methods used. Also, this chapter presents the data collection techniques used with a justification of these choices.

2.2 Basic definitions

Research is a project of academic enquiry conducted for answering valid research questions with a logical sequence of research activities designed to enable answering the raised questions. Subsequently, every research has its unique methodology, philosophical orientation and tools and techniques. Johnson et al. (2007) argued that various research orientations suggest a range of different ontological and epistemological choices.

Research methodology is the "strategy, plan of action, process, or design laying behind the choice and use of particular methods and linking the choice and use of methods to the desired outcomes" (Crotty, 1998). It shows the roadmap of achieving research objectives. Research methodology is different from research methods which are the tools and techniques used for collecting and analysing data. There is no best research methodology or method that can fit any research. Some research methods are more suitable for answering some research questions than other ones. Hence, it is essential to decide on the research methodology and methods that best answer the research questions and ensure the validity and reliability of the results.

Validity is the correctness or credibility of a description, conclusion, explanation, interpretation, or any other sort of account (Maxwell, 1996). Hence, it is a measure of correctness of any type of research findings or results. On the other hand, reliability can be defined as the consistency of results after repeating the same process or methodology many times by different people. Therefore, it measures the extent to which research findings are independent of accidental circumstances (Kirk and Miller, 1986). It is important to appreciate the difference in concept between reliability and validity and to appreciate that none of them guarantees the other.

2.3 Research approaches

The nature of data in any research is directly related to the philosophical viewpoint of the research. The data may be quantitative or qualitative but the presence of data is an essential part of empirical research. The concept of quantitative data is one of quantity, and it is expressed numerically. The use of numbers brings a structure to data and essentially involves the use of measurement, either counting or scaling. Qualitative data is empirical information that is not numerical. Carter and Fortune (2004) argues that qualitative data is generated rather than collected. Interviews, documents, visual images can all be used as a source of data, but it is the researcher's epistemological position that determines how that data is generated. Different research approaches can be followed with different philosophical orientations and different tools and techniques for collecting and analysing data.

2.3.1 Extensive research (Quantitative)

Extensive research focuses on studying the social phenomenon at the event level following a very objective way in dealing with the collected data. The quantitative research approach reflects a positivist epistemological orientation with an aim of explaining and predicting based on empirical facts; it avoids any value judgements or subjective interpretation of the researcher (Scapens 1990). Although there is a long-standing debate about the appropriateness of such an approach to study social phenomena, it is a well-established approach as it can generate objective results especially when the aim is testing hypothesis or theories in a deductive research. Quantitative research assumes an objective ontological orientation. The research is mainly concerned with research concepts, as objective entities, without any concern to their construction within the social reality.

2.3.2 Intensive research (Qualitative)

Different from quantitative research, which seeks regularities and common properties at the event level, qualitative research studies social events and their causal mechanisms in order to reach their actual causes (Sayer 1992). It investigates how generative mechanism works and describes the interaction between the powers that produces a social phenomenon (Danermark 2002). Qualitative data is often generated in interview; focus group, participant observation and existing data. Qualitative data is non-numerical and usually takes the form of people's words or the researcher's description of what has been observed or experienced. Qualitative data can range from pre-structured to not pre- structured.

2.3.3 The Mixed Method Approach

Mingers (1997) argued that adopting a particular approach is like viewing the world through a particular instrument such as a telescope, an X-ray machine, or an electron microscope. Each instrument produces a different and "seemingly incompatible" representation of the reality. He argued that adopting only one paradigm would prevent a researcher from gaining a more representative view of the phenomenon. For this reason, he concluded that it is always wise to utilize a variety of approaches in order to have a better view. Hence, a better strategy would be following a mixed-methods approach in order to overcome the limitations of each approach and to maximise their potentials. This opinion has been recommended and supported by many scholars. Sayer (1992) claimed that the best that can be produced is a narrative supported by some results of extensive survey and a few intensive case studies. He advocated a "synthesis research" that combines the results of intensive and extensive research. Such an approach would enable the researcher to make generalisations covering a wide range of constitutive structures, mechanisms, and events. From the above, one can conclude that the best strategy is to combine the two approaches.

2.4 Sampling techniques

The use of non-probability samples appears to be common in construction research. The sampling technique used for data collection was a purposive sample rather than a randomly chosen sample (Bing et al., 2005). To use random sampling would demand that the population is known (Diekhoff, 1992; Fellow and Liu, 1997).

Therefore, non-probability sampling techniques (Barnet, 1991; Burns, 2000) were used to determine the study sample. Research based on non-probability sampling techniques, such as that using purposive samples, can provide useful insights but it is limited with regard to the accuracy of estimates and its generalizability to larger populations (Fellows and Liu 2008).

The use of multiple types of sampling methods can help overcome some of the inherent limitations of any particular sample of data (Abowitz and Toole, 2010). Thus, purposive and snowball sampling were used in this research. According to Tashakkori and Teddlie (2003), snowball sampling involves using informants which would be useful in the study.

2.5 Data collection methods

No one single data collection method is ideal. Therefore, combined methods such as using both qualitative and quantitative data collection methods, have been highly recommended (Abowitz and Toole, 2009). The way in which the data are collected is inherently related to the research questions and objectives.

2.5.1 Literature review

A literature review is defined as a systematic and reproducible design for identifying, evaluating and interpreting the existing body of recorded documents

(Fink, 1998). According to Meredith (1993), literature review aims to achieve two objectives. First, they summarise existing research by identifying patterns, themes and issues. Second, they help to identify the conceptual content of the field. However, there is one challenge, which is that it is impractical to read everything. It may be possible to provide complete reviews only for narrowly defined issues.

A great deal of research has been conducted on a variety of aspects of RM (Wiguna and Scott, 2006; Wang et al., 2004). It has drawn massive attention from researchers and has become a debatable subject in the literature. However, the research topics that are encompassed by RM are diversified, with insufficient analysis of related issues. The classification of the existing literature within the RM domain may pave the way for future researchers to gain a clear understanding of the topic. Therefore, a systematic analysis of articles published in high rank journals would assist researchers to explore the current status and future trends of the chosen topic (Tsai and Wen, 2005).

Although a literature review plays a part in most previous studies, it can be a stand-alone work. In construction management, various researchers introduced a literature review: Abudayyeh et al. (2004); Lehtiranta (2014); Tang et al. (2010); Xue et al. (2010); and Bygballe et al. (2010), as shown in Table 1. In the context of RM, there have been several literature reviews on construction risk in the past, but most of these reviews were focused on specific aspects of construction risk, rather than being comprehensive and systematic. For example, Edwards and Bowen (1998) conducted a literature review on construction and project RM during the period from 1960 to 1997. They analysed the literature to identify trends and foci in research and practice. Moreover, they discussed the "soft systems" aspects of RM and human problems of implementation of RM in different organisational contexts.

Table 1 Previous literature reviews in construction management

Literature	Focus	Time period covered
Williams (1995)	Project RM	-
Edwards and Bowen (1998)	Construction and project RM	1960 - 1997
Abudayyeh et al. (2004)	Construction research trends	1985 - 2002
Al-Sharif and Kaka (2004)	PPP	1998 - 2003
Abudayyeh et al. (2004)	A historical perspective on construction research trends	1985 - 2002
Tsai and Wen (2005)	Science education	1998 - 2002
Ahmed et al. (2007)	Risk analysis and management techniques	-
Aloini et al. (2007)	RM in ERP	1999 - 2007
Ke et al. (2009)	Research trend of PPP	1998 - 2008
Tang et al. (2010)	Studies on PPP projects	1998 - 2007
Bygballe et al. (2010)	Partnering relationship in construction	1991 - 2009
Yung and Yip (2010)	Review on construction quality	1993 - 2001
Xue et al. (2012)	Collaborative working in construction projects	-
Hong et al. (2012)	Partnering research trend	1989 - 2009
Lehtiranta (2014)	Risk perceptions and approaches	2000 - 2012
Taroun (2014)	Modelling and assessment of construction risk	1983 - 2012
Zhou et al. (2015)	Safety management	1978 - 2013

Williams (1995) present a bibliography of research relating to project RM which includes 241 references, bringing together relevant research scattered across a range of publications. The risk analysis and management techniques have been described in detail by Ahmed et al. (2007). They provided a review of techniques that support RM in product development projects using the concurrent engineering (CE) philosophy.

Moreover, several new studies are concerned with risk analysis in general: (Hartono et al., 2014; Nasirzadeh et al., 2014; Taroun, 2014; Zhang and Fan, 2014; Zwikael et al., 2014). Taroun (2014) reviewed the literature of construction risk modelling and assessment. He also discussed the various contributions towards investigating various techniques and theories for risk assessment.

2.5.2 Questionnaires

Among the different data collection methods, the questionnaire has been recognised as the most cost-effective and most popular means of collecting information (Gravetter and Forzano, 2012). It has been widely used by researchers in studies relating to RM (Hwang et al., 2013a; Liu et al., 2011; Wang et al., 2004; Zhao et al., 2013).

Questionnaires can be administrated online, face-to-face, by post, by fax, or through email addresses. The questions can be open-ended, closed-ended or categorical. Open-ended questions are useful for exploration purposes, whereas close-ended questions have a specific set of answers and force the respondent to choose from a list of options.

The categorical type of question is useful for obtaining general information that can be easily assigned into categories. Multi-choice questions can also be applied; these permit different statistical techniques to be used to analyse the collected data (Tang et al., 2007).

2.5.3 Interviews

Interviews can be structured, semi-structured or unstructured. In structured interviews, the researcher comes with predefined questions and an interview schedule regarding a research topic. In unstructured interviews, the interview is a smooth discussion between the researcher and the interviewees, directed by a number of open-ended questions to guide the dialogue.

Between these two extremes lies the semi-structured interview. This contains a mixture of close-ended and open-ended questions discussed through the interviews. This type of interview combines the benefits of both structured and unstructured interviews. The level of structure depends on the research questions and the researcher's objective.

2.5.4 Case study

A case study is a research strategy and a data collection tool for understanding the dynamics within a specific setting (Eisenhardt, 1989). It has attracted attention from researchers who favoured it due to the depth and richness of data that it can generate. Yin (2009) recommended case studies as a way of focussing on the questions "what, why, and how?"

A case study is an empirical inquiry that investigates a contemporary phenomenon within its real life context using multiple sources of evidence (Yin, 2003). The key point of the study is the "case" or the unit of analysis which can be an organisation, an individual, an industry, a project, etc. A case study can be conducted using a single case or multiple cases. It includes data collection techniques such as reviewing historical records, interviews, observations and questionnaires. As a result, it provides researchers with a very rich account of data with deep insights about the unit of analysis. A case study can be adopted for different purposes. It can be used in exploratory studies, to provide description, for building theories, and for evaluating propositions and testing theories (Eisenhardt, 1989). Additionally, a case study is regarded as a powerful research methodology due to its capabilities regarding triangulation of data.

Triangulation means considering different perspectives and using multiple data collection methods from different evidence sources. It is considered as a powerful tool for enhancing the validity of research results and conclusions. According to Love et al. (2002), the triangulation approach is useful because it enables both qualitative and quantitative data to be used in generalising the findings. Yin (2011) discussed the generalising of a case study by differentiating it into two categories: statistical generalisation and analytical generalisation. Rather than statistical generalisation, a case study can demonstrate analytical generalisation by using the theoretical framework of a study to establish a logic that might be applicable to other situations (Yin 2011).

2.6 The design of this research project

This research adopted a mixed method approach. Combining multiple methods has been recommended for use in construction management research. Also this approach overcomes some of the inherent limitations of a single approach and facilitates a complete understanding of a given construction management research phenomenon (Love et al., 2002). Also, combining both qualitative and quantitative approaches in research design and data collection has been advocated because of its greater utility, even though it is more expensive in terms of time, money and energy (Abowitz and Toole, 2009; Tashakkori and Teddlie, 1998). Figure 3 shows the overall research process. A detailed account for each stage in the research process is discussed below:

2.6.1 Literature review

The initial stage of this research involved carrying out an in-depth literature review and content analysis to build the foundation of this study and develop an appropriate data collection instrument. Content analysis can assist in classifying textual material, and reduce it to more relevant and manageable bits of data (Weber, 1990). To ensure a high credibility review, the literature search was targeting peer-reviewed papers published in top-tier journals in the construction engineering and management field, along with conference papers and books. This approach is similar to the review methods adopted by Al-Sharif and Kaka (2004), Tsai and Wen (2005), Ke et al. (2009), and Hong et al. (2012) to illustrate the major research outputs published under their chosen topics.

In the review, as shown in Table 2, papers relevant to RM in the construction industry published in the following seven leading construction management journals were used: Construction Management and Economics (CME), the ASCE

Journal of Construction Engineering and Management (JCEM), Engineering Construction and Architectural Management (ECAM), the Journal of Management in Engineering (JME), Automation in Construction (AIC), the International Journal of Project Management (IJPM), and Project Management Journal (PMJ). Extensive studies on the subject of construction RM abound in the literature from these journals.

2.6.1.1 Conceptual research framework

To facilitate in-depth illustration of related publications, a systematic review strategy, involving a four-stage literature process, as shown in Figure 4, was employed to identify relevant literature. The first step of the process was to develop a criterion for including papers in the review.

Table 2 High rank journals in construction management

Publication name	Total number of papers	Number of RM papers
Journal of Construction Engineering and Management (JCEM)	3216	159
Construction Management and Economics (CME)	2609	110
Engineering Construction and Architectural Management (ECAM)	857	37
Journal of Management in Engineering (JME)	1833	54
International Journal of Project Management (IJPM)	2626	200
Automation in Construction (AIC)	2330	25
Project Management Journal (PMJ)	1036	56
Total	14507	641

The conceptual research framework consists of four stages, namely: (1) literature search; (2) literature selection; (3) literature coding; and (4) data analysis and discussion. The first three stages, namely the literature search, literature selection and literature coding, are discussed in detail in the following sections. The data analysis and discussion stage will be discussed in Chapter 4.

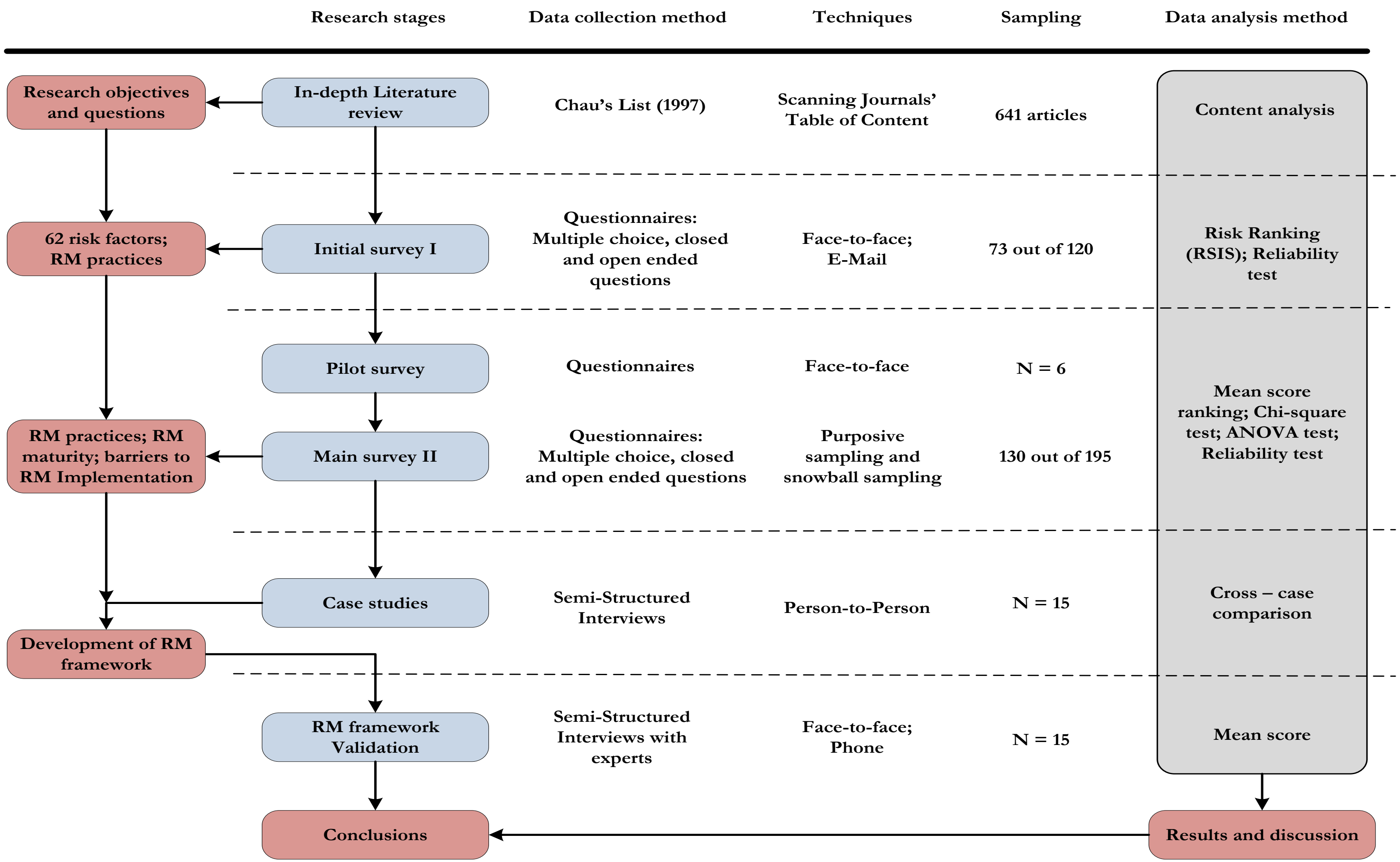

Figure 3 The design process of this research

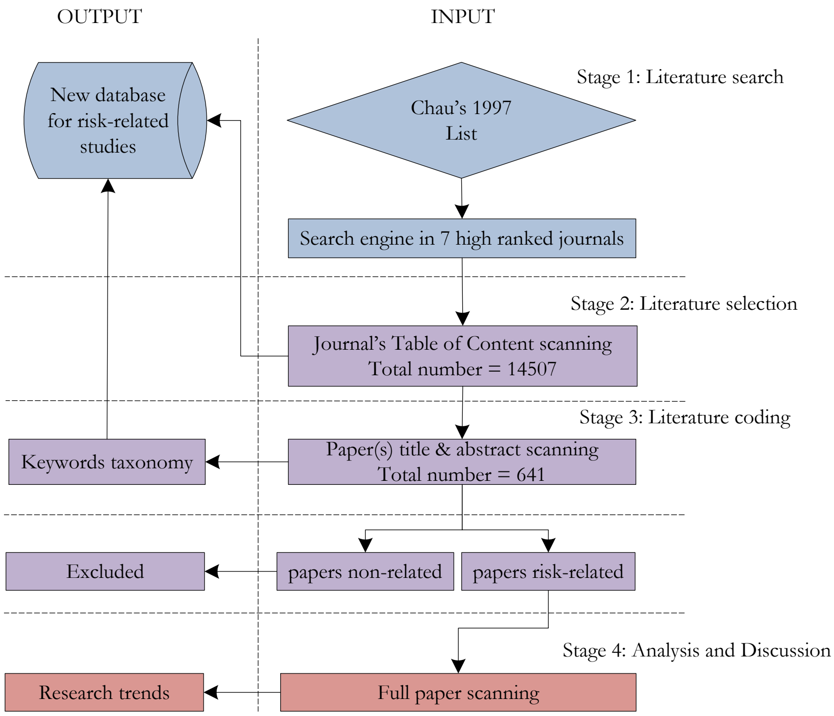

Figure 4 Framework followed in critically reviewing the study literature

2.6.1.2 Literature search

In this stage, a comprehensive desktop search was conducted using keywords as a starting point. Powerful engines as shown in Figure 5 were used through the Brunel University London Library including ABI Inform Global, EBSCO, Scopus, Science Direct, Emerald and the Web of Science.

The Google Scholar search engine was also utilised. The desktop search was further refined by choosing the related journals in the area of construction management and project management, as suggested by Chau (1997), to support the focus of targeted journals.

Figure 5 Databases used in the literature search

2.6.1.3 Literature selection

Webster and Watson (2002) argue that the major contributions are likely to be found in the leading journals. Also, they argue that in order to identify relevant articles; it is useful to scan a journal's table of contents. A table of contents page provides a list of all available content for a specific issue.

Hence, all the target journals' tables of contents were scanned in the first step. Articles that met the criteria shown in Figure 6 were chosen for further classification. Then, construction RM-related articles in the seven journals have been scanned as shown in Appendix I. The total number of papers published in the seven selected journals during the period 1983 – 2015 was 641.

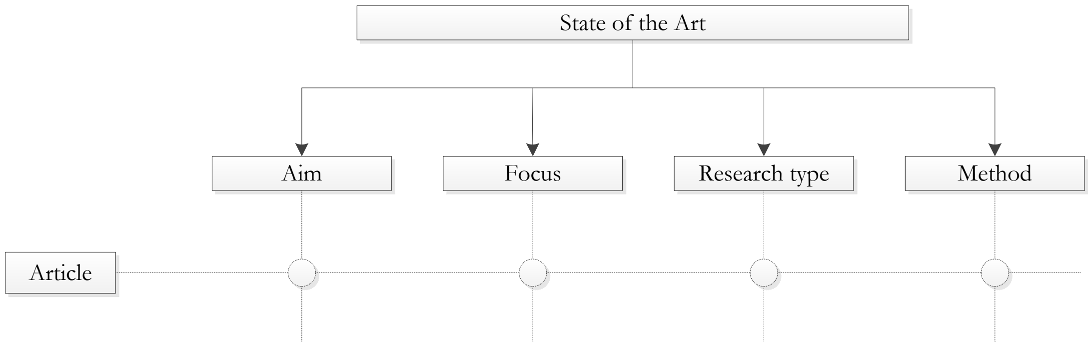

Figure 6 Criteria used for article coding

2.6.1.4 Literature coding

The title, keywords, and abstract were the main sources for literature coding. If complete information could not be found from them, then the full paper was evaluated to facilitate coding. In the process of coding papers, the following information was stored in the database:

1. the title of each paper, the publication year, and the publication name;
2. the aim of the study;
3. methods used (namely literature review, questionnaire survey, interviews, case study, and workshop;
4. country or region;
5. participants (namely owner, contractor, subcontractor, consultant);
6. research level (namely industry level, company level, project level, and process level);
7. project type (namely infrastructure, highway, housing, development projects, oil and gas, and underground);
8. RM process (namely planning, identification, qualitative assessment, quantitative assessment, response, and monitoring and control);
9. techniques, tools and theories;
10. keywords.

2.6.2 Pilot study

In this research, before a full-scale survey was implemented, a pilot study was carried out to rid the questionnaire of any ambiguous or unclear questions, and to obtain feedback on the questionnaire's content. According to Kumar (2005), the main purpose of a pilot survey is to test the questionnaire and thus ensure that it is coherent and comprehensible. Usually, a pilot survey is carried out among a small sample before a full-scale survey is implemented.

The questionnaire was shown to a number of participants of the construction industry, including three practitioners from construction companies in the construction industry, two officials from related governmental departments, and one university academic member of staff in a relevant discipline. These people were selected for the pilot study on the grounds that they have proper knowledge of and/or prior experience in project RM and empirical research. All of them had over 10 years of working or research experience. Access to the participants was arranged through personal relations with key persons.

Thereafter, individual discussions were carried out to address general and specific issues of the questionnaire regarding relevance, accuracy, phrasing, sequencing and layout of the questionnaire. The respondents in the pilot study commented that generally the questionnaire was comprehensible and coherent and that the features listed in the questionnaire were complete. As they believed that the risk factors and the 28 RM maturity criteria could comprehensively reflect the characteristics of a mature RM program, no new criteria were added.

In addition, based on their comments, revisions were made to improve the clarity and relevance of the statement of RM practices, and the barriers to RM implementation. The results of a pilot survey enabled the development and fine-tuning of the research questionnaire. Based on the feedback received in the pilot study, refinements were made.

The pilot study was an exploratory study, the aim of which was to gain a good understanding of the real RM practice in the respondents' companies. In addition to the findings from the literature review, the pilot study was helpful in revising the initial questionnaire survey questions. The responses from the pilot study were used to validate the questionnaire which was then finalised. The pilot study also helped to convince the study participants to continue their collaboration in the next stage of data collection.

2.6.3 Initial survey

As the need to manage risks in construction is relevant to key project stakeholders (Akintoye and MacLeod, 1997), project owners and contracting organisations with many years of construction practical experience were sought to participate in the study. One-hundred and fifty (150) questionnaires were emailed to senior staff in client organisations, and contracting organisations responsible for RM in the Kuwaiti Construction Industry (KCI). An introduction letter was attached to the survey questionnaires to explain the purpose of this study. The main objectives of questionnaire survey (I) were:

- To survey the perspective of construction professionals on risk factors;
- To survey the current practice of RM in the KCI;

Eighty-two (82) of the questionnaires sent out were filled out by the professionals who occupied different roles in their respective organisations. This represents a response rate of 54.6%, which is acceptable according to Moser and Kalton (1971) Ott and Longnecker (2010) and Ling et al. (2009). In addition, the quality of the responses was considered reliable for further analysis due to the respondents' level of experience.

2.6.4 Main survey

A questionnaire was chosen as the principal survey method. Both questionnaires were conducted through fieldwork, with the projects and respondents being chosen and conducted in advance. Questionnaire survey (II) was intended to target the entire GCC region. The design philosophy of the questionnaires was based on the fact that they had to be simple, clear, and understandable for respondents. The questionnaires were completed face-to-face, by emails or handed out to be collected from each respondent. The questionnaire design took into consideration the main objectives and research questions of interest. In order to achieve the objectives of this research, the questionnaire targeted several dimensions. Those dimensions are:

- To survey the current RM practice of construction firms undertaking projects in the GCC region;
- To survey the use of tools and techniques of RM in construction projects;
- To investigate the major barriers to RM implementation in the GCC construction firms;
- To investigate the RM maturity level of construction firms

2.6.4.1 Design of the questionnaire

One of the objectives of the questionnaire was that it should be quick and easy to complete. This was a crucial objective, as there were many questions due to the fact that the field of RM is so broad. Therefore, the objective was to keep the respondents answering these questions quickly, but efficiently.

Three techniques for used for answering the questions contained within this questionnaire. The five-point Likert scale ranking technique was the most favoured and was used extensively. It is possible to ask more closed than open questions, as responses to closed questions can be given more easily and quickly (Fellows and Liu, 2008). Most of the questions utilised a five-point Likert scale, and some were multiple choice, which permits different statistical techniques to be used to analyse the collected data (Tang et al., 2007). This method offered the respondents a number between 1 and 5, where 1 and 5 were the contrasting extremes of a possible answer (e.g. 1= strongly disagree and 5= strongly agree and the numbers 2, 3, 4 were on a sliding scale in between).

It becomes apparent that the definitions of the ranking systems can vary from one to another, depending on the question's aim (e.g. in other questions: 1= strongly informal and 5= strongly formal). The five-point scale has been widely used in RM studies (Shen et al. 2001; Sun et al. 2008; Zhao et al. 2013b) because it yields better dispersion than the three-point scale (Curtis and Carey 2012).

Also, the questionnaire utilised many simple "yes" and "no" questions. According to Nkado (1995), the "closed" type question is easier to respond to and consequently improves the response rate. A few open-ended questions were also employed. The sequence of the questions was carefully considered, in order to maintain interest and encourage the participants to continue with the questionnaire until the end. This depended heavily on the layout and structure of the questionnaire.

2.6.4.2 Rationale for administrating the questionnaire

The overall objective of the investigation was to ascertain the details of RM practices carried out by professionals in the construction industry in Kuwait (questionnaire I) and the GCC countries (questionnaire II). Some of the respondents from these then served as case studies for the GCC countries (Bahrain, Kuwait, Oman, UAE, Saudi Arabia, and Qatar). The questionnaire was biased specifically towards major projects, therefore it was necessary to involve the largest companies within local sectors, in addition to overseas companies, as they would possess more or the most advanced RM practices.

While there are over 250 companies listed in the Engineering News Record (ENR) Database for the top international companies, only the largest construction companies were identified for the survey as they were most likely to be involved in 'current projects'. These were initially contacted concerning their interest in the survey. The main process followed in distributing the questionnaire was as follows:

1. To identify the largest construction companies operating currently in the GCC countries. The views of the top international firms, regional and local firms were collected.

   An introductory letter was composed and sent to the key persons of each of these companies using verbal communication, in order for them to identify the candidate most pertinent to RM. The objective of this initial contact was to send an electronic copy of the questionnaire to each key person by email. The participant could be in the areas of design, planning, contract, sites, health and safety, quality, control, technical departments, document control, interface, or execution, and personnel at the highest level of management were also contacted. The reason for this was to attain a clear overall picture of any particular company from different perspectives. Also, certain questions were quite specialised, so only specific employees could answer them.

2. If the construction company agreed to participate, then

3. The questionnaires were e-mailed to the relevant people and their responses anticipated. In order to increase the response rate, they were given the choice to complete the survey electronically (i.e. by email), manually (i.e. paper-based form), or by telephone.

2.6.4.3 Format of the questionnaire

An introduction letter was attached to the survey questionnaires to explain the objectives of this study. In this research, the first questionnaire was designed to elicit information on how risks were analysed, managed, evaluated and finally controlled (McKim, 1992). The first questionnaire consisted of three main sections. Section I solicited general information about the respondent such as their contact details, organisational type, qualifications, nationality, years of working experience and position in the organisation. Section II assessed an inventory of risk factors that cause time delays and cost overruns. Section III mapped the actual practice of RM in the KCI.

The second questionnaire consisted of five sections. Section I solicited general information about the respondent. Section II mapped out the general characteristics about their construction company, such as location of projects, location of the company, age of company, list of projects involved with, rate of time delay and cost overruns experienced in these projects, their RM know-how, whether RM activities are undertaken as an individual exercise or group exercise, and if a designated RM department exists in their organisations.

Section III included four questions. The respondents were asked about the performance of construction projects in their organisations. Using a five-point Likert scale (where 1 = strongly disagree, and 5 = strongly agree), the respondents were asked to state the average success of completed projects in terms of schedule adherence, budget adherence, and quality requirements in their organisations. Also, the respondents had to rate to what extent projects' objectives were affected by the risks they had defined. Moreover, the respondents were asked whether there was a difference in managing risks at different stages of the project lifecycle. Also, the respondents were asked whether there is a difference between risk and uncertainty in their opinion. These last two questions were of the yes/no type.

Section IV comprised 13 questions in total. It was designed to obtain deeper insight into the understanding of RM in the respondents' organisations. The respondents were requested to describe the RM approach in their organisations. Also, they were asked to rate how this approach had been standardised, and the adequacy of their organisation's RM system, using a five-point Likert scale. In addition, the respondents were asked to rate the importance of the application of RM, the organisation's capability, and the level of difficulties during the implementation of different RM processes. Moreover, the respondents had to indicate the RM techniques currently used in construction projects using multiple choice questions.

In section V, a total of 15 probable barriers to the success of RM implementation in construction projects were presented and the respondents were requested to rate their agreement to the existence of these barriers in projects that they had participated in. In the last section of the survey, the respondents were asked to express their opinions about the current RM practices in their organisation, regarding different RM processes (identification, analysis, response, and monitoring).

2.6.5 Sample composition

The sampling technique used for this research was a combination of purposive sampling and snowballing. The population of this research study comprises overseas, regional, and local construction companies operating in GCC countries. In this context, overseas construction companies are defined as companies that operate and deliver services globally and away from their country of establishment. These include owners, design consultants, construction project managers, contractors, subcontractors and suppliers, who can be working independently or as a joint venture with local firms.

Purposive sampling procedures were used owing to the nature of the respondents who were to be involved in the study. According to Creswell (2009), purposive sampling is a helpful sampling method as it enables a researcher to collect data from a sample of the target population who know most about the subject theme and meet set criteria.

A sample size of 185 construction companies was extracted from the ENR database of top international contractor companies for the period 2013-2015, and their views were collected. The real issue was to determine which person was at the appropriate level in the organisation to be able to provide the data required for the research (Fellows and Liu, 2008). The respondents were advised of the nature and extent of the data required, including the time required for the completion of any questionnaire or interview (Fellows and Liu, 2008).

The population consisted of all industry practitioners with extensive experience in RM in GCC countries. The non-probability sampling plan has been recognised as appropriate when respondents are not randomly selected from the entire population, but are rather selected based on whether or not they are willing to participate in the study (Wilkins, 2011), and according to (Patton, 2001) it can be used to obtain a representative sample.

2.6.6 Response rate

The first questionnaire was sent to the professionals in the KCI. A total number of 150 questionnaires were produced. Out of the 150, 82 questionnaire responses were received. However, a number were incomplete and following data validation the final sample size was 73. The effective response rate was 48.6 percent. This is considered acceptable since it significantly exceeds the minimum sample size of 30 proposed by many researchers for valid statistical analysis and generalisability of the results (Ott and Longnecker, 2001; Ling et al., 2009). This is based on the central limit theorem that states that even if a population distribution is strongly non-normal, its sampling distribution of means will be approximately normal for large sample sizes (Hair et al., 2010).

The second questionnaire was sent to the top management staff by email or it was handed to them personally. Being handed out personally was preferable to emails because it provided opportunities for conducting interviews in order to collect data for the case studies. All of the fieldwork activities were conducted in GCC countries. In fact, this result has been achieved by guiding the whole questionnaire process through face-to-face contact and follow-up by telephone.

Also, the respondents were recognised experts in their respective organisations (mostly, directors, and managers) with at least 10 years of construction industry experience. The total number of questionnaires distributed was 193, and 130 out of the 193 were completed and returned. Thus the response rate was 67.3 percent. Those participants who had requested the results would then be informed of the results' summary.

Although only 130 samples were collected, the number of samples was considered adequate and representative when compared with other similar studies on risk management in construction. For example, the sample size in Al-Sabah et al. (2014) was 81 out of 122 sent to top multinational companies operating in the Gulf region. Also, the sample sizes in Kuwait (Kartam and Kartam, 2001) and UAE (El-Sayegh, 2008) were 31 out of 61; and 70 out of 200 respectively. Thus the sample size of the study presented compares favourably with those reported in earlier relevant studies.

2.6.7 Semi- structured interviews

Ten semi-structured interviews were conducted with construction professionals in different construction firms in GCC region. The interviews aimed to investigate the same issues surveyed in the questionnaire but more in depth and with a focus on understanding the causes and the reasons behind any practice or decision. The information from the semi-structured interviews was used in the case studies. The interviews were guided by an interview schedule which is available in Appendix 6.

2.6.7.1 Face-to-Face Interviews

Face-to-face interviews allow the interviewer to adapt the questions and to clarify any doubts and issues. During face-to-face interviews, Cavana et al. (2001) affirm that the interviewer has an option to rephrase a question that has not been understood by the interviewee.

2.6.7.2 Telephone Interviews

Telephone interviews were conducted when the potential interviewee and the researcher had difficulty in agreeing on meeting dates. Additionally, telephone interviews were conducted with the interviewees who were demographically difficult to meet due to financial and time constraints for travel. According to Holt (2010), the use of the telephone should be considered as a preferred alternative to face-to-face interviews.

Additionally, telephone interviewing provides an opportunity to obtain data from potential participants who are reluctant to participate visually (Sturges and Hanrahan, 2004). Holt (2010) stressed that telephone interviews provide comfort and convenience to the interviewee, and their success is dependent upon the skills of both the interviewer and the interviewee.

2.7 Data analysis methods

Because most of the respondents' responses were ratings measured on the Likert scale, the data obtained from the survey were mainly ordinal. However, categorical data were also included. Such type of data cannot be treated using parametric statistics methods unless unrealistic assumptions are made about the underlying distributions (Siegel and Castellan, 1988).

Therefore, it was found appropriate to analyse the data using non-parametric statistics involving descriptive statistics analysis, relative index analysis, Correlation test, Chi-square tests and one- way analysis of variance (ANOVA). In all of these, the Statistical Package for the Social Sciences (SPSS) and the Microsoft Excel for Windows application software package were employed. Previous studies adopted different analysis techniques to analyse the collected data, such as: rank cases, ANOVA, and Spearman rank correlation (Tang et al., 2007; El-Sayegh, 2008; Shen et al., 2001; and Tam et al., 2007).

2.7.1 Descriptive statistical analysis

2.7.1.1 Risk Significance Index Score (RSIS)

It is generally accepted that the impact of a risk is calculated by the product of its level of severity and likelihood of occurrence (Cox and Townsend, 1998; Bunni, 2003; Garlick, 2007). A similar approach applied by Shen et al. (2001) to the calculation of the significance scores for the 58 risks encountered with Joint Ventures (JVs) in mainland China. Zou et al. (2007) used this approach for the computation of the significance index scores for the risk factors inherent with construction projects in mainland China.

Knowledge of the significant risk factors at play in KCI projects would offer a useful reference source to practitioners for the factors that require more attention by way of planning to control them. This research adopted the ranking technique often used by many researchers (e.g., Shen et al., 2001; Zou at al., 2007), which is based on the risk significance index score (RSIS), to calculate the different risk factors. Many researchers are of the opinion that means and standard deviations of risk factors do not represent a suitable means of assessing risk rankings as they do not consider both the probability and impact. William (1996) and Andi (2006) contend that the proper consideration of project risks' significance requires consideration of both their impact and probability.

Therefore, in measuring the significance of each risk, participants in this research were requested to rate separately the likelihood of occurrence of each risk and the magnitude of impact on project objectives once the risk occurs. The respondents were required to rate the factors by the extent to which they affect delays and increase costs in construction projects, based on their own experiences on building sites. The significance score for each individual risk assessed by each respondent can be obtained through the equation:

$$S_j^i = \propto_j^i \; \beta_j^i \qquad (1)$$

where S_j^i = significance score assessed by respondent *j* for risk *i*; $\propto_j^i =$ probability of occurrence of risk *i*, assessed by respondent *j*; and β_j^i = degree of impact of risk *i*, assessed by respondent *j*. By averaging the scores from all the 82 responses, it was possible to obtain an average significance score for each risk. This average score is called the risk index score, and it was then used to rank all the risks. The equation used for the calculation of the risk index score can be written as:

$$RS^i = \frac{\sum_1^{82} S_j^i}{82} \qquad (2)$$

where $RS^i =$ index score for risk *i*; and S_j^i = significance score assessed by respondent *j* for risk *i*. To calculate S_j^i, the five-point scales for α and β (very low, low, medium, high, and very high) were converted into numerical scales, where ‘very low’ = 0.1, ‘low’ = 0.3, ‘medium’ = 0.5, ‘high’ = 0.7, and ‘very high’ = 0.9. Based on this numerical scale, the responses from the 82 respondents were input into equations (1) and (2) to calculate the index scores for all risks.

2.7.1.2 Mean score ranking technique

The data collected from both questionnaire surveys were analysed using the mean score method. The mean score method for Likert-type data proved to be a simple and effective tool to establish the relative importance in previous studies (e.g. Wang and Yuan, 2011). The five-point Likert scale (1= strongly disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree) was used to calculate the mean score of each statement, which showed the relative level of agreement with each statement. Then, the mean scores were used to determine the importance ranking of all the variables.

2.7.2 Analytical statistics

2.7.2.1 A one-way between groups of variance (ANOVA)

ANOVA test was conducted to test whether there was any significant difference in the perceptions of the respondents. A p-value < 0.05 indicates that the two groups have different opinions on those particular variables. The significance level of the analysis was set at a p-value of 0.05.

2.7.2.2 Chi- square test

Furthermore, to check the relationship between RM capability levels and firm characteristics, the Chi-square (X_2) contingency table analysis was performed at the significance level of 0.05. This method determines the extent to which a statistical relationship exists between two variables (McClave et al., 2010) and has been viewed as one of the most widely used statistical tools for categorical data analysis (Hwang et al., 2014).

2.7.2.3 Reliability test: internal consistency analysis

The internal reliability of a given scale was evaluated using Cronbach's Alpha. High values of Cronbach's Alpha indicate that all the items included in the scale are measuring the same thing and that their correlations between each other and with the latent variable measured though the items are very strong (DeVellis, 2003). As the average inter-item correlation increases, Cronbach's Alpha increases as well. The lower limit for Cronbach's Alpha can be 0.6 (Hair et al., 2006). In this research, a cut-off value of 0.7 was used to indicate an acceptable level of internal consistency (Nunnally, 1978). However, values above 0.8 are preferable (Pallant, 2013).

2.8 Summary of this chapter

This research adopted a combination of multiple methods in research design and data collection. Two rounds of surveys were conducted. The initial survey identified the importance of key risk factors and the overall performance of construction projects. The main survey questionnaire investigates the RM capability of construction firms in GCC region. Also, it identified the critical barriers to RM implementation. Various descriptive and statistical analysis methods were used to analyse the data collected from the two rounds of surveys.

Chapter Three
Risk and Risk Management

3.1 Introduction

This chapter starts with definitions of risk and uncertainty in general and in construction as the context of this thesis. A differentiating between the concepts risk and uncertainty is clarified. RM process, sub-processes, tools and techniques are discussed and illustrated in accordance to different researches, standards and professional bodies. Later, the current practice of RM in the construction industry is highlighted. This chapter provides a theoretical basis for the next chapters. Table 3 shows the mainstream view of RM studies in the literature review.

Table 3 Literature about different RM streams

Streams	Literature
1. RM systems, barriers, benefits, and techniques	Lyons and Skitmore (2004); Tang et al. (2007); Liu et al. (2007); Wyk et al. (2008); Hwang et al. (2013); Choudhry and Iqbal (2013); Goh et al., (2013); Hartono et al. (2014)
2. Risk identification, assessment, mitigation and allocation	Chan, D. W., Chan, A. P., Lam, P. T., Yeung, J. F., & Chan, J. H. (2011); Gündüz, M., Nielsen, Y., & Özdemir, M. (2013); Wang, J. and Yuan, H. (2011); Hwang, B., Zhao, X. and Gay, M.J.S. (2013); Zhao et al (2013); Gunduz et al. (2013); Liu et al. (2013); Al-Sabah et al. (2014)
3. Risk perceptions	Zou, P. X., & Zhang, G. (2009); Bryde and Volm (2009); Acar and Goc (2011); Mahamid (2011); Zhao et al. (2012); Hartono et al. (2014)
4. RM processes, frameworks, and maturity models	Zhi (1995); Bing and Tiong (1999); Hastak and Shaked (2000); Tah and Carr (2000); Schatteman et al. (2008); Hartono and Yap (2011); Li, J., & Zou, P. X. (2011); Subramanyan et al. (2012); Zhao et al. (2013); Liu, J. Y., Zou, P. X., & Gong, W. (2013); Mu et al., (2014); Zhao et al., (2015)

3.2 Risk definition

Risk is originated from the word, *risqué*, French word. Smith et al. (2006) noted that risk began to appear in England around 1830 when it was used in insurance transactions. The Oxford Dictionary of English (2010) defines the term 'risk' (noun) as 1) a situation that could be dangerous or have a bad outcome; 2) the possibility that something unpleasant will happen; or 3) a person or thing causing a risk. According to Ward and Chapman (2003), this definition illustrates one problem with the term risk – its ambiguous use as a synonym of probability or chance in relation to an event or outcome.

Risk is a multifaceted concept, and there were many different attempts to define risk, among which was that risk is "the potential for unwanted or negative consequences of an event or activity" (Rowe, 1977); "the likelihood of a detrimental event occurring to the project" (Baloi and Price, 2003); or "a barrier to success" (Hertz and Thomas, 1983). Those definitions of risk tend to ignore its double-edged nature, which was recognised in defining risk as "the chance of something happening that will have an impact on objectives; may have a positive or negative impact" (Al-Bahar and Crandall, 1990; Raftery, 1994; Chapman, 1997; Perry and Hayes, 1985). In accordance to Winch (2003) risk is the condition where information is still missing, but a probability distribution can be assigned to the occurrence of the event.

In a project context, risk was defined by the well-known organisation in project management, The Project Management Institute in the Guide to the project Management body of knowledge (PMBoK) as "An uncertain event or condition that, if it occurs, has a positive positive (opportunity) or negative (threat) effect on at least one project's objective, such as time, cost, scope, or quality" (PMI, 2008). Also in UK, the Association for Project Management (APM) has defined risk in its body of knowledge as "uncertain event or set of circumstances that should it occur, will have an effect on the achievement of the project objectives" (APM, 2006). A similar definition was presented by the British Standards Institute. According to the British standard BS IEC- 62198 (2001) risk is "a combination of the probability of an event occurring and its consequences for project objectives". Furthermore, Niwa (1989) and Wideman (1992) define project risk as the chance of certain occurrences adversely affecting project objectives.

These definitions are much representing the perception of risk from construction professionals' point of view. Hence, the aforementioned definitions highlight the direct link between risk and the objectives of project success. Generally, it was found that systemic project RM has an effect on the project success. Since (Ford, 2002) classified the objectives of project success to three main criteria, cost, duration and quality, researchers used to view risk as a probability that any of these performance criteria goes wrong combined with the consequences of such going wrong (Odeyinka et al. 2008).

However, for most practitioners, project RM seems to be about identifying and managing threats. According to Akintoy and MacLeod (1997), construction contractors perceived risk as the likelihood of unforeseen events, which could affect the successful completion of the project in terms of cost, time and quality. Although risk has been defined in various ways, some common characteristics can be found (Chia, 2006). This research has adopted the definition of risk as presented by (PMI, 2008). However, positive events are not our focus in this research.

Risk is a problem that has not happened yet (Cervone, 2006). It may happen or it may not. Risk is characterized by three components i.e. (1) *the risk event*: what might happen to the detriment or in favour of the project; (2) *the probability of occurrence*: the chance of the event occurring; and (3) *the potential loss/gain*: consequence of the event happening that can be specified as loss or gain.

Based on the above characteristics, risk may be measured by multiplying probability of occurrence with its impact (Al-Bahar and Crandall, 1990; Wideman, 1992; and Raftery, 1994). Careful attention should be put, however, in calculating expected value since measuring and ranking risks according to this calculated figure is sometimes misleading (Williams, 1996). Common consequences of project risks are cost overruns, time overruns, poor quality, and disputes among the parties to a construction contract. These risks can be managed, minimized, shared, transferred or accepted but it cannot be ignored (Latham 1994).

3.3 Uncertainty definition

Oxford dictionary define the term ‘Uncertainty’ as following (Hornby 1995): (noun) means 1) the state of being uncertain and 2) a thing that is uncertain or causes one to be uncertain. Whereas ‘uncertain’ (adjective) means 1) feeling doubt about something; not knowing something definitely; not sure, 2) not know definitely; that cannot be confidently predicted or described, 3) not to be depended on; unreliable, 4) likely to vary; tending to change frequently, and 5) not confident.

Uncertainty might be defined as “a situation in which there are no historic data or previous history relating to the situation being considered by the decision-maker.” Uncertain situation is situation that the potential outcomes cannot be described in terms of objectively known nor subjectively known probability distribution (Haimes, 1998). In contrast, the risky situation is the situation when the probability distribution functions of the potential outcomes are known.

Uncertainty is often defined as a result of a shortage of information, defined as the difference between the amounts of information required to perform the task and the amount of information already possessed by the organisation (Galbraith, 1977). Winch (2003) defined uncertainty as the absence of information required for a decision that must be taken at a point in time. According to Raftery (1994), the word “uncertainty” is used where it is impossible to describe a situation in terms of probability of occurrence of an event.

Zimmermann (2000) argued that lack of information is the most probable and frequent cause of uncertainty. However, it can be caused by:

- Complexity and inability to process large amount of data
- Conflicting evidence and contradictory information

- Ambiguity due to linguistic measures, which have different meanings, used to describe a situation
- Imprecise measurements, and
- The subjectivity and belief of the decision maker towards the phenomenon.

By contrast, uncertainty can be stated as a situation, in which the decision-maker has no historic data or experience available to realize the decision-making process related with the future. In other words, uncertainty arises as decision-making is oriented towards the future. Risk can also be defined as the uncertainty that exists as to the occurrences of some events (Odeyinka, 1999).

3.4 Risk and Uncertainty

It is noteworthy that risk is distinguished from uncertainty. The pioneering economist Frank Knight (1921) established the distinction between risk and uncertainty in his seminal work *Risk, Uncertainty, and Profit*. He introduced the differentiating between risk and uncertainty based on the availability of information and the ability to generate a probability distribution.

Risk and uncertainty are inherent in all construction projects, regardless its size (Carr and Tah, 1999; Abdul Rahman Ayub et al., 2007). A review of the literature reveals that the concepts of uncertainty and risk are often used interchangeably. For instance, Achrol (1988) distinguish between uncertainty and risk in the following way: "Risk is said to exist in situations where each outcome has a known probability of occurrence, whereas uncertainty arises where the probability of the outcome of events is unknown".

Hillson (2002) argued that there are two options:

1. ''Risk'' is an umbrella term, with two varieties:

- ‘‘opportunity’’ which is a risk with positive effects;
- ‘‘threat’’ which is a risk with negative effects.

2. ‘‘Uncertainty’’ is the overarching term, with two varieties:
   - ‘‘risk’’ referring exclusively to a threat, i.e. an uncertainty with negative effects;
   - ‘‘opportunity’’ which is an uncertainty with positive effects.

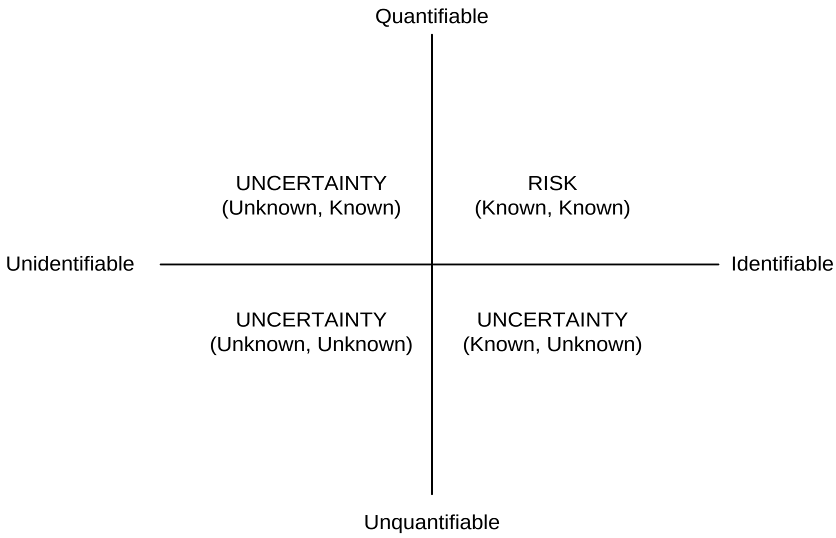

Figure 7 Classification of risk and uncertainty characteristics (Pipattanapiwong, 2004)

Normally, for distinguishing between risk and uncertainty, there are few key variables:

- The uncertainty exists when probability of occurrence of the event is not known (Jaafari 2001);

  The probability of occurrence of an event is considered as the variable used to distinguish between risk and uncertainty. The uncertainty varies between certain, the case in which the probability of occurrence is 100 percent, and impossible, the case in which the probability of occurrence is 0 percent.

- Risk exists when there is a range of possible outcome and the probability of outcome is known, whereas uncertainty exists when the probability of each outcome is not known (Smith, 1999);
  The risk and uncertainty is distinguished by considering the knowledge of probability of outcome.

- Uncertainty is realized when both the probability of occurrence of event and the consequence and probability of outcome are not known.

3.5 RM definition

One of the earliest efforts to define RM process belonged to Hertz and Thomas (1983). They proposed a step-wise procedure of risk identification, measurement, evaluation and re-evaluation. Furthermore, Hayes et al. (1986) defined RM as three stages which are risk identification, analysis and response. They suggested that RM is particularly appropriate during three phases which are project appraisal, development of contract strategy and tender preparation.

According to BSI Guide 73 (2003), RM is defined as coordinated activities to direct and control an organisation with regards to risk and generally includes risk assessment, risk treatment, risk acceptance and risk communication. The Australian / New Zealand standard AS/NZ 4360 (1999) defined RM as a generic framework for establishing the context, identification, analysis, evaluation, treatment, monitoring and communication of risk (Best practices guideline, 2004).

Similarly, The Association for Project Management (2000) defines RM as the process which enables the analysis and assessment of project risks. Project RM is an integrated process which includes activities to identify project uncertainty, estimate their impact, analyse their interactions, control them in the execution stage, and even provide feedback to the maintenance of collective knowledge asset (Williams, 1995).

Dikmen et al. (2004); Turner (1999); and Chapman (1997) have all presented the wider perspective of RM and have stated that RM is one of the most critical project management practices to be followed for successful project completion. In line with these definitions, RM in the construction project management context is a systematic way of identifying, analyzing and dealing with risks associated with a project in an aim to achieve the project objectives.

3.6 RM Process

RM has drawn massive attention from researchers, becoming a debatable subject in the literature. It has taken its part in project management literature from early 1970's till today and preserved its importance as a research topic. Because of that, the Project Management Institute (PMI) recognised RM as one of its nine main knowledge areas in the PMBOK. The process of RM has been widely studied by researchers, organisations, and institutes across the world. However, the most popular sources for generic project RM processes are:

- Project Risk Analysis and Management Methodology (PRAM) introduced by Association of Project Managers (Chapman 1997);
- Risk Analysis and Management for Projects Methodology (RAMP) promoted by Institution of Civil Engineers (2002);
- PMBoK Guide of Project Management Institute (PMI), (2008);
- The International Organisation for Standardization (ISO), (2009); and
- RISKMAN endorsed by European Community (Carter et al. 1994)

All published standards attempt to eliminate informality of RM activities and integrate RM with other project management functions. As shown Table 4, which compares on RM processes amongst these standards, it can be seen that there are close similarities among the given processes. Among all proposed RM version in literature, some prominent RM framework can be mentioned such as: Perry and Hayes (1985), Carter et al. (1994), and Kliem and Ludin (1997).

Table 4 Comparison of general RM processes

RM processes	PMI (2008)	ISO (2009)	IRM (2002)	RAMP (2002)
1. Establish the context				
2. RM planning	√	√		
3. Risk identification	√	√		√
4. Risk analysis	√	√		√
5. Risk assessment		√	√	
6. Risk evaluation				
7. Risk responses	√	√	√	√
8. Risk monitoring	√	√	√	√
9. Risk control	√			
10. RM review and reporting		√	√	
Total processes	6	7	4	4

According to Perry and Hayes (1985), the RM process may consist of elements more or less closely connected. The RM process consists of three phases, as shown in Figure 5:

1. Risk identification;
2. Risk analysis;
3. Risk response

Figure 8 Linear RM process by Perry and Hayes (1985)

During the project's entire life cycle, qualitative or quantitative analysis are carried out for every identified risk and an adequate response prepared. This kind of process is linear by nature and is a good starting point for successful RM. However, any activity undertaken as a risk response may produce new risks, which should be in their turn be identified, analysed and responded to. Thus some authors view RM as a cyclical process.

Carter et al. (1994) produced RISKMAN methodology, which is a practical approach to the management of risk. The purpose of the RISKMAN methodology is to provide a general framework for professional project RM, and guidance for its implementation. According to Carter et al. (1994), the RM process consists of six phases that cyclically repeat themselves:

1. risk identification and documentation;
2. risk quantification and classification;
3. risk modelling (often called risk analysis);
4. risk reporting and strategy development;
5. risk mitigation, reduction and/or optimisation;
6. risk monitoring and control.

Al-Bahar and Crandall (1990) introduced a risk model entitled Construction Risk Management System (CRMS). This CRMS provides an effective and systematic framework for quantitatively identifying, evaluating, and responding to risk in construction projects. It incorporates an influence-diagramming technique to identify the risk-related factors and Monte Carlo Simulation to analyse project risks.

Flanagan and Norman (1993) proposed a RM framework by breaking RM process down to RM system that consists of five stages as:

3 risk identification,
4 risk classification,
5 risk analysis,
6 risk attitude and
7 risk response

This approach contains identification of the source and type of risks and then considers the type of risk and its effects on the project or organisation. Actually, this framework gives a major idea for the forthcoming researches about RM methodologies.

Del Cano and de la Cruz (2002) present Project Uncertainty Management (PUMA) methodology that has been particularized for construction projects, from the point of view of the owner and the consultant. The PUMA is a generic methodology that is proposed based on professional experience of the authors, an analysis of the previously published project RM process and interviews with professionals. The proposed methodology has to be undertaken by companies or institutions with the highest level of RM maturity in the largest and most complex construction project.

Chapman and Ward (2003) introduced Shape, Harness, and Manage Project Uncertainty (SHAMPU). The SHAMPU is a generic RM process consisting of nine steps, is explicitly defined to be iterative with the level of detail (Saari, 2004), and is established based on risk efficiency concept (Chapman and Ward, 2003).

Raftery (1994) proposed his RM cycle as risk identification, risk analysis and risk response. He emphasized that during risk identification three separate risk factors should be considered. These factors are;

1. risks internal to project which are found by breaking the project down into major work packages;
2. risks external to project with emerge from the business and physical environment; and
3. risks due to different perspectives of client, project team and poor quality documentation

Kliem and Ludin (1997) divided the RM process into four phases, as shown in Figure 6:

1. risk identification;
2. risk analysis;
3. risk control;
4. risk reporting.

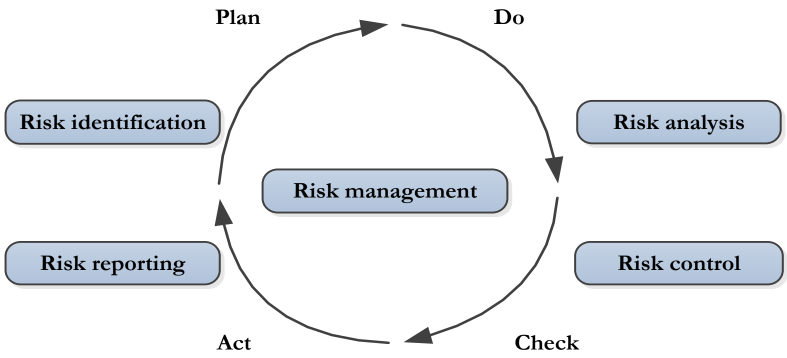

Figure 9 Cyclical RM process, Kliem and Ludin (1997)

The RM process, as proposed in the International Standard ISO 31000, is defined as a set of coordinated activities to control and direct an organisation with regard to risk and consists of four phases: communication and consultation, establishing the context, risk assessment, risk treatment, and monitoring and review. Figure 7 shows RM process phases and relation between phases.

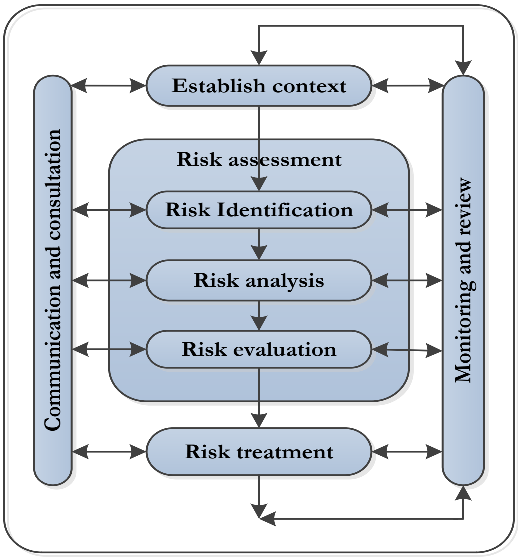

Figure 10 RM process in the ISO 31000

Project Risk Analysis and Management (PRAM) Guide was drafted by Chapman (1997) for the Association of Project Managers. It designed to provide a formal RM processes (RMP) for the largest projects in generic terms. PRAM has a special importance because it was the first highly comprehensive process developed by a large number of persons, including a mix of practitioners and academics, with results of very high quality. Nine phases of PRAM methodology start with define phase and continues with focus, identify, structure, ownership, estimate, evaluate, plan phases and finishes with manage phase. The PRAM guide (APM, 2004) clearly states that although the process can be implemented at different levels of detail, it all depends on the degree of maturity of organisational risk capability. The combination of all those phases forms PRAM approach, which provides a clearly defined, formal, flexible RM methodology. PRAM facilitates application of RM principles to the projects. Figure 8 shows nine-phase structure of PRAM methodology.

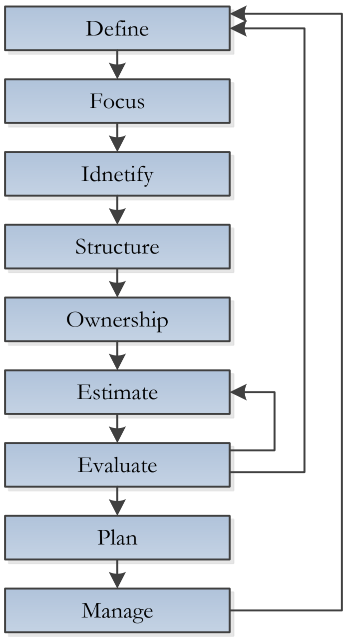

Figure 11 Nine phase RM process of PRAM methodology, Chapman (1997)

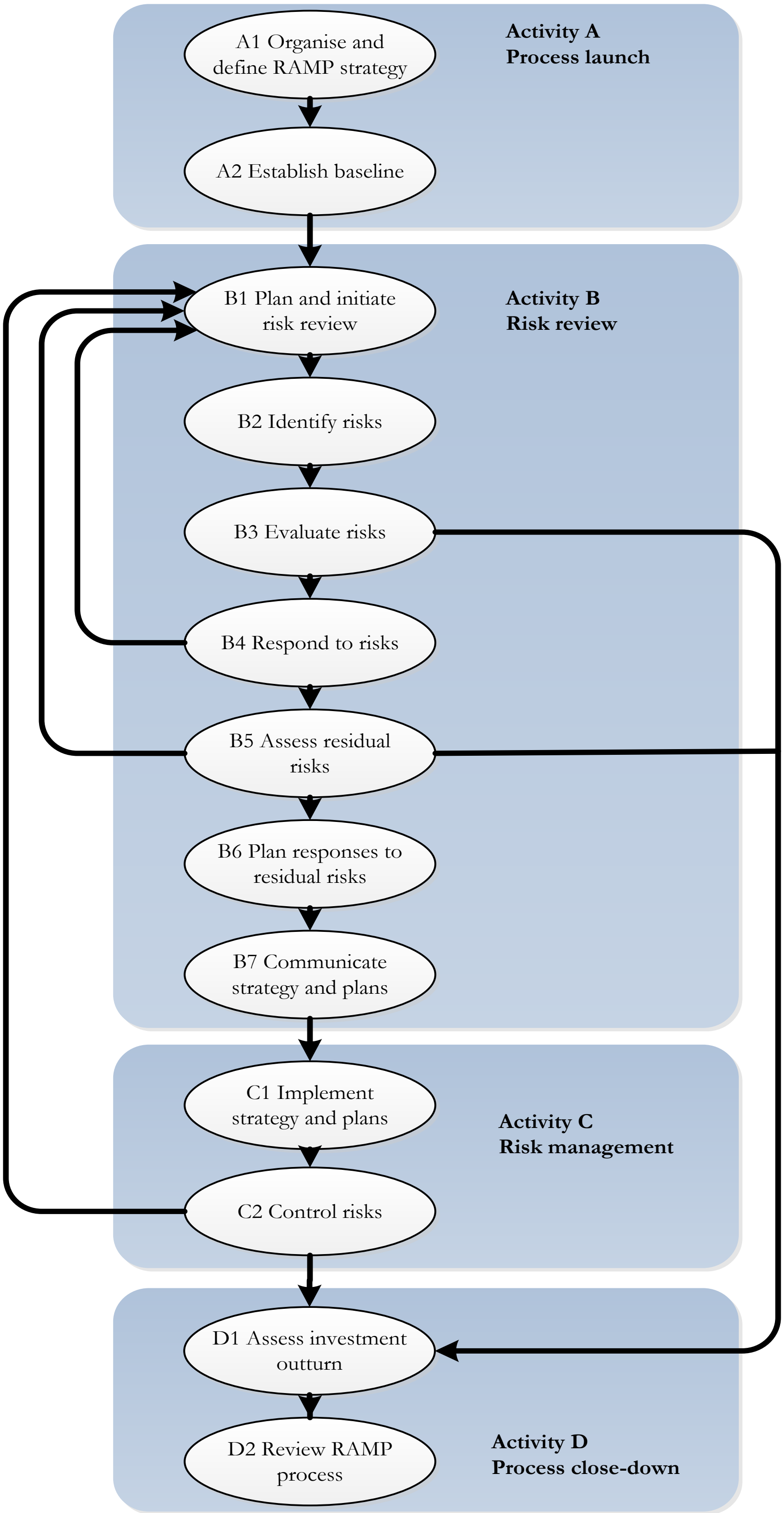

Figure 12 RAMP process flowchart (ICE et al., 2002)

Risk Analysis and Management for Projects Methodology (RAMP) promoted by Institution of Civil Engineers (1998) is a comprehensive framework designed to provide a useful and practical framework for the identification, analysis, mitigation and control of risks inherent in a complex activity, shown in Figure 9. In the case of a project, RAMP covers entire lifecycle of the project, from initial conception till eventual termination. The process facilitates risk mitigation and supplies a system for the control of residual risks. The RAMP process consists of four major activities, which are generally carried out at different times in the lifecycle of a project.

British standards institute provided a similar RM process as shown in Figure 10. According to BSI-6079-3 (2000), there are two broad stages within the RM process. The first stage concentrates on defining the scope of risks to be managed. The second stage deals with assessing, and managing risk. Under these two main phases, the RM process consists of five key steps:

- Defining context: acknowledging the objectives of the business or the project and understanding the linkage between project objectives and the organisation's strategy.
- Identifying and categorising risks affecting the pre-defined objectives
- Assessing risks' likelihoods and impacts
- Combining the assessments of probability of occurrence, and potential impact to prioritise the risks for further analysis.
- Treating risks by identifying different treatment options and then applying the suitable strategies.

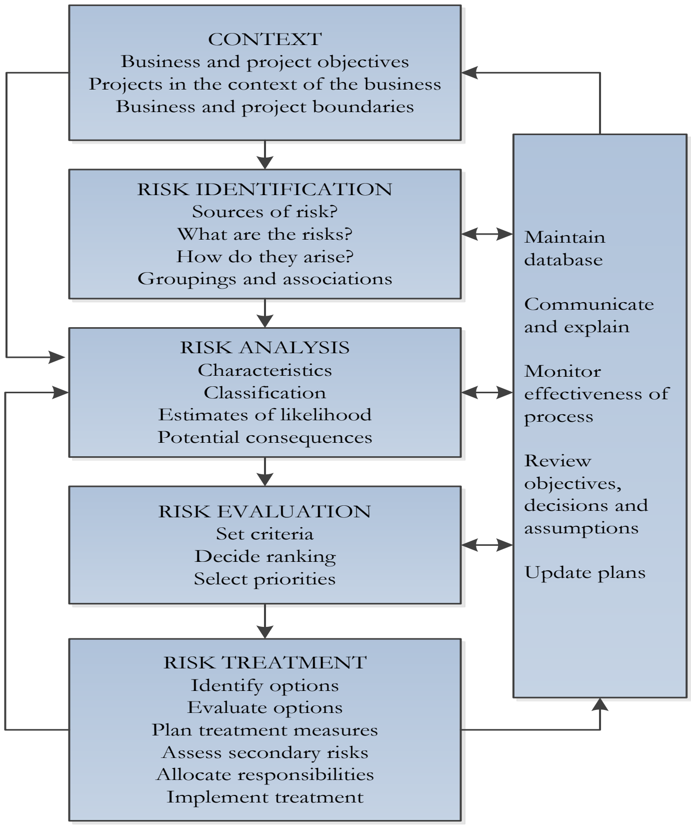

Figure 13 RM process (BS 6079-3:2000)

PMI which is the largest professional organisation is dedicated to project management field. PMI (2008) proposes six major processes for RM. These processes are iterative and their phases are developed over the project life cycle. PMI proposed this methodology to eliminate informality of RM application by the sector participants. The processes should interact with each other.

Each process may involve effort from one or more individuals or groups of individuals based on the needs of the project. From the framework of RM process shown in Figure 11, it is observed that each phase is a complementary process of the forthcoming one. Furthermore, outputs are the inputs for other processes, which facilitate making feedback and updating the RMP. According to PMI (2004), project RM processes include the following elements:

- RM planning: comprehending the business case and the project objectives and deciding how to plan and execute RM activities.
- Risk identification is about determining the key risks that might affect the project and documenting their characteristics. This information will be stored in risk register.
- Qualitative risk analysis is about assessing the likelihood of occurrence and the impact of the identified risks in linguistic terms.
- Quantitative risk analysis is a sophisticated and numerical analysis based on historical data to assess the effect of the identified risks on achieving project objectives.
- Risk response planning is about developing strategies to deal with the downside of the risks and planning for turning them into opportunities.
- Risk monitoring and control: tracking the identified risks, monitoring any new risks, monitoring the execution of the response strategies and evaluating their effectiveness.

RM is not constrained to a project level; it is widely performed on an organisation level. Actually, Enterprise risk management (ERM) is perceived as the ultimate approach to RM (COSO, 2004). Literature is rich of standards and guidance to manage risk on an organisation level such as ISO 31000 and the RM standard published by AIRMIC, ALARM and IRM in 2002.

By reviewing the different approaches recommended by the main professional bodies and standard organisations, one can appreciate a clear consistency between them regarding the component of a formal RM process. Because risk analysis and response generation are performed considering the predefined risks, risk identification is accepted to be the most critical step in RM (Al-Bahar and Crandall, 1990). However, risk identification is not an easy task; construction projects usually involve a high level of uncertainty, vagueness, complexity and vulnerability to both internal and external conditions.

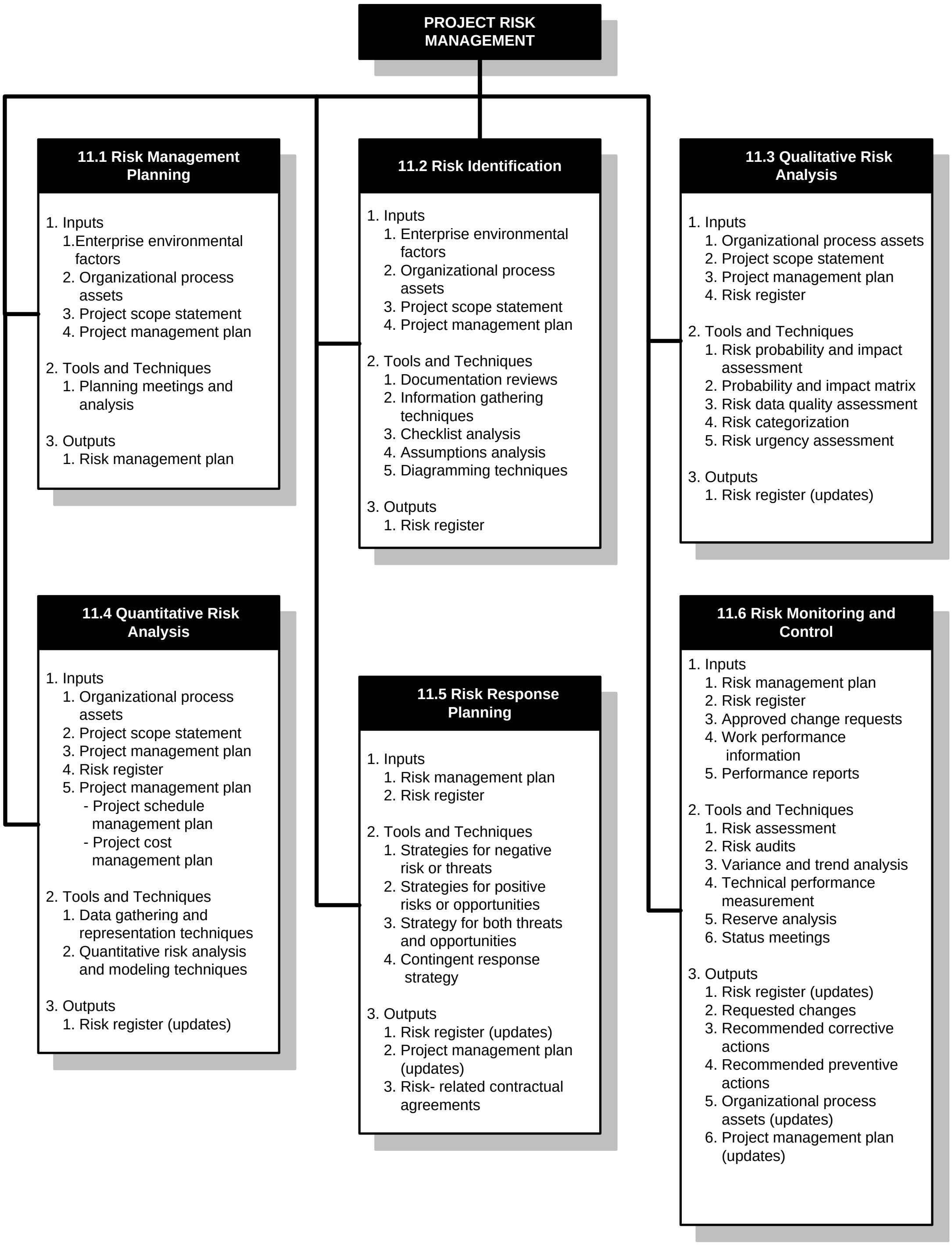

Figure 14 PRM process according to PMI (PMI, 2008)

Among the main components, risk assessment is probably the most difficult one to be conducted (Thomas et al. 2006). The focus of this research is on risk identification, risk assessment, risk response, and risk monitoring in construction industry. However, before investigating each phase in detail, it is worth illustrating how to identify and classify the key risks which are to be assessed later.

Finally, it can be noted that the aforementioned RM methodologies and standards, have similar characteristics and common goals. The researchers agree that RM frameworks and methodologies propose several benefits to users, for example:

- imply a systematic approach for RM by following a risk identification-analysis-response monitoring loop (Dikmen et al., 2004)
- aim to minimize overall risk impacts
- aim to eliminate informality of RM activities
- aim to formalize and systematize RM process
- aim to integrate RM with other project management functions
- there are slight differences in model architectures, number of phases, level of detail, and coverage of project life cycle
- facilitate clear definition of specific risks associated with particular projects and force the user full use of his/her experience and skills
- give necessary importance to documentation and propose development of a knowledge pool by accumulation of individual's knowledge which can be further converted to corporate knowledge
- the aim of risk identification and risk analysis is to enable the decision maker to take action or response in advance of problem solving
- encourage the user to make pre-planning which leads to use of pre-evaluated responses to risks

3.6.1 Risk identification

Risk identification is the first stage in RM process and considered by many authors to be the most important element of the process. This is acknowledged by many authors, such as, Cooper and Chapman (1987), Hertz and Thomas (1983), and Perry and Hayes (1986). The main benefits of RM come from the identification stage (Bajaj et al., 1997), but, it has received the least attention in the literature (Raftery , 1994).

Hertz and Thomas (1983) described risk identification as equivalent to risk diagnosis. Al-Bahar and Crandall (1990) defined risk identification as "the process of systematically and continuously identifying, categorizing, and assessing the initial significance of risks associated with a construction project". Toakley and Ling (1991) reported that if a risk is not identified it cannot be controlled, transferred or otherwise managed. The risk identification is an iterative process because the risks may evolve or new ones may become known as the project progresses through its life cycle (Nieto-Morote and Ruz-Vila, 2011). Therefore, it is desirable to identify the risks as early as possible (Wang et al., 2004). There are some risk identification tools in use, including: checklist, influence diagrams, cause and effect Diagrams, failure mode and effect analysis, hazard and operability study, fault trees and event tree (Ahmed et al., 2007).

There is no single best method for risk identification (Hillson, 2002) and an appropriate combination of techniques should be used. In literature, a large number of techniques exist for risk identifications, such as brainstorming, workshops, checklists, questionnaires, interviews, Delphi groups, Nominal Group Techniques, and various diagramming approaches (cause- effect diagrams, systems dynamics, influence diagrams, etc.)

A comprehensive literature review of 55 previous studies on risk identification and assessment was conducted to survey the common risk factors affecting construction projects. Table 5 shows risk factors used in this research. Risk factors have been assessed using RSIS method by construction professionals in Chapter 5.

3.6.2 Risk categorization

As an integrative part of risk identification, risk categorization structures the diverse risks that affect a project (Zou et al., 2007). There are many different risk sources in the construction projects and some approaches have been suggested in the literature for classifying them. Some classifications are focused on the risks nature and their magnitude (Cooper and Chapman, 1987; Shen et al., 2001) or on the risks origin (Edwards and Bowen, 1998; Zhou et al., 2008).

Other proposals use a hierarchical structure of risks (Tah et al., 1993; Wirba et al., 1996) to classify risks according to their origin and to the location of the risk impact in the project. There are various ways for categorizing risks in construction projects. Some researchers categorize risks into internal risks and external risks (El-Sayegh, 2008; Fang et al., 2004; Wang and Chou, 2003; Aleshin, 2001; Al-Sabah et al., 2014), while others classify risk in more detailed categories of political risk, financial risk, market risk, intellectual property risk, social risk, safety risk, etc. (Songer et al., 1997).

Many existing categorisations which reflect the widely differing views of authors on risk have been reviewed to develop a categorisation scheme for risk in a construction project. As there is no single categorization of risk which is agreed upon by all researchers, different typologies are proposed serving different purposes (Dikmen et al., 2004).

The fact is that a standard or consensus on how to classify risks does not currently exist. However, the rationale for choosing a method must serve the purpose of the research. In this research, risks were grouped with reference to (Zhi, 1995; Wang et al., 2004) method in order to study risks from an international perspective, such as: country level, industry and market level, firm capability level, and project implementation level.

3.6.2.1 Classification criteria and hierarchical structure of risks

As there is no single categorization of risk which is agreed upon by all researchers, different typologies are proposed serving different purposes (Dikmen et al., 2004). The fact is that a standard or consensus on how to classify risks does not currently exist. However, the rationale for choosing a method must serve the purpose of the research. In this research, risks were grouped with reference to (Zhi, 1995; Wang et al., 2004) method in order to study risks from an international perspective, such as: country level, industry and market level, firm capability level, and project implementation level. Figure 12 shows the hierarchical structure of risks identified in this research.

For the country and surroundings level, the risks are divided into four categories:

1. Political
2. Economy and finance
3. Society and culture
4. Region and environment

For the construction industry and market level, the risks are divided into three categories:

1. Construction market
2. Regulation and law
3. Government

For the capability of construction firms' level, the risks are divided into four categories:

1. Organisation and human resources
2. Finance administration
3. Techniques
4. Project management capability

For the project management and implementation level, the risks are divided into six categories:

1. Conflicts and claims
2. Quality and safety
3. Design and construction
4. Operation and maintenance
5. Site management
6. Contracts

Table 5 Risk identification in previous studies

ID	References	Country and surroundings				Industry and market			Capability of construction firms			Project management and implementation					
		Political	Economy & Finance	Society & Culture	Region & Environment	Construction	Regulation & Law	Government	Organisation & Human	Finance Administration	Project Management	Conflicts & Claims	Quality & Safety	Design & Construction	Equipment & Maintenance	Site Management	Contracts
	Overseas construction market																
1	Mansfield (1994)					√						√		√			√
2	Zhi (1995)	√	√	√		√	√		√	√	√			√	√		√
3	Ashley and Bonner (1987)	√															
4	Ahmed et al. (1999)	√	√		√	√	√	√		√		√	√	√	√		√
5	Ogunlana et al. (1996)								√	√	√	√	√	√	√	√	√
6	Chan and Kumaraswamy (1997)								√	√	√	√	√	√	√	√	√
7	Kaming et al. (1997)				√					√	√	√	√	√	√	√	√
8	Han and Diekmann (2001)	√	√	√	√	√					√	√			√		
9	Shen et al. (2001)	√	√		√	√	√	√	√	√	√				√		√
10	Chan and Tse (2003)			√													
11	Frimpong et al. (2003)		√		√					√	√	√	√	√	√	√	√
12	Baloi and Price (2003)	√	√	√	√	√			√					√			
13	Fang et al. (2004)	√	√					√			√	√	√	√	√	√	√
14	Wang et al. (2004)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
15	Ghosh and Jintanapakanont (2004)	√	√	√	√	√	√		√	√	√	√	√	√	√	√	√
16	Andi (2006)	√	√		√			√	√	√		√	√	√	√	√	√
17	Wiguna and Scott (2006)	√	√		√			√	√	√		√	√	√	√	√	√
18	Sambasivan and Soon (2007)				√	√			√	√	√	√		√	√	√	√
19	Dikmen et al. (2007)								√		√	√			√		√
20	Ozorhon et al. (2007)	√	√	√	√	√			√								
21	Tang et al. (2007)				√				√	√	√	√	√	√	√	√	√

Table 5 Risk identification in previous studies – continuation

	References	Country and surroundings				Industry and market			Capability of construction firms			Project management and implementation					
		Political	Economy & Finance	Society & Culture	Region & Environment	Construction	Regulation & Law	Government	Organisation & Human	Finance Administration	Project Management	Conflicts & Claims	Quality & Safety	Design & Construction	Equipment & Maintenance	Site Management	Contracts
22	Zhang and Zou (2007)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
23	Zou et al. (2007)				√	√		√	√	√	√	√	√	√	√	√	√
24	Jha and Devaya (2008)	√	√	√		√						√	√				√
25	Skorupka (2008)	√	√	√	√						√	√	√	√	√	√	√
26	Zayed et al. (2008)	√	√	√		√	√		√			√	√	√	√	√	√
27	Luu et al. (2009)								√	√	√	√	√	√	√	√	√
28	Chan et al. (2011)	√	√		√	√	√	√	√		√	√	√	√	√	√	√
29	Zhang (2011)			√													
30	Nieto- Morote and Ruz-Vila (2011)					√			√	√	√		√	√		√	√
31	Alarcon et al. (2011)		√						√			√	√	√	√	√	√
32	Subramanyan et al. (2012)	√	√		√	√	√	√	√	√	√	√	√	√	√	√	√
33	Gündüz et al. (2012)				√						√	√		√	√	√	√
34	Kuo and Lu (2013)	√	√		√	√			√	√		√	√	√	√	√	√
35	Lu and Yan (2013)				√			√	√	√			√	√	√		√
36	Goh et al. (2013)											√	√	√	√	√	√
37	Hwang et al. (2013)								√	√	√			√	√	√	√
	Regional construction market																
38	Assaf et al. (1995)											√		√			√
39	Mezher and Tawil (1998)									√		√					√
40	Al-Khalil & Al-Ghafly (1999)									√		√					√
41	Al-Momani (2000)																√
42	Kartam and Kartam (2001)	√	√		√		√	√			√	√	√	√	√	√	√
43	Odeh and Battaineh (2002)				√	√			√		√	√		√	√	√	√

Table 5 Risk identification in previous studies – continuation

ID	References	Country and surroundings				Industry and market			Capability of construction firms			Project management and implementation					
		Political	Economy & Finance	Society & Culture	Region & Environment	Construction	Regulation & Law	Government	Organisation & Human	Finance Administration	Project Management	Conflicts & Claims	Quality & Safety	Design & Construction	Equipment & Maintenance	Site Management	Contracts
44	Koushki et al. (2005)									√							
45	Faridi & El-Sayegh (2006)				√	√	√	√	√	√	√	√	√	√	√	√	√
46	Assaf and Al-Hejji (2006)			√	√	√	√	√	√	√	√	√	√	√	√	√	√
47	El- Razek et al. (2008)	√								√		√	√	√	√	√	√
48	El-Sayegh (2008)	√	√	√	√		√		√	√	√	√	√	√	√		√
49	Sweis et al. (2008)				√				√	√	√	√	√	√	√	√	√
50	Tumi et al. (2009)				√				√	√	√	√	√	√	√	√	√
51	Alnuaimi et al. (2009)								√	√	√	√	√	√	√	√	√
52	Abdul-Rahman et al. (2011)	√	√			√	√	√	√	√	√	√	√	√	√	√	√
53	Mahamid (2011)	√	√	√	√	√	√	√		√	√	√	√	√	√	√	√
54	Loo et al. (2013)	√	√	√	√												
55	Al-Sabah et al. (2014)	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

Table 6 Risk factors identified from previous studies

Level	Category	Factors
Country level	Political	Monopoly materials because of closures or unexpected political factors
		Restricted access/ external or internal military action
		Unstable political situation and change of government
		Workers strike
		Civil wars and revolutions
		Delay and difficulty in approval of permits to work
	Economy and Finance	Unanticipated inflation and interest rates
	Society and Culture	Language barriers and cultural differences
		The lack of security and stability
		Theft
	Region and Environment	Delay in land acquisition
		Differing site conditions from what was expected
		Force majeure by natural disasters
		Adverse weather conditions and environmental change
		Unforeseen ground conditions
		Poor accessibility to the construction site and vulnerable construction conditions
Industry and market level	Construction	Shortage of skilled labour
		Low performance level of labour
		Low capability of subcontractor
		Low availability of experienced and qualified subcontractors
		Unavailability of required materials in markets
		Shortage in equipment / and required spare parts
	Regulation and law	Lack of presence of engineering specialists in resolution of conflicts
		Third party delays
	Government	Change in standards and specifications
		Delay in the settlement of contractor claims
		Lack of presence of arbitrators
		Delay of materials procurement
Firm capability level	Organisation & Human Resources	Absence of advance information (host country and firms)
		Lack of technical skills and construction experience
	Finance Administration	Lack of capability to provide sufficient cash flow
		Lack of capability in cost estimation and price
		Lack of capability in materials estimation
	Project Management	Inadequate cost forecasting
		Insufficient use of management techniques
		Lack of capability of contract management and administration
		Inadequate of method of statements

Table 6 Risk factors identified from previous studies – continuation

Level	Category	Factors
Project implementation level	Conflicts & Claims	Worsening in relations between constituent members and organisations
		Conflicts between local firms and subcontractors
		Conflicts among project parties
		Unreasonable requests for changes in design from employer
		Delay in progress payments
	Quality and Safety	Changes in material types and specifications during construction
		Gaps between implementation and specifications
		Reconstruction on account of design errors and defects
		Occurrence of accidents
	Design and Construction	Client induced additional work beyond
		Project complexity
		Lack of design capabilities and experience
		Creep in scope of project
	Equipment and Maintenance	Unexpected breakdown for equipment
		Failure in equipment
		Equipment maintenance difficulties
	Site Management	Lack of capability of financial planning for the project
		Lack of capability in supervising engineers/supervisors and dealing with business
		Effects of subsurface conditions (type of soil, water table)
		Shortage of construction materials on site
		Delay in the approval of the materials used
	Contracts	Actual quantities differ from the contract quantities
		Unclear contract terms, conditions, and provisions
		Delay in preparation of shop drawings
		Delay in approval of shop drawings
		Lack/inaccuracy of BOQ in contracting total amount
		Inaccurate time estimate

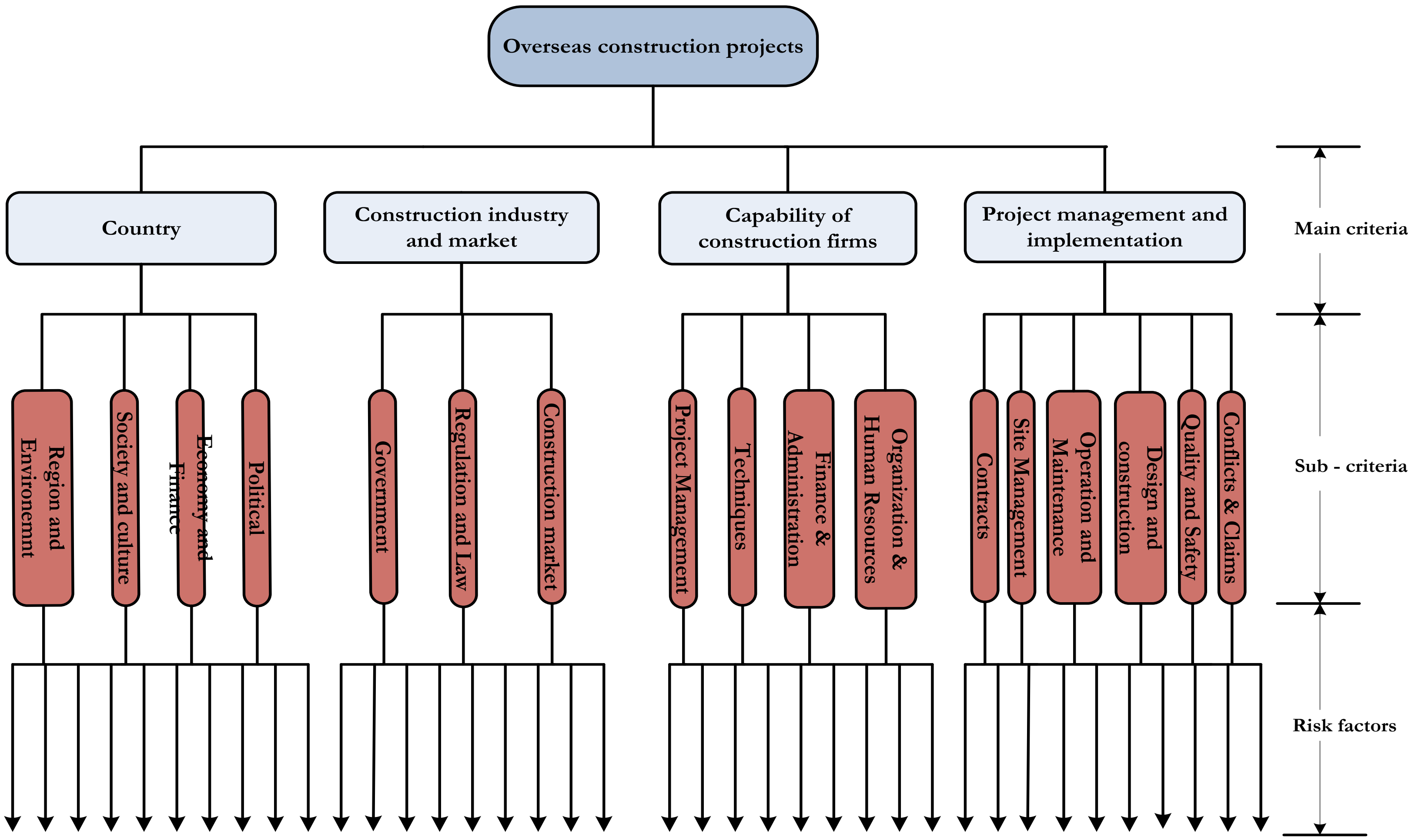

Figure 15 The hierarchical structure of risks

3.6.3 Risk assessment

The purpose of risk assessment is to understand and quantify the likelihood of occurrence and the impact of a risk on project outcomes (The Office of Government Commerce, 2007). According to PMI (1992), risk assessment aims to increase the understanding of the project, identify alternative delivery methods, consider all risks and uncertainties adequately in a systematic and structured way and ascertain the effects of risks on all project aspects.

Flanagan and Norman (1993) argued that there is a gap between the existing RM techniques and their applications by construction contractors. Many reasons have been put forward to explain why this is the case. It seems that risk assessment is believed to be a major reason. However, risk assessment is frequently perceived as the most useful part of the RM process (Smith et al., 2006).

Risk assessment can be conducted qualitatively or quantitatively. The choice between quantitative or qualitative method depends upon the amount and type of information available for the analyst. Usually, risk assessment starts, as in the early stages of the project life cycle, with a qualitative approach because of lack of sufficient information to properly apply any quantitative methods (Smith et al. 2006). Quantitative analysis may be applied later when more data become available (BS-IEC-62198 2001).

3.6.3.1 Qualitative risk assessment

Identified risks are assessed qualitatively to determine their likelihood and potential effect on project objectives, allowing risks to be prioritised for further attention. The primary technique for this is the Probability– Impact Matrix, where the probability and impacts of each risk are assessed against defined scales, and plotted on a two-dimensional grid. Position on the matrix represents the relative significance of the risk, and high/ medium/low zones may be defined, allowing risks to be ranked.

Table 7 Probability-Impact Matrix (PMI, 2008)

Probability	Threats					Opportunities				
0.90	0.05	0.09	0.18	0.36	0.72	0.72	0.36	0.18	0.09	0.05
0.70	0.04	0.07	0.14	0.28	0.56	0.56	0.28	0.14	0.07	0.04
0.50	0.03	0.05	0.10	0.20	0.40	0.40	0.20	0.10	0.05	0.03
0.30	0.02	0.03	0.06	0.12	0.24	0.24	0.12	0.06	0.03	0.02
0.1	0.01	0.01	0.02	0.04	0.08	0.08	0.04	0.02	0.01	0.01
	0.05	**0.10**	**0.20**	**0.40**	**0.80**	**0.80**	**0.40**	**0.20**	**0.10**	**0.05**

Impact (numerical scale) on an objective (e.g., cost, time, scope or quality)

3.6.3.2 Quantitative risk assessment

After conducting a qualitative analysis, the prioritised risks are subject to numerical and more detailed analysis. Different tools can be used for assessing risk quantitatively. According to PMI (2004), the most commonly used techniques in quantitative risk assessment are:

- Sensitivity analysis: determines risks which have the biggest potential impact on project objectives. However, this tool has a limitation of being unable to deal with more than one risk simultaneously; it is difficult to consider the effect of multiple risks.
- Expected monetary value analysis (EMV): calculates the weighted average outcome when different scenarios are likely to happen with different probabilities.
- Decision tree analysis: evaluates different options based on their EMVs.
- Modelling and simulation, mainly Monte Carlo Simulation (MCS), techniques: widely used in construction management for cost and duration estimation. However, simulation methods can only analyse either duration or cost risks (Poh and Tah, 2006).

3.6.4 Risk response/ treatment

The third stage of RM process is the risk response/ treatment stage. According to Aloini, *et al*. (2012), risk response/treatment deals with developing a mitigating strategy to effectively minimise the effects of the identified risks.

These risks can be managed, minimized, shared, transferred or accepted but it cannot be ignored (Latham, 1994). There are three classic approaches to risk response, such as:

- Risk retention or acceptance is the decision to acknowledge and manage the risk.
- Risk reduction entails activities that reduce the probability of the risk occurring or the severity of the impact if the risk does occur.
- Risk transfer is the shifting of risk to another party either by “selling” the risk or outsourcing to an appropriate specialist (Schatteman, *et al.*, 2008).

3.6.5 Risk communication, monitoring, and control

The final stage of a RM process is risk communication, monitoring and control. This stage aims to ‘put the plan into action’ in order to improve project performance, for example, monitor the status of identified risks, identify new risks, ensure the proper implementation of agreed responses and review their effectiveness, as well as monitoring changes in overall project risk exposure as the project progresses. The output of previous stages is transferred onto a standardised framework such as a ‘risk register’ and then communicated to the project team for action. Therefore, RM becomes on-going or cyclical – the dynamic nature of the construction environment warrants continuous identification of new risks which spark off the entire process yet again.

Risk treatment and risk monitoring and control are within the scope of this research. Hence, a capability criterion was covered in the capability model to investigate the current status of construction organisations through RM processes.

3.7 Summary of this chapter

Earlier in this chapter the definitions for risk and RM were discussed, and the distinction between risk and uncertainty was described. Also, RM processes in different international guidelines were explained and highlighted. Moreover, this chapter summarized the mainstream view of RM studies as presented in the RM literature within the construction industry. The following sections present the results for each of the four key dimensions as well as how the literature has observed them in combination. The papers were reviewed and then categorised into four different streams of literature, which form the basis for the rest of the thesis. The available research studies reported in the literature can be categorised into four main research themes:

1. Investigations into RM barriers, benefits, and usage of RM techniques and tools (see for example, Chapman, 1998; Lyons and Skitmore, 2004; Tang et al., 2007; Choudhry and Iqbal, 2013; Goh et al., 2013);

2. Studies focusing on risk identification, assessment, mitigation and allocation (see for example, Wang et al., 1999; Kartam and Kartam, 2001; Shen et al., 2001; Al-Sabah et al., 2014);

3. RM as practiced in both developed and developing nations (see for example, Kangari, 1995; Ahmad et al., 1999; Thevendran and Mawdesley, 2004; Zhao et al., 2012; Hartono et al., 2014).

4. Development of RM processes, frameworks, and maturity models (see for example, Hastak and Shaked, 2000; Ng et al., 2003; Warszawski and Sacks, 2004; Zhang and Zou, 2007; Imbeah & Guikema, 2009; Liu, et al, 2013).

Chapter Four
RM Implementation in Construction Firms

4.1 Introduction

This chapter discusses the RM implementation in construction firms and the barriers for effective implementation of RM system. It also, mapped the common barriers of using RM techniques and tools in practice in both developed and developing countries.

4.1.1 Number of selected papers annualy

The number of published research papers continues to grow as shown by Figure 16, which depicts the annual publication rate over 30-year period from 1985 to 2015. The rational behind focusing on this period is that mainstream construction RM studies generally began to emerge from 1985 onwards. As can be seen, the rate of publication remind relatively uniform until 2001, beyond which it exhibited substantial increase in number.

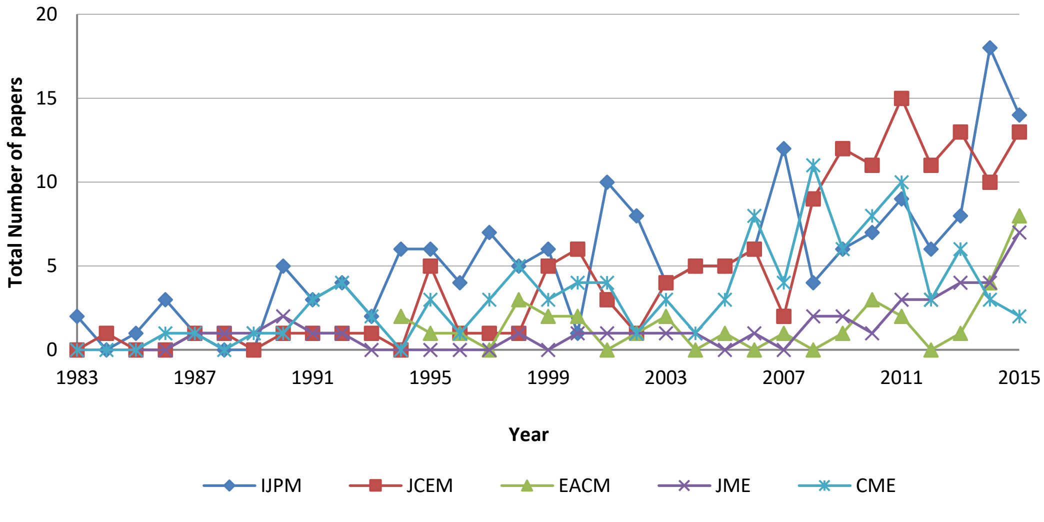

Figure 16 Number of RM papers published

4.1.2 Publication name

The journals belong to the list of top construction journals ranked by Chau (1997), including *Construction Management and Economics*, *Journal of construction Engineering and Management*, *Engineering Construction and Architectural Management*, *Journal of Management in Engineering*, and *International Journal of Project Management.*

There were 248 papers from *Journal of construction Engineering and Management*, which comprised 40% of all papers. This demonstrates the significance of *Journal of construction Engineering and Management* in the domain of construction RM.

4.1.3 Country/ region distribution

As shown in Table 10, this review focused on where each study was conducted. Some of the papers, which couldn't be classified within one country, or which couldn't be cleared in which country the study was conducted, would be classified under 'others'.

Both developed countries/regions and developing countries/regions were contained. This indicates that there has been a global focus on the topic of RM in construction industry. Approximately a third (33.3 %) of the studies were conducted in the United States.

Following this were studies in United Kingdom, Australia, China, Singapore, Hong Kong, South Korea, Canada and Taiwan. In other countries, not more than ten studies were conducted. The developed countries/regions accounted for a large proportion of publications (up to 82.7%).

Table 8 Articles according to country/region distribution

Country/ region	Number
United States*	184
United Kingdom*	62
Australia*	49
China*	31
Singapore*	30
Hong Kong*	29
South Korea*	25
Canada*	20
Taiwan*	12
Sweden*	10
Turkey	9
Israel*	7
United Arab Emirates	5
New Zealand*	5
South Africa	5
India	5
Spain*	4
Finland*	4
Saudi Arabia	4
Malaysia	3

**Developed countries*

4.1.4 Research level

Zhou et al. (2013) classified the studies in construction management to five levels: industry level, company level, project level, sub-project level and process level. This research, adopted a similar classification approach from the perspective of RM. A diverse number of papers in construction RM were conducted on project level, which represents 49% of the total number of RM studies, followed by 24.5% and 9.43% for industry level and country level, respectively.

For instance, Baloi & Price (2003) developed a fuzzy decision framework for contractors to handle global risk factors affecting construction cost performance at a project level. Ghosh and Jintanapakanont (2004) identified the essential risk variables associated with infrastructure projects. Medda (2007) analysed through a game framework the behaviour of the players when confronted with opposite objectives in the allocation of risks at a project level.

Several papers studied the RM from industry level. Al-Khattab et al. (2007) described and explained the political risks that concern the managers of Jordanian international projects. El-Sayegh (2008) identified and assessed the significant risks in the United Arab Emirates construction industry and addresses their proper allocation. Kartam and Kartam (2001) examined the perspective of contractors on construction risk in the Kuwaiti's construction industry. Other studies concentrated on construction process. Zeng et al. (2007) presented a new risk assessment methodology to cope with risks in complicated construction situations at process level (steel erection).

4.1.5 Project Objectives/Goals

Most of the developments in RM in the engineering construction industry have focused on project cost (Hayes et al., 1986; Perry, 1986; Cooper and Chapman, 1987; Flanagan et al., 1987; Jaafari, 1988; Yeo, 1990; Ranasinghe, 1994b). Ang et al. (1975) and Ranasinghe (1994a) developed approaches to manage risks in project duration. Perry and Hayes (1985b); Thompson and Wilmer (1985); Ranasinghe and Russell (1992) and Russell and Ranasinghe (1992) developed approaches to manage risks in both project duration and cost. Previous research has mainly focused on examining the impacts of risks on one aspect of project strategies with respect to cost (Chen et al., 2000), time (Shen, 1997) and safety (Tam et al., 2004).

4.1.6 Project phase

There is a better chance of providing a risk-free environment for construction projects if measures are taken from the outset of a project (Zhou et al., 2013). According to the literature review coding results, several papers focused on the construction phase. This could relate to the high number of risks in this stage of project. Some researchers investigated RM for construction projects in the context of a particular project phase, such as conceptual/feasibility phase (Uher and Toakley, 1999), design phase (Chapman, 2001), construction phase (Abdou, 1996), rather than from the perspective of a project life cycle. However, Zou et al. (2007) developed strategies to manage the unique risks from the perspectives of project stakeholders and life cycle in light of Chinese construction industry.

4.2 Barriers to successful RM implementation

In construction projects, RM implementation faces some barriers and challenges. A various number of studies have examined the barriers hindering the successful implementation of RM. However, majority of these studies have been conducted within the context of developed countries. The barriers of RM implementation literature has taken two directions, where some have focused on barriers for level of adoption of RM techniques (Hull, 1990; Simister, 1994; Williams, 1994; Akintoye and MacLeod, 1997; Bajaj et al., 1997; Chapman, 1998; Baker et al., 1999; Uher and Toakley, 1999; Kim and Bajaj, 2000; Patterson and Neailey, 2002; Lyons and Skitmore, 2004; Tang et al., 2007; Goh et al., 2013); while others have focused on barriers for RM practices and implementation (Tummala et al. 1997; Mok et al., 1997; Baldry, 1998; Uher and Toakley, 1999; Elkington and Smallman, 2002; Tang et al., 2007; Hwang et al., 2014; Choudhry and Iqbal, 2013; Zhao et al., 2015).

4.2.1 Barriers to the usage of RM techniques and tools

RM techniques has been studied and introduced in the literature, and are included in the RM processes of risk identification, risk analysis, risk response, and risk monitoring. However, all these techniques may not be applicable in local environment (Choudhry and Iqbal, 2013). The proper use of these techniques can add value to the performance of RM in the delivery of project objectives (Goh et al., 2013). Also, it improves the efficiency of the construction industry during practice (Tang et al., 2007). First and focusing on the application of RM techniques around world, various studies investigated the key issues and challenges for practitioners in using these techniques and they propose solutions to improve the provision of RM techniques and skills in the construction industry.

In the context of developing countries, Shen (1997) investigated practitioners' RM actions through a questionnaire survey in Hong Kong. The results reveal that experience and subjective judgement were the most effective RM actions used by practitioners. Also, methods using quantitative analytical techniques have been rarely used due to limited understanding and experience. This might also demonstrate that certain quantitative analytical techniques are not always applicable in the construction industry. Their findings also suggest a need to promote the application and awareness of various analytical techniques for RM in a proper context in the Hong Kong construction industry. Also, in the UK, Akintoye and MacLeod (1997) used a questionnaire to survey general contractors' usage of risk analysis and management techniques. Their results showed that the construction industry has approached RM in terms of individual intuition, judgement and experience gained from past contracts. Also, they found contractors' lack of familiarity as one reason for not using risk analysis techniques. Moreover, they found that formal risk analysis techniques are rarely used due to lack of knowledge and the doubts on the suitability of these techniques for construction industry activities.

Wood and Ellis's (2003) study focussed on RM practices of leading UK cost consultants. They found that usefulness of RM techniques, relative lack of knowledge and understanding, awareness of RM culture, the amount of time and money to invest in RM process, lack of RM training and skills, were the most important issues underpinning the RM provision. Simister (1994) carried out a survey among practitioners of project risk analysis and management (PRAM). The study investigates the level of awareness of available techniques for PRAM. Client demand was found to be the major reason for using PRAM. Conversely, he found that reasons given for it not being used is that clients do not see its benefits or not prepared to pay for it. Checklist was found to be the most favoured and used technique. Kim and Bajaj (2000) investigated RM in Korean construction industry. Using interviews with 13 managers in construction firms, they identified three reasons limiting the usage of RM techniques like: a lack of familiarity with techniques; most clients and / or owners wanted to see tangible calculations and unambiguous evidence of risk; and lack of expertise with techniques. The contractors' unfamiliarity with RM techniques caused them to manage risks based on intuition, judgement and past experience.

From the literature review above, there is a tendency among RM practitioners to rely on professional judgement, intuition and experience and the approach to RM tends to be unsophisticated (Wood and Ellis, 2003). Many studies have investigated the application of RM tools and techniques in the construction and engineering industry, and the most common techniques used in practice are shown in the Table 11.

4.2.2 Barriers to the implementation of RM process

On the other hand, a number of studies have focused on the existing status of RM systems and the barriers to effective RM as shown in Table 13. Tang et al. (2007) carried out a general survey of 115 stakeholders in China. They identified eleven barriers to RM such as: lack of joint management mechanisms by parties; shortage of knowledge and techniques on RM; different recognition of risk control strategies; ineffective implementation of risk control strategies; ineffective monitoring; lack of formal risk control strategies; ineffective monitoring; lack of formal RM systems; no incentive for better RM; lack of risk consciousness; inappropriate risk allocation; lack of historical data for risk trend analysis; inappropriate risk allocation; and insufficient ongoing project information. Liu et al. (2007) investigated the key issues and challenges in RM and insurance in the Chinese construction industry. They found that the biggest barrier to the development of RM is the unsupportive culture in the Chinese construction industry. Also, they also found that the attitude and perception of contractors play an important role in the developing RM.

Table 9 Mapping RM techniques and tools in literature

Techniques / Tools	References																			
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**Total**
Intuition/subjective judgement/experience					✓		✓	✓			✓			✓	✓		✓			7
Questionnaire						✓				✓					✓					3
Delphi Technique									✓	✓										2
Nominal Group Technique (NGT)									✓											1
Risk register				✓									✓	✓						3
Decision analysis	✓		✓		✓										✓		✓			5
Monte Carlo simulation	✓	✓	✓		✓			✓				✓		✓	✓		✓			9
Risk premium					✓										✓					2
Subjective probability analysis					✓					✓		✓			✓		✓			5
Brainstorming									✓	✓		✓			✓	✓	✓		✓	7
Workshop														✓				✓		2
Historical data use														✓	✓					2
PI matrix																	✓			1
Sensitivity analysis	✓		✓				✓	✓		✓	✓				✓		✓			8
FMEA																	✓			1

1: Perry & Hayes (1985); 2: Hull (1990); 3: Simister (1994); 4: Williams (1994); 5: Akintoye & MacLeod (1997); 6: Bajaj et al. (1997); 7: Tummala et al. (1997); 8: Mok et al. (1997); 9: Chapman (1998); 10: Uher & Toakley (1999); 11: Kim and Bajaj (2000); 12: Raz & Michael (2001); 13: Patterson and Neailey (2002); 14: Wood and Ellis (2003); 15: Lyons & Skitmore (2004); 16: Tang et al. (2007); 17: Forbes et al. (2008); 18: Goh et al. (2013); 19: Choudhry and Iqbal (2013)

Table 9 Mapping RM techniques and tools in literature – continuation

Techniques / Tools	References																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Total
Hierarchical risk breakdown structure																	✓			**1**
Use case diagram																				**0**
Checklists			✓		✓	✓				✓		✓		✓	✓	✓	✓		✓	**10**
Case-based reasoning/approach						✓				✓					✓		✓			**4**
Utility theory	✓		✓														✓			**3**
Algorithms															✓					**1**
Consulting experts																✓			✓	**2**
Industry information																			✓	**1**
Risk review meetings																			✓	**1**
Incident investigation																			✓	**1**
Risk audit/inspection																			✓	**1**
Flowcharts approach						✓				✓					✓					**3**
HAZOP															✓					**1**
Influence diagram			✓			✓				✓					✓					**4**

1: Perry & Hayes (1985); 2: Hull (1990); 3: Simister (1994); 4: Williams (1994); 5: Akintoye & MacLeod (1997); 6: Bajaj et al. (1997); 7: Tummala et al. (1997); 8: Mok et al. (1997); 9: Chapman (1998); 10: Uher & Toakley (1999); 11: Kim and Bajaj (2000); 12: Raz & Michael (2001); 13: Patterson and Neailey (2002); 14: Wood and Ellis (2003); 15: Lyons & Skitmore (2004); 16: Tang et al. (2007); 17: Forbes et al. (2008); 18: Goh et al. (2013); 19: Choudhry and Iqbal (2013)

Rostami et al. (2015) conducted a study in SMEs in the UK construction industry to facilitate RM processing aimed at improving the competitiveness of SMEs. The difficulties in RM implementation were identified using postal questionnaire sent to 153 SMEs who have experience of construction management. Of the 153 of SMEs responding, most highlighted that the main difficulty experienced is how to scale RM process to meet their requirements. None of the available standards explain the fundamental principle of applying RM to the situations that SMEs find themselves in. This difficulty is further exacerbated by a lack of management skills and knowledge in the adoption of RM tools or techniques to identify and analyse the business' risks.

In Australia, Lynos and Skitmore (2004) surveyed the opinion of 17 contractors, 11 consultants, 10 clients and 6 developers in Queensland construction engineering organisations. They identified nine barriers inhibiting the implementation of RM like: lack of time; lack of familiarity with the techniques; lack of dedicated resources; lack of expertise; lack of information; difficulties in seeing the benefits; human/organisation resistance; lack of accepted industry model for analysis; and cost effectiveness. In Australia too, Uher and Toakley (1999) found that lack of knowledge; lack of skills; ignorance; negative attitude; lack of understanding of potential benefits; and fear of working with probability and statistics; were to be the main barriers to the implementation of RM in construction project development.

Mok et al. (1997) conducted a survey of 52 building services engineers responsible for cost estimation in the Building Services Branch in Hong Kong. They identified 5 barriers expressed in terms of ‘inherent problems’ and 5 barriers expressed in terms of ‘implementation problems encountered’. The following five inherent problems encountered during implementation of RM processes (RMP) were: difficulty in obtaining input estimates and assessment of their probabilities; time involvement; difficulty in understanding and interpreting outcomes of RMP; and inability of managers to agree on quantification of uncertainty/subjective probability. The following five were the 'implementation problems encountered' in ranking order are: (i) human/organisational resistance to change; (ii) managers' understanding of RM process techniques; (iii) lack of computing resources and assistance; (iv) lack of middle management support; and (v) lack of top management support.

Carter and Chinyio (2012) used a questionnaire survey of 113 construction professionals in the U.K construction industry and they identified the following barriers: making a late start, using inexperienced personnel; attitude towards risk not being robust enough; incompetency of risk managers; and not being fully pro-active. Paape and Spekle (2012) surveyed respondents from 825 organisations with annual revenues of more EUR 10 million, and more than 30 employees in the Netherlands. They identified the following five broad group of factors as antecedents to the extent of ERM implementation: (1) the regulatory influences; (2) internal influences; (3) ownership; (4) auditor influence; and (5) firm and industry related characteristics.

Chileshe and Yirenyi-Fianko (2012) carried out a general survey of 34 contractors, 46 consultants and 23 clients in public/private construction projects in Ghana. They identified seven main barriers to risk assessment and management practices such as: awareness; lack of experience; lack of coordination between parties involved; lack of information; availability of specialist RM consultants; time constraints; and lack of knowledge and expertise. Hwang et al. (2014) carried out a questionnaire survey of 15 consultants and 19 contractors in Singapore based on data collected from 668 projects. They identified 10 probable barriers to RM implementation in small projects such as: competition among small and medium enterprises (SMEs); complexity of analytical tools; lack of potential benefits; lack of budget; lack of government legislation; lack of knowledge; lack of manpower; lack of time; low profit margin; and feeling that the techniques were not economical.

Table 10 Barriers to successful implementation of RM

Author (Year)	Study	Main barriers identified
Simister (1994)	Reasons for not using PRAM	• Do not see the benefits for using project risk analysis and management (PRAM) techniques • Not prepared to pay for it
Tummala et al. (1997)	Barriers to successful implementation of RM in Hong Kong	***Inherent problems encountered:*** • Difficulty in obtaining input estimates and assessment of their probabilities; • Time involvement; • Difficulty in understanding and interpreting outcomes of RM process; • Managers cannot agree on quantification of uncertainty/subjective probability assessment; • Cost-justification of RM process techniques. ***Implementation problems encountered:*** • Lack of middle managers/supervisors' support; • Managers' understanding of RM process techniques; • Lack of top management support; • Human/organisational resistance to change; • Lack of computing resources and assistance.
Mok et al. (1997)	Barriers of RM process in building services cost estimation	***Inherent problems encountered:*** • Difficulty in obtaining input estimates and assessments of their probabilities • Time involvement • Difficulty in understanding and interpreting outcomes of RMP • Managers cannot agree on quantification of uncertainty/subjective probability assessment • Cost justification of RM process ***Implementation problems encountered:*** • Managers' understanding of RM process techniques • Human/organisational resistance to change • Lack of top management support • Lack of middle management support • Lack of computing resources and assistance
Akintoye and MacLeod (1997)	Usage and Barriers for using the techniques of risk analysis and management in the UK	*Barriers for not using RM techniques* • Lack of familiarity with the techniques • The degree of sophistication involved in the techniques is unwarranted for project performance • Time plus lack of information and knowledge • Doubts whether these techniques are applicable to the construction industry • Most construction projects are seldom large enough to warrant the use of these techniques or research into them • They require availability of sound data to ensure confidence

Table 10 Barriers to successful implementation of RM - continuation

Author (Year)	Study	Main barriers identified
Uher and Toakley (1999)	RM in the conceptual phase of a project in Australia	• Inadequate knowledge • Inadequate skill • Ignorance • Negative attitude • Lack of understanding of potential benefits • Fear of working with probability and statistics • Other
Kim and Bajaj (2000)	Reasons for not using RM techniques for contractors in South Korea	• A lack of familiarity with the techniques • Most clients and/or owners wanted to see tangible calculations and unambiguous evidence of risk • A lack of expertise with the techniques
Wood and Ellis (2003)	RM services, tools, and techniques currently used by consultants in the UK	• Usefulness of RM techniques • Lack of knowledge or understanding • Awareness of RM culture • RM training is patchy • Willingness to invest time and money in the RM process
Lyons and Skitmore (2004)	Frequency of items preventing implementation of RM	• Cost effectiveness • Difficulties in seeing the benefits • Human / organisational resistance • Lack of accepted industry model for analysis • Lack of dedicated resources • Lack of expertise in the techniques • Lack of familiarity with the techniques • Lack of information • Lack of time
Tang et al. (2007)	Importance, application, status and the barriers to RM in China	• Lack of joint RM mechanisms by parties • Shortage of knowledge/ techniques on RM • Different recognition of risk control strategies • Ineffective implementation of risk control strategies • Ineffective monitoring • Lack of formal RM system • No incentive for better RM • Lack of risk consciousness • Lack of historical data for risk trend analysis • Inappropriate risk allocation • Insufficient ongoing project information for decision-making
Liu et al. (2007)	Investigate the key issues and challenges in RM and insurance in the Chinese construction industry	• Unsupportive culture • Lack of knowledge and expertise • Perception and attitude

Table 10 Barriers to successful implementation of RM - continuation

Author (Year)	Study	Main barriers identified
Hwang et al. (2014)	Barriers of RM implementation in Singapore	• Competition among SMCs • Complexity of analytical tools • Lack of potential benefits • Lack of budget • Lack of government legislation • Lack of knowledge • Lack of manpower • Lack of time • Low profit margin • Not economical
Choudhry and Iqbal (2013)	Identification of barriers to effective RM in Pakistan	• Lack of formal RM system; • Lack of joint RM system by parties • Shortage of knowledge/techniques • Complexity • Reactive rather than proactive • Centralized rather than decentralized • Risk analysis rather than risk identification • Periodic rather than continuous • Lack of historical data for risk trend analysis • Lack of risk consciousness
Zhao et al. (2015)	Hindrances to RM implementation	• Lack of data • Insufficient resources (e.g., time, money, and people) • Lack of a formalized ERM process • Lack of RM techniques and tools • Lack of internal knowledge, skills and expertise • Lack of qualified personnel to implement ERM • Lack of a RM information system (RMIS) • Unsupportive organisational structure and culture • Lack of risk awareness in the organisation • Inadequate training on ERM • Lack of perceived value or benefits • Lack of commitment from the board and senior management • Not perceived as priority by senior management • Lack of the board or senior management leadership • Lack of a clear ERM implementation plan • Lack of a set of metrics for measuring ERM performance • Unclear ownership and responsibility for ERM implementation
Chileshe and Kikwasi (2014)	CSF for implementation of risk assessment and management	• Awareness of RM • Teamwork and cooperation • Management style • Cooperative culture • Costumer requirements • Positive human dynamics

Table 11 List of the most frequently cited barriers to RM implementation

Barriers to RM implementation	References								
	Tummala et al. (1997)	Mok et al. (1997)	Wood and Ellis (2003)	Uher & Toakley (1999)	Simister (1994)	Tang et al. (2007)	Choudhry and Iqbal (2013)	Hwang et al. (2014)	Zhao et al. (2015)
Inadequate knowledge	√	√	√	√			√	√	√
Inadequate skill				√			√		√
Shortage of knowledge/ techniques on RM	√	√	√			√	√		√
Lack of understanding of potential benefits			√	√	√			√	√
Ineffective implementation of risk control strategies						√			
Lack of formal RM system									
Lack of historical data for risk trend analysis						√	√		
Insufficient ongoing project information for decision-making						√			
Lack of joint RM system by parties						√	√		
Human/organisational resistance to change	√								√
Lack of top management support	√	√							√
Lack of government legislation								√	
Lack of awareness			√						

Harner (2010) reviewed legal-related studies considering the impact of boardroom dynamics and US corporate culture on RM practices. He examined the following two possible barriers to RM: (i) individual biases; and (ii) cultural norms. The following three cognitive biases that may impede risk assessment: (i) confirmation bias; (ii) overconfidence / optimism; and (iii) framing, were analysed and explored whether 'corporate culture' and 'the environment at entrepreneurial or risk aggressive firms' posed a barrier to effective risk-management practices.

Chileshea and Kikwasi (2014) investigated the perceptions of Tanzanian construction professionals concerning the barriers to the implementation of RAMP, using a triangulated data collection approach. The barriers were identified as significant are: (i) awareness of RM processes; (ii) lack of experience; and (iii) lack of information. In contrast, 'cost implementations' and 'time constraints' were ranked as low.

4.3 RM capability

A recent review has identified project maturity models in the market of which a number of examples are well established. The majority of these models assess project management capability against bodies of knowledge, and test the completeness of process coverage (Hillson, 2003). The concept of "maturity" was seldom used to describe the state of an organisation's effectiveness at performing certain tasks (Crawford, 2006).

The Oxford dictionary defines "maturity" as the state or period of being reached in the most advanced stage in a process. Paulk et al. (1993) defined maturity as a potential growth in capability, and it should also signify both the richness of an organisation's software process and the consistency with which it is applied in projects throughout the organisation. From the viewpoint of the organisation, maturity is defined a state in which an organisation is in a perfect condition to pursue its objectives (Andersen and Jessen, 2003).

Lockamy and McCormack (2004) viewed process maturity as a process with a life cycle assessed by the extent to which the process is explicitly defined, managed, measured, and controlled with the growth in process capability, richness, and consistency across the entire organisation. From the RM perspective, maturity is reflected as the sophistication of an organisation's understanding of its risk portfolio, and how to manage those risks and the internal business continuity systems for coping with and recovering from the eventuality (Zou et al., 2010).

Wang et al. (2004) indicated that RM is a formal process of systematically identifying, analysing and responding to risks throughout the lifecycle of a project to obtain the optimum degree of risk elimination, mitigation and/or control. According to PMI (2004), to be successful, the organisation should be committed to addressing the management of risk proactively and consistently throughout the project; in addition, establishing the maturity level of RM capability in an organisation is very important especially for construction organisations due to the high risk nature of their business.

Akkirajul et al. (2010) argued that enterprise RM capability means the process, data, tools and the culture in the organisation that enables one to manage risks. And it is necessary for organisations to have a clear view on their current approach to risk in order to define goals, specify processes, and manage progress in raising their RM capability (Risk Management Research and Development Program Collaboration, 2002). The mature RM capability can contribute to minimizing costs and improving profitability (Anagnostopoulos et al., 2005).

According to Loosemore et al. (2006) organisations operate at different levels of maturity for different types of risks. For instance, an organisation's RM culture may be as low as level 1 but achieved level 3 in RM processes. This means that while organisations may have developed sophisticated RM systems, they have not fully imbedded it within its organisational behaviour and practices.

Furthermore, Hopkinson (2011) indicated that assessing RM capability can help identify the strengths and weaknesses of the organisation and can also identify areas needing improvement. In general, assessing the current RM capability of construction companies can be used to identify the priority or weakest areas needed for improvement and actions can be taken to increase the performance.

4.4 Existing RM maturity models

Specific to RM capability assessment, several researches have been conducted by researchers and organisations such as Ren and Yeo (2004), HVR Consulting (2006), Risk and Insurance Management Inc. (RIMI) (2006), Loosemore et al. (2006), Zou et al. (2010), Risk Management Research Development Program Collaboration (RMRDPC) (2002), and International Association for Contract and Commercial Management (IACCM) (2003), all of whom have successfully developed RM maturity models. Some developments of maturity models originated from a generic risk maturity model proposed by Hillson, (1997), as shown in Figure 14. A comparison of RM capability models in literature review is shown in Table 17.

Loosemore et al. (2006) indicated that establishing RM capability of an organisation should be the starting point when embarking on a review of current RM practices, systems, and culture. Monetti et al. (2006) also indicated that to understand the RM capability maturity level of a construction organisation, a useful starting point is to review current RM processes and cultures. In addition, a formalized and standardized RM process has been widely seen as a critical attribute to measure the RMC in previous studies (e.g. Hillson, 1997; Hopkinson, 2011; Ren and Yeo, 2004; Zou et al., 2010).

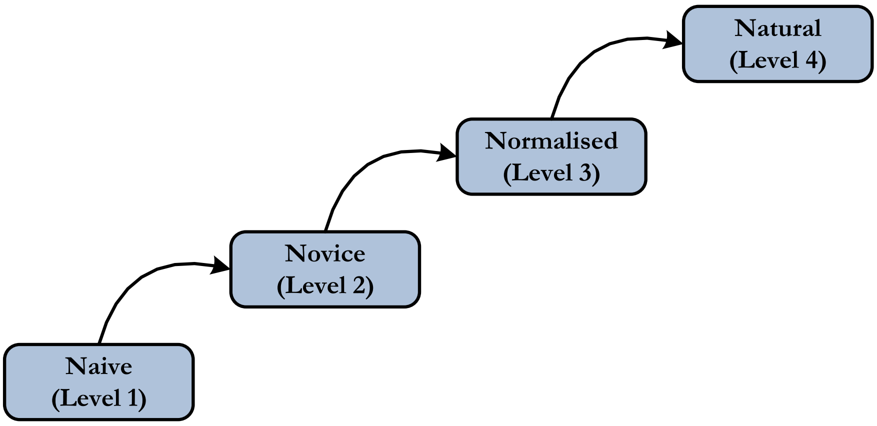

Figure 17 The four levels of risk maturity (Hillson, 1997)

Zou et al. (2010) developed a Web-based RM maturity model (RM3), including its validation and as well as its applications. The main attributes for the RM3 were mainly: management perspective, risk culture within organisation, ability to identify risk, ability to analyse risk, and application of standardized RM process. These attributes are measured against four levels: initial, repeated, managed, and optimized. In addition, they found that the Australian construction industry's overall RM maturity level was relatively low where 32% rated at level 2 and 52% rated at level 3.

However, very few efforts have been committed to research on assessing RM capability of construction firms in the GCC countries. Therefore, this research attempts to fill this knowledge gap.

4.5 Criteria in the RM capability model

To develop a RM model, capability criteria need to be established. In this research study, the criteria for assess RM capability of construction firms were derived from those most commonly found in literature. The key criteria in the existing models and literature were reviewed and assessed (Hillson, 1997; Hopkinson, 2011; IACCM, 2003; Monetti et al., 2006; Ren and Yeo, 2004; RIMI, 2006; Loosemore et al., 2006; RMRDPC, 2002; Zou et al., 2010). Based on the comparison, the most common criteria were determined to evaluate an organisation's RM capability as shown in Table 18.

These criteria should reflect the characteristics of an advanced or successful RM practice. These criteria were established based on the components of the proposed RM framework for construction firms and criteria mentioned in the literature relating to the best practices and key characteristics in RM. By combining these 28 indices, it will show the overall RM capability of construction firms in the GCC countries.

If a firm meets these criteria fully, its RM implementation can be deemed as highly mature. The forgoing was intended to facilitate measuring each of the series of steps for the project RM process. Thus, the construction firm can determine how it was following construction industry best practice. Therefore, based on a literature, the maturity measuring criteria focused on the following variables:

- RM attitude
- RM culture
- Risk identification capability
- Risk assessment capability
- Risk response capability
- Risk monitoring capability
- Development and application of standardised RM system

Table 12 Comparisons of existing RM capability models adopted by different references

References	Attributes of RM capability					
	Culture and awareness	**Experience**	**Management process**	**Application and practice**	**Project stakeholder**	**Knowledge & project management**
Hillson (1997)	Culture	Experience	Process	Application		
Ren and Yeo (2004)	Organisational culture: (1)attitude toward risks and uncertainty; (2)stakeholders relationship; and (3)leadership and commitment to RM		RM process: (1) risk identification; (2) risk analysis; and (3) risk mitigation		Stakeholders relationship	Knowledge management
Zou et al. (2010)	Culture	People and leadership	(1) Identification and; (2) analysis	Application & Practice		RM
Mu et al. (2014)	Culture and Attitude		(1)Identification, (2) analysis, and (3)response	Application		
Hopkinson and Lovelock (2004)	Culture		(1) identification, (2) analysis and; (3) mitigation	Project management	Stakeholders	
Ferrando (2007)	Culture	Experience	Processes	Practical application		
RMRDPC (2002)	Culture	Experience	Process	Application		
IACCM (2003)	Culture	Experience	Process	Application		
Jia et al. (2013)	Culture		(1)RM planning, (2)identification, (3)analysis and evaluation, (4)response, (5) monitoring, and (6) report	Application	Stakeholders	
Hopkinson (2011)	Culture		Identification, analysis and response		Project stakeholders	Project management
Zhao et al. (2014)	Appetite, tolerance and culture	Board and senior management	ERM process	Application and Practice		RM

Table 13 Maturity criteria used in this research

Maturity attributes	Maturity criteria
Risk attitude	There is formal report on the current state of risk and effectiveness of RM submitted to the board level in firm at least annually
	The senior management fully engage with and commit to the RM meetings
	The Department Managers fully engage with and commit to the RM meetings
	The RM team appropriately resourced
	Sufficient resources are dedicated to projects
	Team members are taking risk ownerships during project implementation
Risk culture	RM information is distributed and communicated to all project participants within the firm
	RM system embedded in the firm's behaviour and practices
	The organisation board reviews the risk process on a regular basis
	RM is widely implemented and practiced in all levels within the firm
Risk identification capability	Potential risks are identified each time for new projects
	You are aware of triggers in project causing risks to occur
	You can identify and recognise these triggers easily
	A systematic identification method is used to ensure risks are identified
Risk assessment capability	All project participants are capable of basic risk analysis skills such as qualitative or quantitative analysis
	Qualitative and/or quantitative risk analysis tools and applications are used to assess identified risks
	The results of risk analysis is used as a basis for resource allocation and distribution to projects
	You conduct intensive analyses of causes in terms of the sources of risk
Risk response capability	You have enough freedom of action to react to risks adequately
	You take many actions at the sources of risk (e.g. by contractual obligation)
	You can react to identified risks and carry out the necessary adaptive measures quickly
Risk monitoring capability	Risks are consistently identified, analysed, responded, and continuously monitored throughout the project life cycle
	Risks occurred are compared against to initially identified risks
Development and implementation of standardised RM system	RM process reviewed to ensure the process is effective
	The RM plan & procedures are fully developed
	A standardized RM process is applied to all projects with the firm
	Formalized RM system
	RM tools and techniques are integrated and used in projects

4.6 Maturity levels

Although the general capability maturity model has five levels of maturity (Paulk et al., 1993), literature review helped to identify that four maturity levels are sufficient to reflect the full spectrum of RM capability in construction firm. Also, it is consistent with other contributions (Zou et al., 2010). Table 19 shows a comparison of maturity levels used in different RM maturity models in literature.

Four maturity levels are adopted to describe the progression of a firm maturity. The four maturity levels of a construction firm are generally explained as following:

Table 14 Comparison of maturity levels used in different RM maturity models

References	Maturity levels				
	1	2	3	4	5
Hillson (1997)	Naive	Novice	Normalized	Natural	
Hopkinson and Lovelock (2004)	Naïve	Novice	Normalized	Natural	
Ren and Yeo (2004)	Initial	Repeatable	Defined	Managed	Optimized
RIMS (2006)	Ad hoc	Initial	Repeatable	Managed	Leadership
Zou et al. (2010)	Ad hoc	Repeatable	Managed	Optimized	
Hopkinson (2011)	Naïve	Novice	Normalized	Natural	
Mu et al. (2014)	Naïve	Novice	Managed	Optimized	
RMRDPC (2002)	Ad hoc	Initial	Repeatable	Managed	
IACCM - BRM3 (2003)	Naïve	Novice	Normalized	Optimized	
Ferrando (2007)	Traditional	awareness	Monitoring	Quantifications	Integration
Lacey (2007)	Informal and Ad hoc	Planned and tracked	Defined and institutionalized	Managed and measured	Optimized and agile

Level 1 – initial and/ad hoc

The firm is unaware of the need and value for RM and has no structured approach to dealing with risk. The firm is not experimenting with the application of RM. No attempt is made to identify risks in the project or to develop mitigation or contingency plans. The normal method for dealing with problems is to react after a problem occurs with no proactive thought. Occasionally, capable and forceful managers can identify and work to mitigate risks during the project. In some cases, although the firm is aware, at some level, of the potential benefits of managing their project risks, there is not effectively implemented firm-wide RM process and is not gaining the full benefits. The firm has no formal or structured RM process in place.

Level 2 – repeatable

Basic RM processes are established on a project-by-project basis although they may not be consistently achieved in all cases. The firm makes realistic project commitments based on the results observed on previous projects and on the risks identified for individual projects. The RM is disciplined because planning and tracking of individual project is stable and earlier successes can be repeated. Minimum RM process has been applied including risk identification and analysis and responses. Yet there is a lack of firm wide and standardized RM processes.

Level 3 – managed

Generic RM systems and processes are formalized, implemented, and documented where the benefits are understood at all levels of the firm. This process is based on a common, organisation-wide understanding of the activities, roles and responsibilities. Top management provides strong support while employees are empowered to implement RM processes to take on risks. Level 3 maturity is considered enough for most firms where risk has become an integral part of their daily practices.

Level 4 - optimised

The firm has a risk-aware culture with a proactive approach to RM in all project activities. Risk information is actively used to improve RM processes and gain competitive advantage. The consideration of risk is inherent to routine project and business processes. The RM results from past historical and relevant data are analysed to determine how accurate risk identification and analysis were versus actual impacts and causes. Identifying, assessing and managing uncertainty becomes second nature to the firm and RM is built into all activities and business processes. Risks are not only identified and analysed but also optimized where the opportunities are maximized. Risk review and learning is implemented. RM knowledge base is established and used for risk and opportunity optimisation modelling.

4.7 Summary of this chapter

This chapter presented the barriers to RM implementation in construction industry and the RM techniques used in practice. Also, it reviewed the concept of maturity and the existing RM maturity models. In addition, it discusses different levels of RM maturity in construction firms.

Chapter Five
Survey Results and Analysis

5.1 Introduction

This chapter is designed for analysing the data collected from the questionnaire surveys. The obtained raw data was input and analysed using the Statistical Package for the Social Sciences (SPSS) software. This chapter starts with reviewing similar approaches used for data analysis in relevant studies. Then, a descriptive statistic for the data collected from the questionnaires will be explained and illustrated. Also, different types of statistical analysis were conducted.

5.2 Analysing data of initial survey

5.2.1 Demographic characteristics of respondents

The respondents were practitioners of the KCI with majority of them (28%) having over 25 years of working experience in this sector. Majority of them have high educational qualification as 80.5% hold a bachelor's degree. The construction projects they have been involved with include building (26.5%), housing (30.4%), and infrastructure (10.8%).

More details of the respondents' profiles are as presented in Table 20. The respondents' long working experience, high educational background and their involvement in diverse construction projects suggest that the respondents had relevant knowledge of construction project management and their associated risks and therefore were ideally suited to respond to the questionnaires.

Table 15 Respondents profile in the initial survey

Demographic characteristics	Number	Percentage
Age		
> 60	1	1.2
60-55	13	15.9
54-49	10	12.2
48-43	21	25.6
42-37	13	15.9
36-31	11	13.4
30-25	13	15.9
Role		
Owner (government departments)	72	87.8
Contractor	10	12.2
Level of Education		
Master	12	14.6
High diploma	3	3.7
Bachelor	66	80.5
Diploma	1	1.2
Years of working experience		
> 25 years	23	28
25-21	15	18.3
20-16	14	17.1
15-11	8	9.8
10-5	10	12.2
< 5 years	12	14.6
Position		
Chief engineer assistance	1	1.2
Project manager	19	23.17
Deputy project manager	11	13.4
Project engineer	13	15.8
Design engineer	9	10.97
Head of technical department	5	6.09
Architecture	4	4.87
Quantity surveyor	1	1.2
Planning engineer	4	4.87
Contract engineer	3	3.65
Quality control	3	3.65
Mechanical engineer	3	3.65
Others	3	3.65
Fields of specializations		
Building	54	26.47
Residential	62	30.39
Highway/Roads	19	9.31
Industrial projects	8	3.92
Bridges	2	0.98
Tunnelling	2	0.98
Sewerage & water supply	13	6.37
Infrastructure	22	10.78
Airports	1	0.49
Commercial	13	6.37
Others	8	3.92

5.2.2 Risk ranking results

Based on the results of a questionnaire survey, the risk significance index score (RSIS) was calculated for each risk based on probability and impact, as described in the methodology chapter. These risks were then ranked according to their index score, shown in Table 16.

Table 16 Risk significance index score

ID	Risk factors	Index score	Rank
23	Shortage of skilled labour	0.34	1
11	Inadequate contractor experience	0.31	2
22	Poor labour productivity	0.31	3
1	Variation orders	0.30	4
16	Delay in preparation of shop drawings	0.29	5
13	Financial difficulties/cash flow problem	0.28	6
49	Underestimation of costs	0.28	7
6	Inaccuracy of materials estimate	0.27	8
48	Poor planning for the project	0.27	9
45	Conflict between contractor and subcontractor	0.26	10
15	Subcontractor related problem	0.25	11
24	Shortage of subcontractor	0.25	12
31	Shortage of materials in markets	0.25	13
38	Difficulty in approval of permits to work	0.25	14
55	Unforeseen ground conditions	0.25	15
9	Inaccurate Time estimate	0.24	16
8	Actual quantities differ from the contract quantities	0.23	17
10	Inaccurate Cost estimate	0.23	18
14	Gaps between implementation and specifications	0.23	19
47	Lack of presence of arbitrators engineering specialists in resolution of conflicts	0.23	20
59	Effects of subsurface conditions (type of soil, water table)	0.23	21
7	Errors in the calculation of quantities	0.22	22
27	Shortage in equipment	0.22	23
30	Shortage of construction materials on site	0.22	24
43	Conflicts among project parties	0.22	25
56	Adverse weather conditions	0.22	26
3	Delay in the settlement of contractor claims	0.21	27
25	Workers strike	0.21	28
36	Lack\ Inaccuracy of schemes in the contract documents	0.21	29
41	Differing site conditions from what was expected	0.21	30
44	Lack of commitment of project parties	0.21	31
50	Inflationary pressure	0.21	32
53	Civil wars and revolutions	0.21	33

Table 16 Risk significance index score – continuation

ID	Risk factors	Index score	Rank
54	Monopoly materials because of closures or unexpected political factors	0.21	34
12	Re-implementation as a result of errors during the construction process	0.20	35
20	Delay in approval of shop drawings	0.20	36
46	Lack of presence of arbitrators	0.20	37
2	Delay in progress payments	0.19	38
18	Changes in material types and specifications during construction	0.19	39
19	Delay in the development of design documents	0.19	40
21	Delays in the approval of the materials used	0.19	41
26	Failure in equipment	0.19	42
39	Increase/change in scope of project	0.19	43
52	The lack of security and stability	0.19	44
34	Non-utilization of professional contractual management	0.18	45
42	Third party delays	0.18	46
17	Supervision too late by consultant	0.17	47
35	Lack\ Inaccuracy of BOQ in Contracting total amount	0.17	48
58	Slow land expropriation due to resistance from occupants	0.17	49
60	Fire	0.17	50
4	Client induced additional work beyond	0.16	51
32	Procurement of invalid materials	0.16	52
33	Changed engineering conditions from the contract document	0.16	53
37	Lack\ Inaccuracy of methods of implementation of the project (Method of Statement)	0.16	54
40	Project complexity	0.16	55
51	Changing government policies	0.16	56
57	Restricted access/ Strikes, external or internal military action	0.15	57
61	Earthquakes and floods	0.15	58
28	Unexpected maintenance for equipment	0.14	59
29	Equipment maintenance problem	0.14	60
5	Change in standards and specifications	0.13	61

Table 17 highlights the top ten key risks that were considered to affect delays and cost increases for construction projects in Kuwait. The top three ranked risk factors were ‘shortage of skilled labour’, ‘inadequate contractor experience’ and ‘poor labour productivity’, respectively.

Table 17 Key risks for construction projects in Kuwait

Key risks	Rank	Rank in group	Index score
Shortage of skilled labour	1	2	0.34
Inadequate contractor experience	2	6	0.31
Poor labour productivity	3	1	0.31
Variation orders	4	1	0.30
Delay in preparation of shop drawings	5	11	0.29
Financial difficulties/cash flow problem	6	8	0.28
Underestimation of costs	7	2	0.28
Inaccuracy of materials estimate	8	1	0.27
Poor planning for the project	9	1	0.27
Conflict between contractor and subcontractor	10	1	0.26

Sufficient number of labourers on construction site ensures the smooth progress of work. In contrast, the shortage of labourers on site results in construction delay. The first top risk factor affecting construction project delay is the shortage of skilled labour from the viewpoint of the participants in the questionnaire. This is due to the increased demand on labourers in the GCC region as project numbers, size and complexity increase. Shortage of labourers was also a major cause of construction delay in UAE (Faridi and El-Sayegh, 2006) and Thailand (Ogunlana et al., 1996). A survey was conducted by Sweis et al. (2008) to explore the causes of construction delay in residential projects in Jordan. The shortage of skilled manpower was ranked the third and has been a serious delay cause according to their study. Assaf and Al-Hejji (2006) found that shortage of labourers was the top cause of delay in large construction projects in Saudi Arabia. Recently, the Middle East region has been experiencing a boom in construction due to the results of wars as well as the high prices of oil resulting in access liquidity and thus a higher demand for investment opportunities. The GCC construction industry boom has been accompanied by shortage in foreign manpower leading to higher wages and thus adding to the financial burden on the contractor. This explains the contractor's reliance on cheap, unskilled labour.

The inadequate experience of contractor and insufficient skills affects both technical and management capacities of contractors, and was recognised as a main-criteria for prequalification (Hatush and Skitmore, 1997). Lo, Fung, and Tung (2006) found that the owners and consultants ranked inexperienced contractors among the top three causes of construction delay in Hong Kong. Similarly, Sambasivan and Soon (2007) revealed that inadequate contractor experience was the third most important cause of construction project delay in Malaysia. Therefore, an inexperienced contractor may not be able to cope up with the progress of work or may not understand the complexity of project leading to improper management of site and thus cause time overruns. The production output of labour is a function of skill and motivation (Olomolaiye, 1988). Poor labour productivity has been investigated intensively in developing countries and problems have been identified (Olomolaiye et al., 1987). Poor labour productivity was ranked the second attribute by Doloi et al. (2012) in construction projects in India. Poor labour productivity is caused either by employing unskilled labour or due to lack of proper supervision over them which come under inefficient management skills of the supervisor onsite. In case there is unavailability of work force with the required skill set and hiring of unskilled labour is inevitable, they must be trained properly before putting them at work.

Variations by the client can directly result in changes in the planning, design, and construction. As Zou et al. (2007) argued, variations possibly result from two reasons, the change of mind by clients or the misunderstanding/ misinterpretation of the clients' needs in the project brief. For the former cause, the clients should bear the responsibility; for the latter, a knowledgeable initial project team should be established as early as possible to define the project scope and functions precisely. Hatush and Skitmore (1997) identified financial stability and financial status among the top ten criteria for contractor prequalification and bid evaluation. El-Razek et al. (2008) found that the owners and consultants considered financing by contractor during construction as the top cause of delay in Egyptian building projects. Aibinu and Odeyinka (2006) found that contractors' financial difficulties were the most important cause of construction delay in Nigeria.

Improper planning has been found to be one of the most important causes of delay in Malaysian construction context Sambasivan and Soon (2007). The most significant risk in the UAE highway construction projects was ineffective planning of the project (El-Sayegh and Mansour, 2015). Sweis et al. (2008) found that the owners and consultants recognised poor planning and scheduling as the most critical delay cause of construction projects in Jordan, and demonstrated that this cause was relevant to shortage of technical professionals in contractors, insufficient coordination among parties, as well as ineffective quality control by contractors. In addition, planning and scheduling problems were also perceived as an important source of construction delay in Thailand, where project plans were not in sufficient detail and regularly updated (Ogunlana et al., 1996).

5.2.3 RM practice in KCI

The respondents were also asked to indicate whether their organisations have designated departments for RM or not. Only 9.8% of the respondents answered in the affirmative, whilst the majority (86.6%) answered negatively, and 1.2% indicated that they do not have any idea. A follow-up question posed to those giving negative responses asked them to indicate if they support having a RM department in their organisations. The majority of this group (82.9%) indicated that it is essential to have a RM department in their organisations.

5.2.4 Respondents' RM knowledge and its development

Regarding knowledge in RM, the respondents were asked to indicate their level of knowledge in this subject. The result shows that 12.2%, 54.9%, and 24.4% of respondents respectively indicated "advanced", "fair", and "low" levels of knowledge in RM. To gain some insights into the possible reasons for the high percentage in low-fair level of knowledge, the respondents were asked to indicate if they have ever participated in RM training courses. The results show that, 57.3% of the total respondents have not been involved in such courses with the remaining 42.7% claiming they have ever participated in one or two training courses.

5.3 Analysing data of main survey

As explained in the methodology chapter 2, the questionnaire was composed of four sections: general questions about the participants and their companies, the current practice of RM process, the capability of RM in their company, and the barriers to RM implementation. The objective of carrying the data analysis task is to provide a description of the participants in the survey and their organisations. Also, it captures their attitude regarding the topics under investigation in the questionnaire.

5.3.1 Characteristics of respondents and their firms

The respondents have been asked to give their names and their companies' names as an optional choice in the questionnaire. This option was used to facilitate the coding process of the questionnaires during data analysis. Also it would be helpful to get contacted with respondents about their feedback in case any more information is needed. The majority put their names as well as their company's names without hesitation.

The questionnaire asked the respondents to describe their position within organisation. Both, the respondents in the mail questionnaire and the face-to-face questionnaires were professionals in their companies. The majority of them were project managers in their organisations. Table 23 shows the groupings of respondents according to their designation. Among the respondents, 12.3 percent were from top management staff and 87.7 percent people were from mid management staff. Figure 15 shows the breakdown of mid management staff of the respondents in their organisation. The background of the respondents supports the notion that they were involved with running of the projects at the operational level, therefore had some knowledge of issues related to RM. This also enhances the internal data validity (Bing et al., 2005).

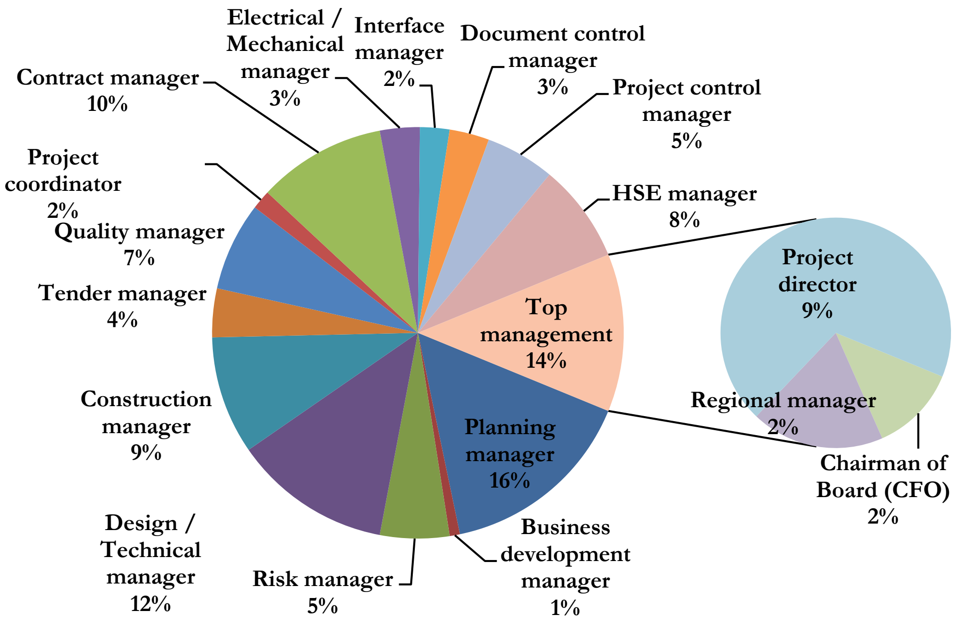

Figure 18 Respondents role in organisation

Table 18 shows the summary of the qualification background about the respondents. It is observable that 100 percent of the respondents have a minimum of bachelor degree. Furthermore, about 31.3 percent of the respondents have attended the PMP training course, this indicate that PMP course was mandatory in overseas companies.

It is worth mention that most of overseas and international companies prefer their staff to be PMP certified, this reflects their interest about project management, especially RM knowledge. Therefore, 100 percent of international and overseas staff had attended at least the preparation PMP course (not the certificate).

The core capabilities of the respondents' firms include architectural consultancy service, engineering consultancy service, contracting/ construction service, and project management office (PMO) service. The main aim business objectives of these firms in exporting their services are to maximize profit and increase revenue. As illustrated in Table 18, the majority of service provided (62 percent) was of construction/ contracting service. The next service chosen by respondents was the project management office (24.1 percent). This is due to the fact that most of projects in GCC were a mega projects and complex, so there is a need to PMO to be a client's representative. PMO act as client's representative for owner, in case of the project was complex and exceeds the employer engineering/management capabilities. All PMO services are performed by professionals in their fields, who are well versed in all aspects of international industry standards project delivery. The next services chosen by the respondents were 13.3 percent and 0.6 percent for engineering consultancy and architectural consultancy, respectively.

The respondents varied in terms of length of experience in the construction industry. About 95 percent of the respondents have working experience above 11 years in the construction industry. Out of the 95 percent, 34.9 percent, 14.7 percent, and 34.9 percent have experience between 11 – 15 years, between 16 – 20 years, and above 25 years respectively, thus assuring the quality of the responses. The background and experience of the respondents supports the notion that they were involved with running of projects at both operational and strategic levels. Therefore, they had some knowledge of issues related to the perceptions and likelihood and degree of impact of the risk factors on construction projects. In the context of GCC region, Table 23 presents the length of experience of respondents in the GCC construction industry. All respondents have a minimum of 5 years' experience or above in the GCC, whereas 42.3 percent of them have experience between 11 – 15 years.

Table 18 Characteristics of respondents and their firms

Characteristics	Categorisation	Responses	
		N	**%**
Educational background	High diploma	8	3.8
	PMP	66	31.3
	Graduate	111	52.6
	Masters	24	11.4
	PhD	2	0.9
	Total	211	100
Length of experience *(Years)*	5 – 10	6	4.7
	11 - 15	45	34.9
	16 – 20	19	14.7
	21 – 25	45	34.9
	Over 25	14	10.9
	Total	129	100
Length of experience *In the GCC (Years)*	5 – 10	66	50.8
	11 - 15	55	42.3
	16 – 20	7	5.4
	21 – 25	2	1.5
	Over 25	0	0
	Total	130	100
Service provided	Architectural consultancy	1	0.6
	Engineering consultancy	22	13.3
	Construction/ contracting	103	62
	Project management office (PMO)	40	24.1
	Total	166	100
Respondent type	Client	7	5.4
	Consultant	28	21.5
	Contracting	95	73.1
	Total	130	100
History of firm *Age in years*	Young firm (less than 50)	68	52.3
	Matured (50 – 100)	55	42.3
	Old/ Established (more than 100)	7	5.4
	Total	130	100
Firm size *number of employees*	Less than 50	6	4.6
	50 – 500	14	10.8
	500 – 5000	14	10.8
	More than 5000	96	73.8
	Total	130	100
Firm size *Annual turnover*	Small (<1B)	11	8.5
	Medium (1-10 B)	20	15.4
	Large (>10 B)	99	76.2
	Total	130	100
Ownership of firm	Joint venture (JV)	8	6.2
	State owned	13	10
	International	99	76.2
	Local private	10	7.7
	Total	130	100
Expansion of firm	Local	13	10
	Regional	49	37.7
	Overseas	68	52.3
	Total	130	100

Table 18 Characteristics of respondents and their firms – continuation

Characteristics	Categorisation	Responses	
		N	%
Country in terms of economic development	Developed	50	38.5
	Developing	73	56.2
	Others	7	5.4
	Total	130	100
Location of projects	State of Kuwait	48	15.5
	Kingdom of Saudi Arabia (KSA)	114	36.9
	Kingdom of Bahrain	24	7.8
	United Arab Emirates (UAE)	52	16.8
	Oman	27	8.7
	Qatar	44	14.2
	Total	309	100
Company nationality	USA	5	3.8
	United Kingdom	3	2.3
	France	5	3.8
	Italy	11	8.5
	Australia	19	14.6
	Austria	1	0.8
	Germany	1	0.8
	Denmark	1	0.8
	Korea	1	0.8
	China	1	0.8
	Turkey	1	0.8
	Egypt	11	8.5
	Saudi Arabia	54	41.5
	UAE	2	1.5
	Qatar	4	3.1
	Multi National	8	6.2
	Spain	1	0.8
	Netherlands	1	0.8
	Total	130	100
Type of construction projects	Building	102	13.5
	Commercial	67	8.9
	Educational	50	6.6
	Residential	81	10.8
	Industrial	52	6.9
	Recreational	44	5.8
	Health	34	4.5
	Heritage	1	0.1
	Energy	40	5.3
	Off-shore	6	0.8
	Infrastructure	109	14.5
	Transportation	89	11.8
	Geotechnical	15	2
	Property development	20	2.7
	Government facility	39	5.2
	Fit out projects	2	0.3
	Others	2	0.3
	Total	753	100

Table 18 Characteristics of respondents and their firms – continuation

Characteristics	Categorisation	Responses	
		N	%
Role in organisation	Chairman of board	2	1.5
	Regional / branch manager	3	2.3
	Project director	11	8.5
	Construction manager	12	9.2
	HSE manager	10	7.7
	Document control manager	4	3.1
	Project risk manager	7	5.4
	Design / technical manager	16	12.3
	Quality manager	9	6.9
	Planning manager	20	15.4
	Contract manager	13	10
	Interface manager	3	2.3
	Tender manager	5	3.8
	Project control manager	7	5.4
	Electrical / mechanical manager	4	3.1
	Business development manager	1	0.8
	Project coordinator	2	1.5
	Commissioning manager	1	0.8
	Total	130	100

The respondents had a wide range of expertise in different types of construction projects. They were asked to choose all the answers applies the types of projects they are experienced in. Table 24 shows that 14.5 percent in infrastructure, 13.5 percent in building, 11.8 percent in transportation, and 10.8 percent in residential, were the most frequently selected types. Moreover, Figure 16 shows a wealth in experience in very different types of construction projects. This is very helpful for generalising the findings of the research over a wide range of construction domains. The members of GCC are proposing to build a heavy programme of railway line to link all six states. This will present a formidable task in a region (Lowe and Altrairi, 2013) which explains the high percentage in the infrastructure and transportation projects in the table above.

The participating firms had undertaken projects in different locations in the GCC region. The majority of projects were concentrated in KSA with 36.9 percent. This is due to the fact that Saudi Arabia occupies most of the Arabian Peninsula and considered the largest exporter of oil in the world. MEED (2014) estimated the value of projects planned or underway in KSA at US$1,07T. For instance, a lot of landmark projects planned and underway in KSA, such as: Riyadh Light Rail Transit: Line 1, 2, 3, 4, 5 and 6; Haramain High-Speed Rail Network; and King Abdul-Aziz International Airport, valued for 35.4 US$ billion (MEED, 2014). Also, UAE was the second with 16.8 percent and Kuwait was the third with a 15.5 percent in the number of projects undertaken by respondents.

Multi-national firms participated in the questionnaire survey. A breakdown for the different nationalities of construction companies is shown in Table 24. The majority was 41.5 percent and 14.6 percent from Saudi Arabia firms and Australian firms, respectively. Also, a relatively large number of companies that participated in the questionnaire were from Italy and Egypt. Moreover, about 56.2 percent of companies involved in the questionnaire survey were from developing countries, whereas 38.5 percent of the responses were from developed countries.

Figure 17 presents organisation size (in terms of number of employees) in the sample distribution. The responses were received from companies of different sizes that is, 4.6 percent of the responses were received from organisations with less than 50 employees, 10.8 percent from organisations with 50 to 500 employees, 10.8 percent from organisations with 500 to 5000 employees, and 73.8 percent from organisations with more than 5000 employees. It is worth noting that organisation size can be classified in different ways; however, the number of employees is the most widely used classification (Ruqaishi and Bashir, 2014).

The classification of organisations adopted is this research that which considers firms with less than 50 employees as small scale enterprises and those between 50 – 5000 employees as medium scale enterprises, and those with more than 5000 employees as large enterprises. Colquitt et al. (1999) found that larger firms are more likely to implement integrated RM concepts than smaller firms. The analysis in this chapter enforces this point. Compared to large enterprises, small enterprises do not generally use the most recognised standards in project management (Sadaba et al., 2014). On the other hand, small enterprises generally have better internal communication, greater flexibility, and better relationships with customers (Ruqaishi and Bashir, 2014).

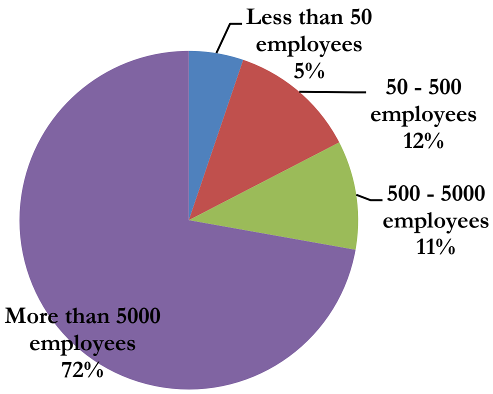

Figure 19 Response distribution based on organisation size (number of employees)

The annual turnover of the companies involved in the questionnaire was surveyed through reviewing the annual reports and web sites of the companies. Figure 18 presents the demographics of the company's size in terms of annual turnover. The results show that the majority of companies participated in the questionnaire was of 73.3 percent of large companies with annual turnover above 10 billion in contrast to 17.2 percent of medium sized companies with annual turnover of 1 billion – 10 billion and 9.5 percent of small sized companies with annual turnover of less than 1 billion.

The GCC construction market is open to local, regional and overseas companies. Many of the mega size projects are handled by international companies with local partners. The sample distribution by organisation type is summarised in

Figure 19. About 10 percent of the responses were received from state – owned organisations, 7.7 percent from local privately owned organisations, 76.2 percent international organisations and 6.2 percent from organisations that are joint ventures between international and local private organisations. The state owned organisations are government owned for profit firms that follow market regulations and are set up to earn profits. They would, like other privately owned firms, network with clients in GCC to win projects. As compared to private organisations, government-owned organisations are less flexible, have more bureaucratic decision-making processes, and usually lack skilled staff (Ruqaishi and Bashir, 2014). However, sate-owned organisations usually do not face any shortage of funds.

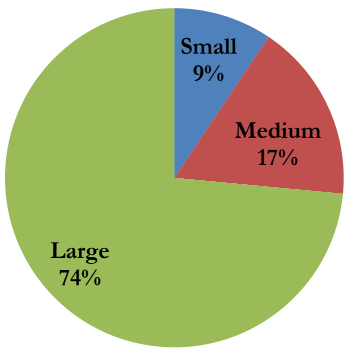

Figure 20 response distribution based on organisation size (annual turnover)

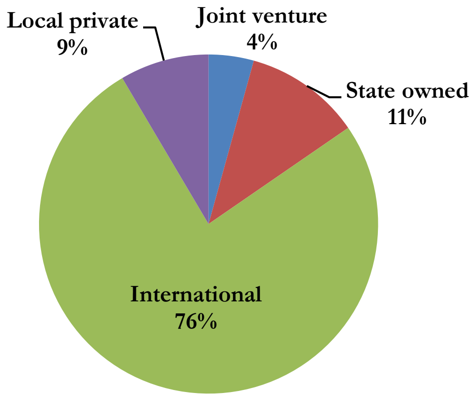

Figure 21 Response distribution based on organisation owner

Regarding the type of the questionnaire's respondent, about 73.1 percent was from contractor type, whereas 21.5 percent from consultant type and 5.4 percent from client type, as shown in Figure 21.

Most countries seek to obtain contracts overseas to increase their volume of foreign construction. International contractors seek to balance the growth of their company to contribute to their security through increased global activities and so to mitigate the impact of the cyclic nature of their workload (Han et al., 2005). Moreover, highly specialized firms view work abroad as a means of capitalizing on expertise and experience gained from long involvement in one type of construction or technology. However, a relatively small number of small sized and medium sized enterprises are participating in the international construction market as shown in Figure 22. It is mainly because international construction contains higher risk than that of domestic markets (Han et al., 2005). The scale used in the questionnaire to assess the expansion of firms involved was local, regional, and overseas companies. Table 23 shows the majority of construction companies were from 52.3 percent from overseas companies, 37.7 percent from regional companies, and 10 percent from local companies.

In this research, the history of firm (*age*) was measured as the number of years since establishment (in the construction industry). The average firm age in the sample is nearly 53 years old, suggesting that the firms are well established rather than ventures that have recently undergone projects. Firm age in this research is divided into three groups, young, mature, and old/established; where 'young' refers to firm that is operating equal to or less than 50 years, 'mature' to those operating between 50 – 100 years, and 'old' to those operating equal to or more than 100 years. Young firms represent 52.3 percent of the sample, mature firms represent 42.3 percent, and old firms represents 5.4 percent of the sample.

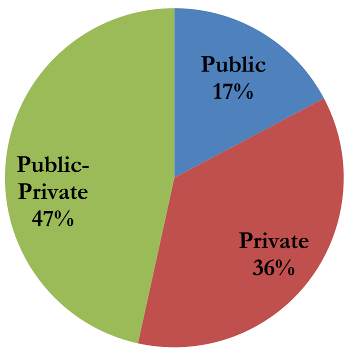

Figure 22 Response distribution based on ownership of facility

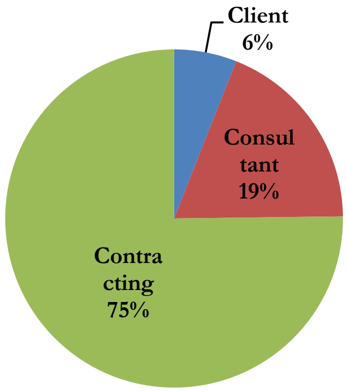

Figure 23 Response distribution based on respondent type

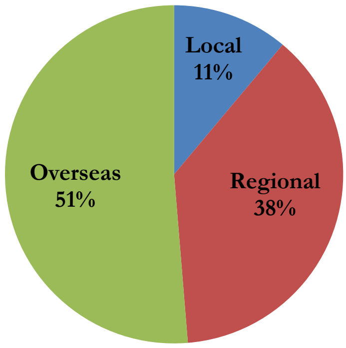

Figure 24 Response distribution based on expansion of firm

5.3.2 Designated department or staff in charge of RM

The respondents were asked whether or not there was a designated department or staff in charge of RM in their organisation. 87.6 percent answered positively and 12.4 percent answered negatively.

5.3.3 RM activities

Another question asked whether or not RM activities undertaken as an individual exercise or as a group exercise. 57.7 percent of the total responses indicated that RM activities were undertaken as an individual exercise, whereas 42.3 percent of the respondents indicated the activities to be undertaken through group exercises. Therefore, it is recommended to define clear responsibilities and risks of each party or make compulsory duties.

5.3.4 Success of completed projects

Respondents have been asked to indicate the level of success of their completed projects. 72.3 percent of the respondents were disagreeing about their completed projects in terms of schedule adherence, whereas 8.5 percent were neutral, and 19.2 percent were agreeing about the level of success. In terms of budget adherence, 53.1 percent were disagreeing about the success of completed projects, whereas 15.4 percent of them were neutral, and 31.5 percent were agreeing about the level of success.

In terms of quality requirements, 37.6 percent of respondents were disagreeing about fulfilling the quality requirements in their completed projects, whereas 20.8 percent of them were neutral and 41.5 of them agreed about fulfilling the quality requirements. The results indicate high time and cost overruns in GCC region. This result was supported by numerous researches in the GCC countries like, Kartam and Kartam (2001) in Kuwait, El-Sayegh (2008) in UAE, Alnuaimi et al. (2010) in Oman, and Assaf and Al-Hajji (2006) in Saudi Arabia.

5.3.5 Respondents' understanding of 'risk' and 'uncertainty'

To ascertain how the GCC construction industry perceives the concepts of risk and uncertainty in construction projects, respondents were asked to indicate their opinion on the difference between risk and uncertainty. It appears that 91.1 percent of the respondents agreed that there is a difference between risk and uncertainty. However, 8.9 percent of respondents suggest that the concept of risk is not differentiated from the concept of uncertainty. Dikmen et al. (2007) argued that major challenges of RM are mainly due to poor definition of risk and vagueness about how and why risks should be managed in construction projects. This means that the industry practitioners may need some further education to help in differentiating between risk and uncertainty.

5.3.6 Evaluation of project's outcome

As a project's outcome is multifaceted, this research considered it only from the view of project delivery. Budget, schedule, quality, safety, sustainability, performance, environment, and reputation were the performance metrics (Konchar and Sanvido, 1998) adopted in this research. The respondents have been asked to indicate on a five – point Likert scale, to what extent the project objectives were affected by the risks they have defined. Table 26 below shows the frequency of answers. Table 26 shows high frequency regarding time, cost, quality, and safety metrics, which indicate the high time and cost overruns in the GCC region.

Table 19 Project objectives affected by risks

Project objectives	Very low	Low	Medium	High	Very high
Time	0.0%	2.0%	5.0%	72.0%	47.0%
Budget	0.0%	3.0%	25.0%	33.0%	65.0%
Quality	3.0%	18.0%	24.0%	67.0%	14.0%
Safety	2.0%	7.0%	20.0%	65.0%	32.0%
Sustainability	16.0%	37.0%	59.0%	7.0%	5.0%
Environment	12.0%	73.0%	29.0%	6.0%	6.0%
Performance	5.0%	21.0%	67.0%	28.0%	5.0%
Reputation	5.0%	46.0%	47.0%	20.0%	8.0%

As shown in Figure 23, the maturity of the respondents indicated that the time of project was highly affected by risks by 72 percent. Also they indicated that the cost of project was highly affected by 65 percent. Moreover, safety was highly affected by 65 percent, whereas sustainability was moderate affected by 59 percent. Environment objective was low affected by 73 percent. In addition, performance and reputation of the company were considered moderate affected by risks.

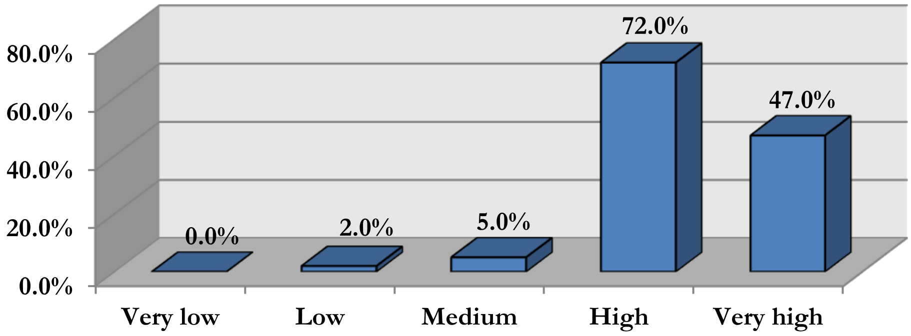

Figure 25 Time of project affected by risks

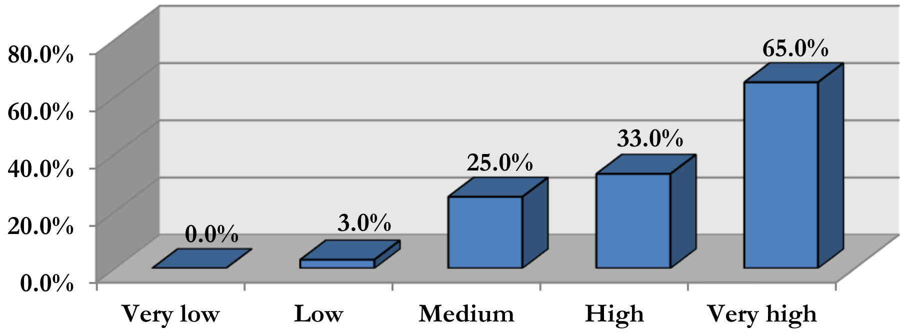

Figure 26 Budget of project affected by risks

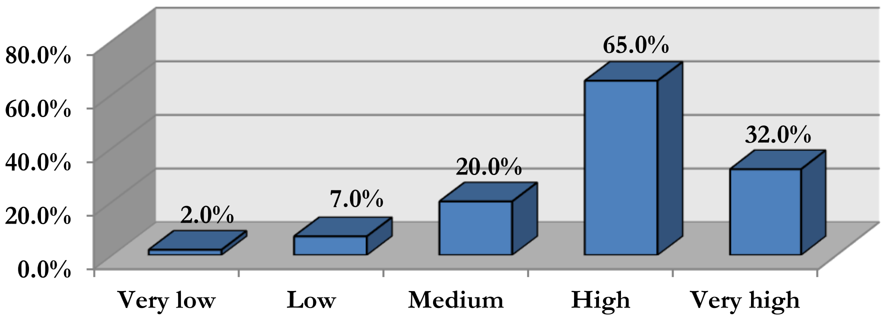

Figure 27 Safety of project affected by risks

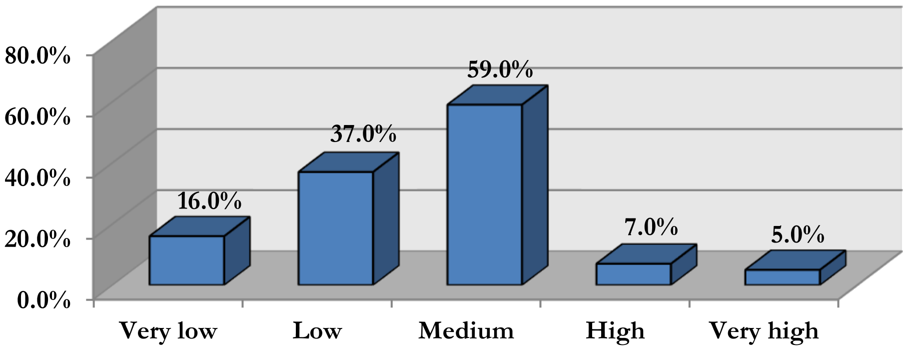

Figure 28 Sustainability of project affected by risks

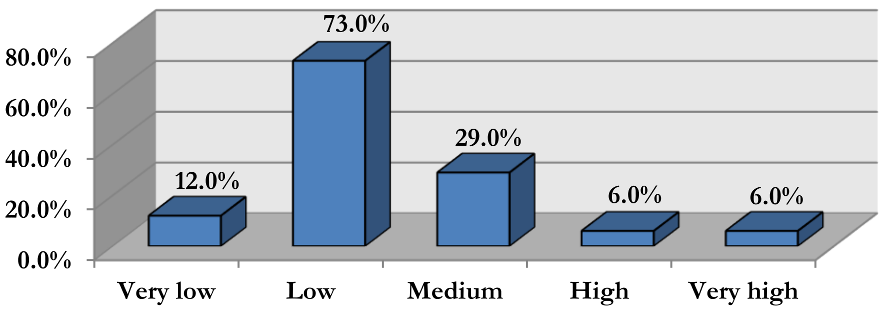

Figure 29 Environment affected by risks

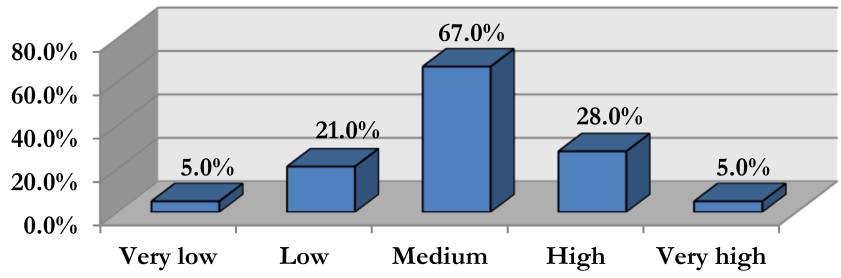

Figure 30 Performance affected by risks

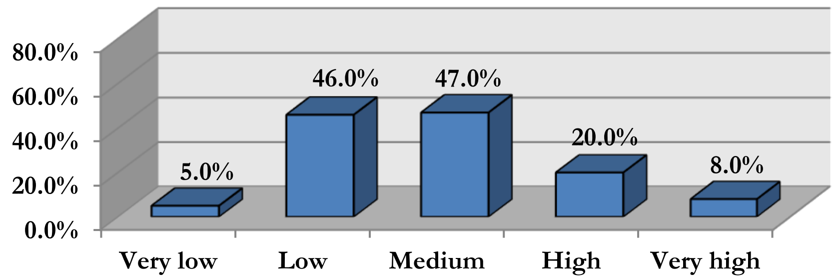

Figure 31 Reputation of company affected by risks

5.3.7 RM through project life cycle phases

Respondents have been asked to state whether or not there are differences in managing risks at different stages of the project life cycle. About 65.4 percent of the respondents said there are differences in managing risks, whereas 33.8 percent of them said there are no differences.

5.3.8 Formalisation of RM system

To investigate the formalization of RM systems being used in the GCC's construction industry, respondents were asked to respond on a scale of 1 – 5, where: 1= strongly informal approach, which views the risks in subjective manner; due to the nature of this approach may organisations implement RM methods but do not realize that they are operating any kind of RM procedure; 2= informal approach, 3= neutral approach, 4= formal approach, and 5= strongly formal approach, which consists of a set of procedures laid down by an organisation for use in the RM process; these procedures are structured and give guidelines to be followed, so that they can be used by any member of the organisation; this enables a uniformity of procedures and ensures that the process is more objective than the informal approach (Smith, 1999). About 31.8 percent indicated that they have informal approach, whereas 26.2 percent considered their systems to be natural formalised, and 41.5 percent indicated formal.

5.3.9 Standardization of RM process

The respondents were asked to indicate to what extent RM process has been standardised in their organisation. A scale of 1 – 5 has been used, where 1= non –standardised and 5= highly standardised. About 42.4 percent of the respondents indicated that their RM process has been standardised. In contrast, 34.1 indicated that their RM process was low to non- standardised.

5.3.10 The adequacy of RM system

To investigate the adequacy of the RM systems being used in the GCC's industry, respondents were asked to respond on a scale of 1 – 5, where 1= inadequate, 2= low adequate, 3= neutral, 4= adequate, and 5= highly adequate. 55.4 percent of the respondents indicate that their RM system was adequate. On the other hand, 21.5 considered their RM system as neutral adequate and 22.5 percent considered their RM system as inadequate. Given the low ratings by all the groups regarding the current RM systems, there is a clear need for the groups in the industry to improve their RM processes systematically, which should enable their RM systems to become more formal to deal with project risks effectively.

5.3.11 Application of RM tools and techniques

Respondents were asked to identify the RM techniques being used in their projects. The common RM tools and techniques mentioned in literature were summarised and presented in the questionnaire, in a way that facilitates understanding for respondents. Respondents were asked to respond on this part by checking all the techniques that could apply in their practice.

As shown in Figure 30, about 95.3 percent of the respondents indicated that brainstorming technique was the most frequent used technique in their risk identification practice, followed by 69.8 percent, 38 percent, and 38 percent for review of historical data, questionnaires, and consulting experts, respectively. This suggests the extent to which all groups use RM techniques is similar. In a study conducted by Choudhry and Iqbal (2013) to survey RM system in the construction industry in Pakistan, consulting experts was ranked the most frequent used technique to identify risks.

As shown in Figure 31, and regarding risk analysis techniques, board and review meetings, experience from previous cases, and P-I Matrix scoring, were the most frequent techniques used with 78.9 percent, 74.2 percent, and 71.1 percent, respectively.

Figure 32 shows risk response strategies, the most frequent strategy used in construction projects according to the respondents was avoiding risk. Also, there was a relatively high agreement of the respondents on other strategies such as, transferring risk with 67.2 percent, insurance with 64.8 percent, and risk reduction with 64.1 percent.

Figure 33 shows risk monitoring and techniques currently used in respondents' projects, incident investigation was the most frequent technique with 78.9 percent, followed by periodic documents reviews with 51.6 percent and risk audit/ inspection with 46.9 percent.

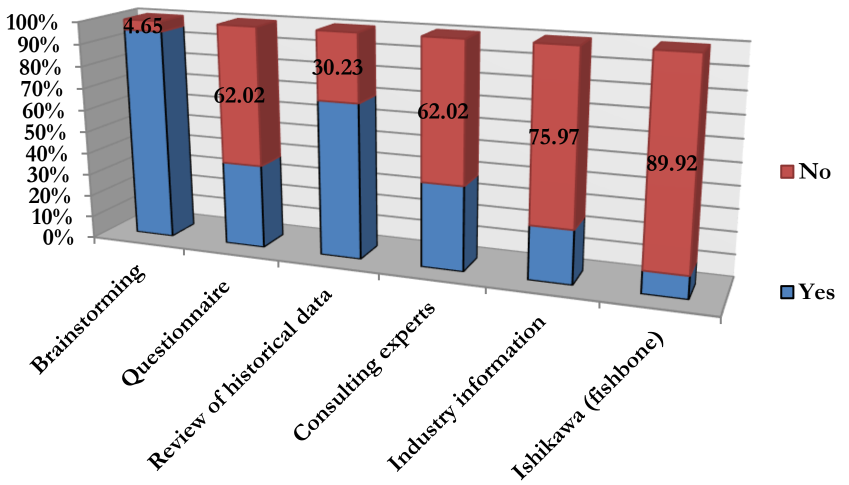

Figure 32 Frequency distribution of risk identification techniques

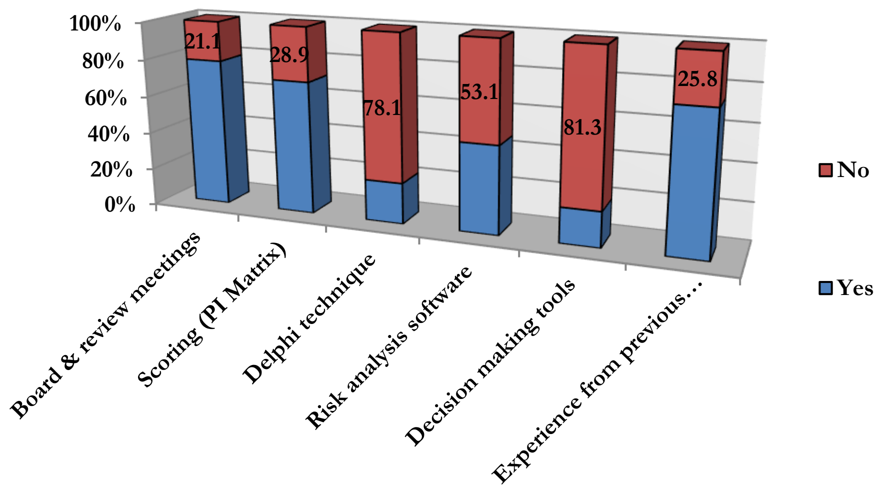

Figure 33 Frequency distribution of risk analysis techniques

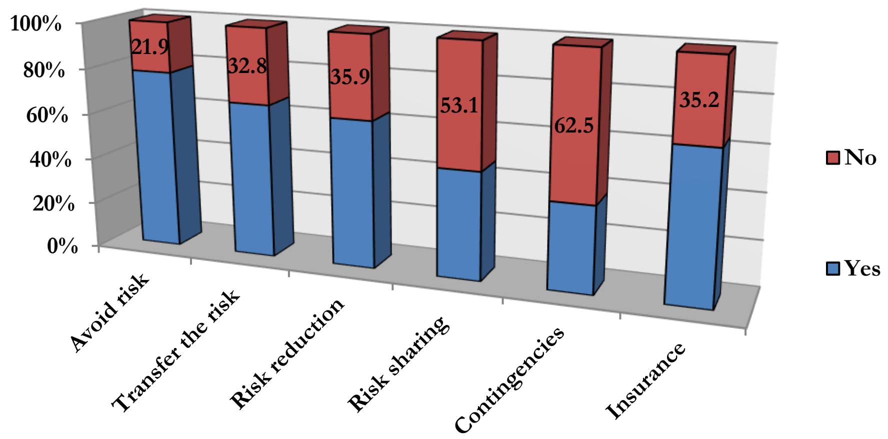

Figure 34 Frequency distribution of risk response strategies

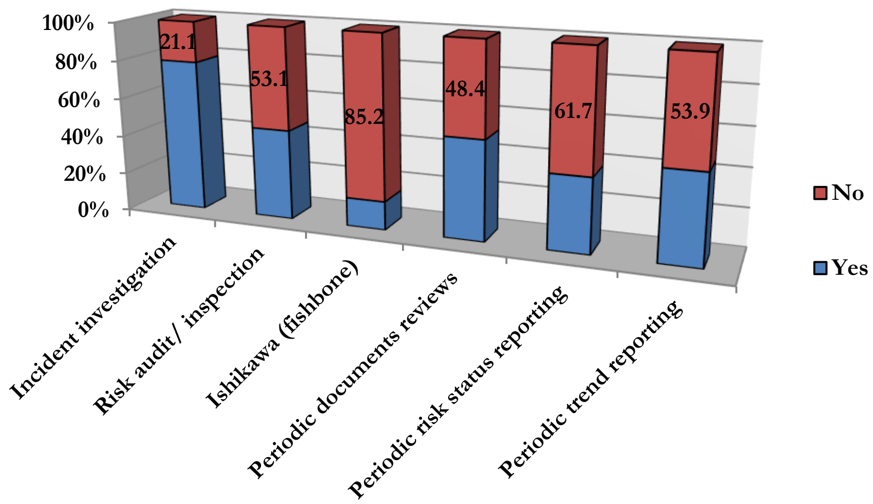

Figure 35 Frequency distribution of risk monitoring techniques

5.3.12 RM maturity criteria scores

The ranking analysis was applied to ascertain the relative importance of the factors through the examination of the mean values and standard deviations. In cases where the factors had the same mean values, the approach adopted was to select the one with lower standard deviation.

This approach has been used in previous studies (Chileshe and Yirenki-Fianko, 2012; Zhao et al., 2014). The RM maturity criterion scores can provide the companies' management staff with a clear understanding of their strengths and weaknesses of the RM implementation. Table 27 presents the overall maturity criterion scores construction companies operating in GCC.

Table 20 RM maturity criteria mean scores

ID	Item Statistics			
	RM maturity criteria	**Mean**	**Std. Deviation**	**Rank**
M1	There is formal report submitted to board level in your organisation at least annually on the current state of risk and effectiveness of RM	3.42	1.048	4
M2	The organisation board reviews the risk process on a regular basis	2.98	1.135	14
M3	The senior management fully engage with and commit to the RM meetings	3.04	1.314	11
M4	The Department Managers fully engage with and commit to the RM meetings	2.83	1.271	19
M5	The RM team appropriately resourced	2.37	1.234	28
M6	RM plans and procedures are fully developed	2.91	1.144	16
M7	RM is widely implemented and practiced in all levels	2.67	1.102	25
M8	RM process reviewed to ensure the process is effective	2.76	1.187	21
M9	Potential risks are identified each time for new projects	3.28	1.181	6
M10	You are aware of triggers in projects causing risks to occur	3.82	.680	1
M11	You can identify and recognise these triggers easily	3.40	.859	5
M12	You conduct intensive analyses of causes in terms of the sources of risk	3.15	.628	9
M13	A systematic identification method is used to ensure risks are identified	2.90	1.147	17
M14	Risks occurred are compared against to initially identified risks	2.99	1.015	13
M15	You take many actions at the sources of risk (e.g.by contractual obligation)	3.17	1.169	8

Table 20 RM maturity criteria mean scores – continuation

ID	Item Statistics			
	RM maturity criteria	**Mean**	**Std. Deviation**	**Rank**
M16	All project participants are capable of basic risk analysis skills such as qualitative or quantitative analysis	2.52	1.006	27
M17	Qualitative and/or quantitative risk analysis tools and applications are used to assess identified risks	2.73	1.002	24
M18	The results of risk analysis is used as a basis for resource allocation and distribution to projects	2.95	.861	15
M19	Risks are consistently identified, analysed, responded, and continuously monitored throughout the project life cycle	3.00	1.071	12
M20	You have enough freedom of action to react to risks adequately	3.66	1.075	2
M21	You can react to identified risks and carry out the necessary adaptive measures quickly	3.52	.900	3
M22	Formalized RM system	3.23	1.228	7
M23	Standardized RM system	3.14	1.255	10
M24	RM information is distributed and communicated to all project participants	2.75	1.263	22
M25	RM tools and techniques are integrated and used in projects	2.74	1.320	23
M26	Sufficient resources are dedicated of projects	2.64	1.242	26
M27	RM ownerships	2.83	.985	20
M28	RM system is embedded in firm's behavior and practices	2.88	1.398	18
RMMI		**3.01**		-

It was anticipated that the characteristics of the respondents' organisations will have a direct impact to their RM maturity levels. Figure 34 shows the relationship between RM maturity of construction firms and the firms' expansion. For example, the results indicated that the contractor organisations that deal with large-scale projects are likely to be more adapting in using RM processes, due to the increased level of project complexities and increased number of project participants. The results show that the RM maturity of construction firm increased when the firm expand its scale of projects.

Furthermore, as shown in Figure 35, the RM maturity levels of the construction firms appear to be influenced by their organisation history, the older organisations tend to have better RM practices. This may be due to the level of experience, financial abilities, and resources available for these organisations to successfully implement RM practices (Zou et al., 2010).

Figure 36 displays the relationship between the number of employees in the respondent’s organisations and their average RM maturity level obtained. The results showed that large and medium firms have a tendency to implement better RM practices that small firms. This result consisted with other researches (Zou et al., 2010; Zhao et al., 2014). Moreover, Figure 37 shows the relationship between RM maturity and firms’ ownership. The result shows that JVs tend to have better RM practices comparing to international, state – owned, and local firms.

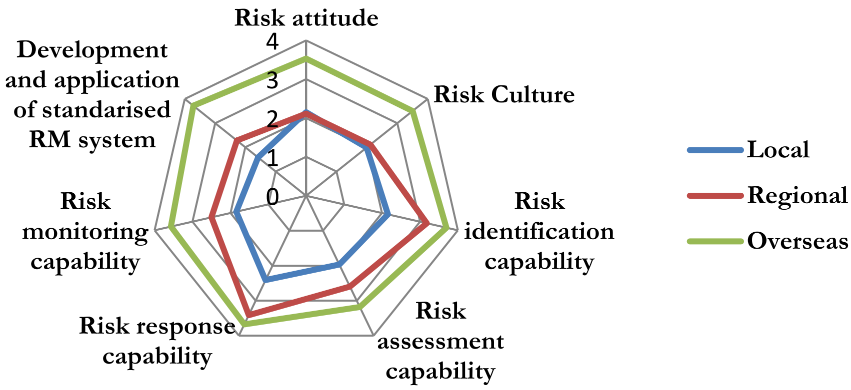

Figure 36 RM Maturity levels and firms’ expansion

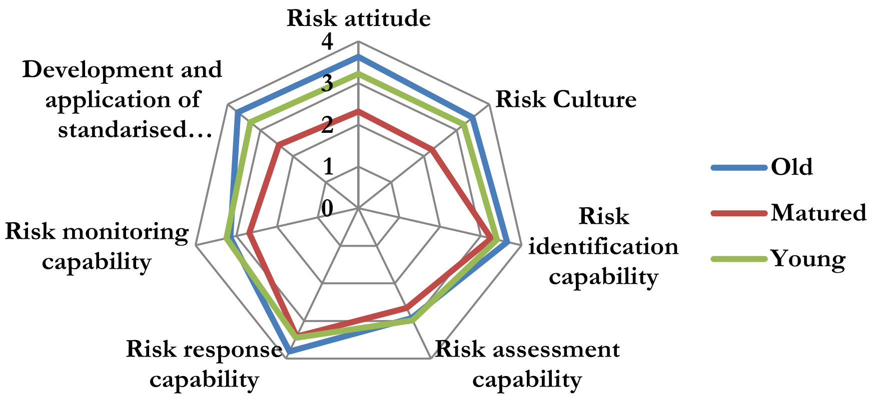

Figure 37 RM Maturity levels and firm age

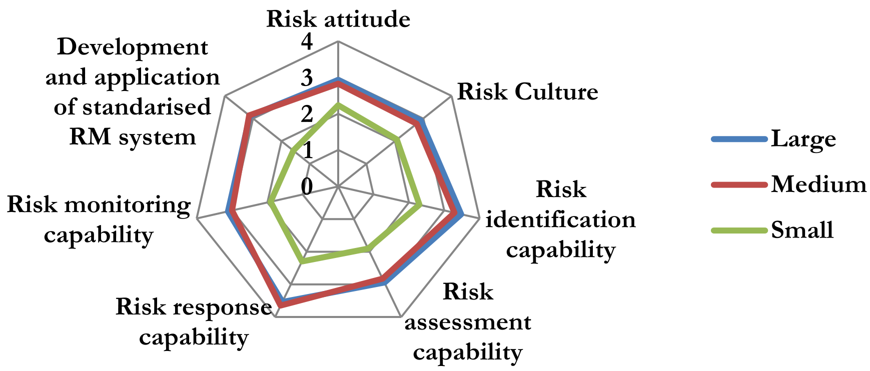

Figure 38 RM Maturity levels and firm size

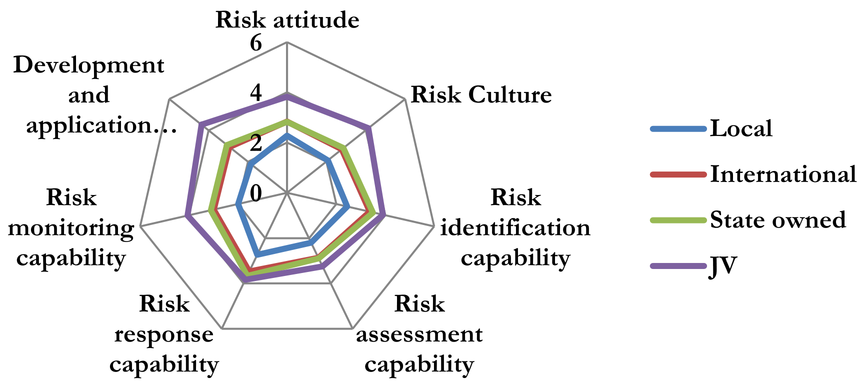

Figure 39 RM maturity levels and firms' ownership

Table 21 Maturity scores according to firms' characteristics

Maturity ID	Overall		Firm age						Firm size					
			Young		Matured		Old		Small		Medium		Large	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
M1	3.42	4	3.51	4	3.22	5	4	3	2.55	4	3.45	4	3.51	5
M2	2.98	14	3.39	9	2.38	15	3.71	10	2.27	10	2.85	15	3.08	14
M3	3.04	11	3.54	3	2.31	18	3.86	6	2.45	5	2.95	13	3.12	11
M4	2.83	19	3.31	10	2.15	24	3.57	12	2.45	6	2.7	21	2.9	20
M5	2.37	28	2.71	27	1.87	28	3	25	1.73	18	2.35	28	2.44	28
M6	2.91	16	3.31	11	2.33	17	3.57	13	1.64	22	2.85	16	3.06	16
M7	2.67	25	3.03	23	2.16	23	3.14	22	1.55	24	2.65	25	2.8	24
M8	2.76	21	3.06	22	2.31	19	3.43	14	1.55	25	2.55	26	2.94	19
M9	3.28	6	3.49	5	2.95	8	3.86	7	2.73	2	3.1	10	3.37	7
M10	3.82	1	3.72	1	3.91	1	4	4	2.64	3	3.8	2	3.95	1
M11	3.4	5	3.18	20	3.69	2	3.29	18	1.73	19	3.4	6	3.59	4
M12	3.15	9	3.25	13	3.09	6	2.71	27	2.36	7	3.15	9	3.24	9
M13	2.9	17	3.19	18	2.47	14	3.43	15	2.09	12	2.85	17	3	18
M14	2.99	13	3.24	15	2.69	11	3	26	1.82	15	3.05	11	3.11	13
M15	3.17	8	3.26	12	3.04	7	3.29	19	2.18	11	3.45	5	3.22	10
M16	2.52	27	2.68	28	2.29	21	2.71	28	1.73	20	2.4	27	2.63	27
M17	2.73	24	3	25	2.35	16	3.14	23	1.82	16	2.7	22	2.84	22
M18	2.95	15	2.99	26	2.89	9	3.14	24	1.73	21	3.05	12	3.07	15
M19	3	12	3.24	16	2.67	12	3.29	20	2	13	2.95	14	3.12	12
M20	3.66	2	3.59	2	3.69	3	4.14	1	2.36	8	3.9	1	3.76	2
M21	3.52	3	3.49	6	3.51	4	4	5	2.36	9	3.6	3	3.64	3
M22	3.23	7	3.49	7	2.8	10	4.14	2	1.45	26	3.3	7	3.42	6
M23	3.14	10	3.48	8	2.64	13	3.86	8	1.45	27	3.2	8	3.32	8
M24	2.75	22	3.18	21	2.15	25	3.43	16	1.64	23	2.8	19	2.87	21
M25	2.74	23	3.19	19	2.09	26	3.43	17	1.82	17	2.8	20	2.83	23
M26	2.64	26	3.03	24	2.04	27	3.71	11	2	14	2.7	23	2.7	26
M27	2.83	20	3.25	14	2.25	22	3.29	21	3.45	1	2.7	24	2.79	25
M28	2.88	18	3.24	17	2.31	19	3.86	9	1.45	28	2.85	18	3.04	17
RMMI	3.01	-	3.251	-	2.651	-	3.5	-	2.03	-	3.00	-	3.12	-

Table 21 Maturity scores according to firms' characteristics – continuation

Maturity ID	Firm expansion						Firm ownership							
	Local		Regional		Overseas		JV		State owned		International		Local private	
	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
M1	2.62	2	3	7	3.87	5	4.13	9	3.54	5	3.40	5	2.80	3
M2	2.23	9	2.16	19	3.72	9	4.00	12	2.92	15	2.98	14	2.20	12
M3	2.38	6	2.04	23	3.88	4	4.38	5	2.92	16	3.02	11	2.30	11
M4	2.15	10	2.02	25	3.54	14	4.00	13	2.54	25	2.82	19	2.40	10
M5	1.69	21	1.71	28	2.97	27	2.50	28	2.38	28	2.41	28	1.80	22
M6	1.77	18	2.18	18	3.65	11	4.00	14	2.77	19	2.92	16	2.10	13
M7	1.62	23	2.14	21	3.25	24	3.75	20	2.62	24	2.66	25	2.00	17
M8	1.54	25	2.16	20	3.43	19	3.63	21	2.69	22	2.80	20	1.80	24
M9	2.38	7	2.76	9	3.82	7	3.88	18	3.46	7	3.28	6	2.50	8
M10	2.54	3	3.9	1	4	2	4.25	7	3.92	1	3.85	1	3.00	2
M11	1.85	14	3.86	2	3.37	22	3.25	25	3.54	6	3.48	4	2.50	9
M12	2.38	8	3.04	5	3.38	21	3.50	23	3.23	9	3.16	8	2.70	5
M13	1.85	15	2.2	15	3.6	12	4.25	8	3.08	12	2.88	17	1.80	23
M14	1.77	19	2.55	11	3.54	15	4.13	10	3.23	10	2.97	15	2.00	18
M15	2.15	11	3.04	6	3.46	18	3.50	24	3.38	7	3.16	9	2.70	6
M16	1.77	20	2.27	14	2.84	28	2.62	27	2.69	23	2.55	27	1.90	21
M17	1.85	16	2.2	16	3.28	23	3.62	22	2.54	26	2.75	21	2.10	14
M18	1.85	17	2.86	8	3.24	26	3.25	26	3.08	13	3.00	13	2.10	15
M19	1.92	12	2.45	13	3.6	13	4.00	15	3.00	14	3.02	12	2.00	19
M20	2.54	4	3.69	3	3.85	6	4.00	16	3.92	2	3.69	2	2.80	4
M21	2.54	5	3.51	4	3.72	10	4.00	17	3.69	3	3.55	3	2.70	7
M22	1.46	26	2.61	10	4.03	1	4.88	1	3.62	4	3.17	7	2.00	20
M23	1.46	27	2.47	12	3.96	3	4.75	2	3.38	8	3.12	10	1.70	25
M24	1.62	24	2.02	24	3.51	16	4.38	6	2.85	17	2.71	23	1.70	26
M25	1.69	22	1.96	26	3.51	17	4.50	4	2.85	18	2.69	24	1.60	27
M26	1.92	13	1.8	27	3.4	20	4.13	11	2.77	20	2.56	26	2.10	16
M27	3.08	1	2.18	17	3.25	25	3.88	19	2.77	21	2.72	22	3.10	1
M28	1.38	28	2.08	22	3.75	8	4.63	3	3.15	11	2.85	18	1.40	28
RMMI	2	-	2.53	-	3.55	-	3.92	-	3.09	-	3.00	-	2.20	-

5.3.13 RM implementation in firm's projects

Table 30 shows the percentage of projects implemented with RM to the total number of projects implemented in the firms participated in the questionnaire.

5.3.13.1 Status of RM implementation: company level

To identify the status quo of RM implementation, the respondents were asked to provide project RM implementation in their companies. Thus, the RM implementation index (RMII), which describes the extent of RM implementation in a company, can be calculated using the following equation (Hwang et al., 2013):

$$\text{RMII}=\frac{\text{Number of projects with RM implementation}}{\text{Total number of projects of a company}}\times 100$$

In this study, the denominator of this equation was the total number of the projects that a company had participated in during the past three years (2012-2014). Thus, the RMII of each company surveyed was calculated. The results indicated that only 15.4 percent companies did not implement RM (RMII=0%) in all their projects, while none obtained a RMII with 1-9 percent, 10-19 percent, and 50-59 percent.

Table 22 RMII: company level

RMII	**Overall**	
	N	**%**
0 %	20	15.4
1 – 9%	0	0
10 – 19%	0	0
20 – 29%	1	0.8
30 – 39%	43	33.1
40 – 49%	5	3.8
50 – 59%	0	0
60 – 69%	3	2.3
70 – 79%	9	6.9
80 – 89 %	1	0.8
90 – 100%	48	36.9
Total	130	100

As shown in Figure 38, 70.6 percent of overseas firms have 100 percent RMII in their projects, whereas 15 percent of regional firms have 30 – 39 percent RMII. Also, 24.7 percent of local firms have 0 percent RMII. The result indicated that larger contractors, which were better equipped with resources, experience, advanced technology and professionals with expertise (Hwang and Low, 2012; Hwang et al., 2014), were more likely to implement RM in their projects.

5.3.13.2 *Status of RM implementation: project level*

Table 31 presents the number and proportion of the projects with RM implementation. In terms of project type, 72.3% of public projects had RM implementation while the proportion of private projects was only 32.7%. This was probably because the public sector tended to place higher emphasis on the overall quality than the tender price (Hwang et al., 2014) and RM would increase the quality of the tender, thus contributing to higher scores during the tender evaluation of public projects. On the other hand, the private sector usually awards the contract to the tender with the lowest price (Wong et al., 2000), which may not have sufficient resources for RM implementation.

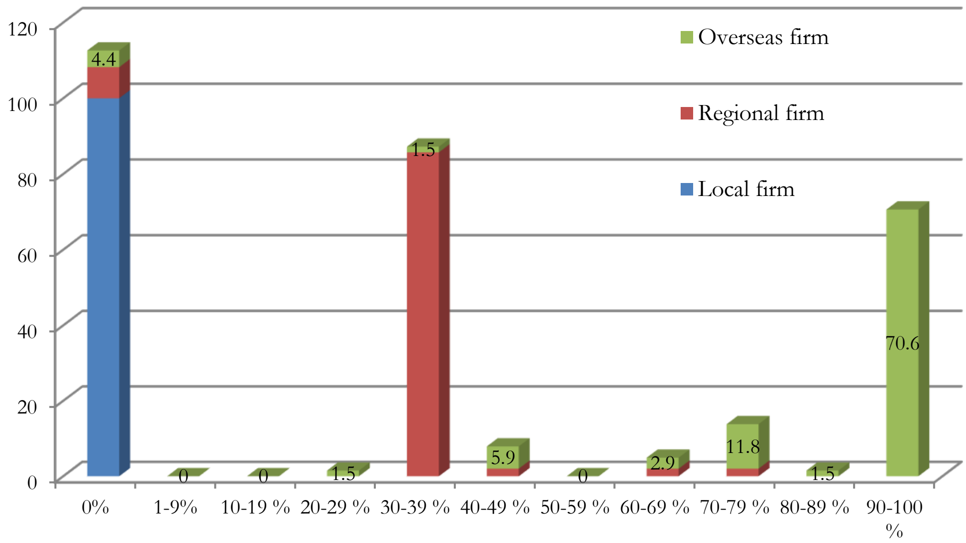

Figure 40 RMII in overseas, regional and local firms

Table 23 RMII: project level

Project characteristics		No. of projects	No. of projects with RM	% of projects with RM
Project type	Public	357	258	72.3
	Private	214	70	32.7
Total		571	328	57.4

5.3.13.3 Difficulty of firms in RM implementation

Contractors always regard risk analysis as the most difficult phase and care less about the risk response and risk monitoring in construction projects. As shown in Figure 39, 69.7 percent of the respondents indicated that risk response was the most difficult to implement during RM processes.

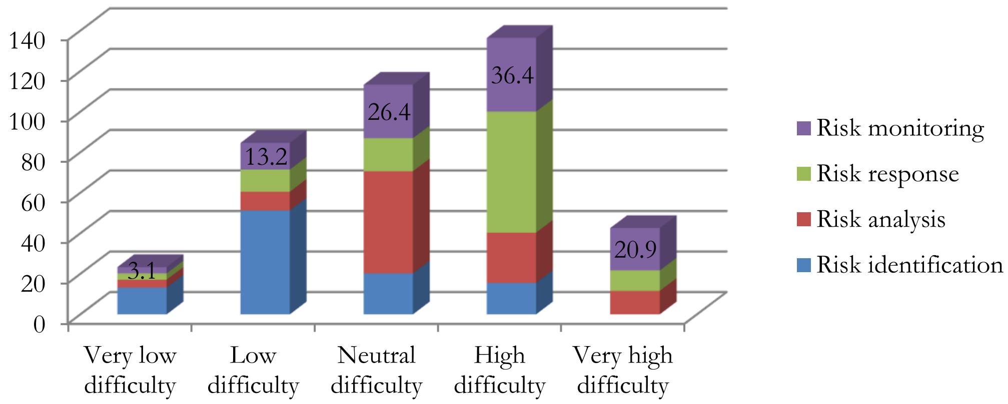

Figure 41 Difficulty of construction firms in RM implementation

5.3.13.4 Capability of firms in RM implementation

As Figure 40 shows, there is low capability of respondents in the risk response stage and risk monitoring stage, whereas high capability in risk identification stage.

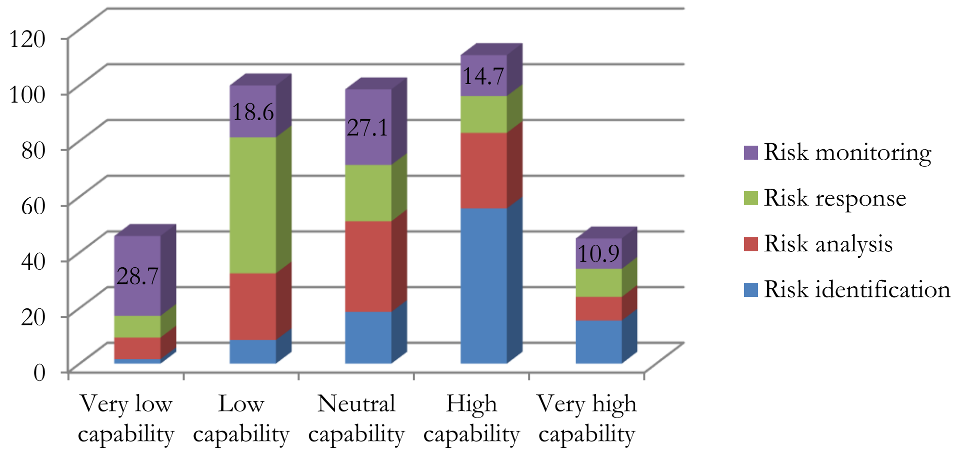

Figure 42 Capability of construction firms in RM implementation

5.3.13.5 Barriers to successful RM implementation

The respondents were asked about the significance degree of pre-identified barriers of implementation of RM in the GCC construction industry. In the first place, the data acquired from questionnaire survey in this section have been analysed by the means of mean index analysis to identify the key barrier hindering the implementation of RM.

Table 32 illustrates the respondents' responses described as mean index and ranking for each barrier. There are 15 barriers identified. The ratings based on mean index show that respondents consider that the political environment (=4.18), the bureaucratic attitudes (=4.15), lack of required knowledge and skills in RM (=4.13), lack of interest or motivation (=3.95), cultural differences (=3.85), employees not empowered to implement RM process (=3.85), RM responsibilities not clearly defined (=3.74), lack of joint RM mechanism by parties (=3.74), lack of historical data for risk trend analysis (=3.74), and project participants do not regard RM as an integral part of the project management (=3.69), were the major barriers to successful implementation of RM in their projects.

The results in Table 32 below were consistent with the results of a study conducted by Choudhry and Iqbal (2013) in the construction industry in Pakistan. In their study, lack of formal RM system was ranked first, whereas lack of a joint RM system and shortage of knowledge/techniques were ranked second and third, respectively.

Table 24 Barriers to RM implementation

ID	Barriers	Mean	Rank
B1	The political environment is one of our main concerns in managing risks in GCC	4.18	1
B2	Bureaucratic attitudes are an ever – present problem in GCC	4.15	2
B3	The language barriers is an obstacle for us	2.28	15
B4	Cultural differences have been a problem for us	3.85	5
B5	The hosting country (local laws, permits, etc.) is one of major reason for barriers to RM implementation	3.28	13
B6	Lack of required knowledge and skills in RM	4.13	3
B7	Lack of RM awareness among top management staff	3.55	11
B8	Lack of interest or motivation	3.95	4
B9	Employees not empowered to implement RM process	3.85	6
B10	RM responsibilities not clearly defined	3.74	7
B11	Project participants do not regard RM as an integral part of the project management	3.69	10
B12	Lack of accepted industry model for analysis	3.12	14
B13	Lack of joint RM mechanise by parties	3.74	8
B14	Lack of historical data for risk trend analysis	3.74	9
B15	Insufficient ongoing project information for decision making	3.29	12
	Total	3.636	-

5.4 Analytical statistics

After presenting the descriptive results of both questionnaires, it is worth investigating the effect of firm' characteristics, such as: size of firm, expansion of firm, history of firm, and ownership of firm; on the RM maturity level and on the status of RM implementation. Such an analysis enriches the findings of the research and further explains the presented results. The questionnaire included two data types of questions, categorical and ordinal. Chi – square statistical tests are used to analyse the relationship between the categorical data type. Also, non – parametric tests are used to analyse the variance between the ordinal data type.

5.4.1 One – way ANOVA

A one - way between groups of variance (ANOVA) was conducted to test if there was any significant difference in the responses of respondents. The respondents were divided into three groups (Group 1= overseas; Group 2: = regional; and Group 3= local). A *p*-value < 0.05 indicates that the two groups have different opinions.

In order to see if there is a significant association within the firm capabilities in RM process relating to effectively implement RM. A series of ANOVA test has been carried out to examine whether there was an association between the variables. The result shows that, there are no statistically significant differences (at confidence level 95%) within the variables as shown in Table 33, where *p*-value is higher than 0.05.

Also, Tables 34 and 35 shows *p*-values for statistical association between Maturity criteria and firm age. The results show that there is a significant association between RM maturity and the age of firm, and expansion of firm.

Table 25 ANOVA test 1

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Rows	0.15	3	0.05	0.0001	0.999997518	3.490295
Columns	1703.2	4	425.8	1.2097	0.356795797	3.259167
Error	4223.6	12	351.966			
Total	5926.95	19				

Table 26 ANOVA test 2

Firm age			
Maturity criteria	*P*-Value	Maturity criteria	*P*-Value
M 1	0.218	M 15	0.000*
M 2	0.000*	M 16	0.003*
M 3	0.000*	M 17	0.000*
M 4	0.000*	M 18	0.262
M 5	0.012*	M 19	0.002*
M 6	0.000*	M 20	0.196
M 7	0.000*	M 21	0.032*
M 8	0.000*	M 22	0.000*
M 9	0.185	M 23	0.000*
M 10	0.138	M 24	0.000*
M 11	0.072	M 25	0.000*
M 12	0.000*	M 26	0.000*
M 13	0.059	M 27	0.000*
M 14	0.010*	M 28	0.000*

*It is the significant association at confidence level of 95%

Table 27 ANOVA test 3

Firm expansion			
Maturity criteria	*P*-Value	Maturity criteria	*P*-Value
M 1	2.354E-06*	M 15	3.0E-07*
M 2	1.139E-12*	M 16	2.6E-05*
M 3	8.218E-15*	M 17	7.6E-11*
M 4	6.239E-11*	M 18	1.1E-07*
M 5	6.542E-06*	M 19	2.5E-12*
M 6	5.115E-13*	M 20	1.1E-05*
M 7	7.461E-10*	M 21	3.0E-04*
M 8	2.616E-15*	M 22	1.9E-22*
M 9	8.801E-08*	M 23	1.6E-17*
M 10	5.496E-12*	M 24	2.0E-10*
M 11	5.432E-18*	M 25	4.4E-10*
M 12	8.518E-14*	M 26	8.8E-11*
M 13	1.037E-10*	M 27	3.1E-06*
M 14	9.670E-01*	M 28	1.3E-11*

*It is the significant association at confidence level of 95%

5.4.2 Chi – square tests

5.4.2.1 Relationship between RM maturity and firm characteristics

In this research, the relationship between RM maturity and firm size and experience was examined. The chi – square (x^2) contingency table analysis can determine the extent to which a statistical relationship exists between two variables and this method was performed with the significance level of 0.05 as shown in Table 36. In terms of the relationship between RM maturity and firm size, the x^2 was 86.562 with a *p*-value of 0.0000, suggesting there was significant association between RM maturity and firm size.

Thus, the larger firms were more likely to have higher-level RM maturity, which was consistent with the previous findings in other industries (Colquitt et al., 1999; Hoyt and Liebenberg, 2011; Zhao et al., 2014). The relationship between the size of the company and the expansion of the company is investigated. Cross - tabulation was conducted between the answers of the company's size and the expansion of the company. Chi square analysis was conducted to examine any significant statistical differences between the different categories. Actually, the results showed significant differences in company's expansion according to company size.

Table 37 shows a clear tendency of large companies to expand their scope of business in other countries. Only 53.5 percent of large companies operate overseas, however, in small and medium scale enterprises, 2.9 percent and 19.1 percent operate in overseas projects. In particular, small and medium sized firms are less likely to enter culturally distant markets because environmental uncertainty makes them shy away from new investments or opportunities and minimize their resource commitments (Lynn and Reinsch, 1990; Krishna and D'Souza, 1993; Han et al., 2005).

Table 28 Chi –square test

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	86.562[a]	8	.000
Likelihood Ratio	53.641	8	.000
Linear-by-Linear Association	18.795	1	.000
N of Valid Cases	129		

a. 8 cells (53.3%) have expected count less than 5. The minimum expected count is .85.

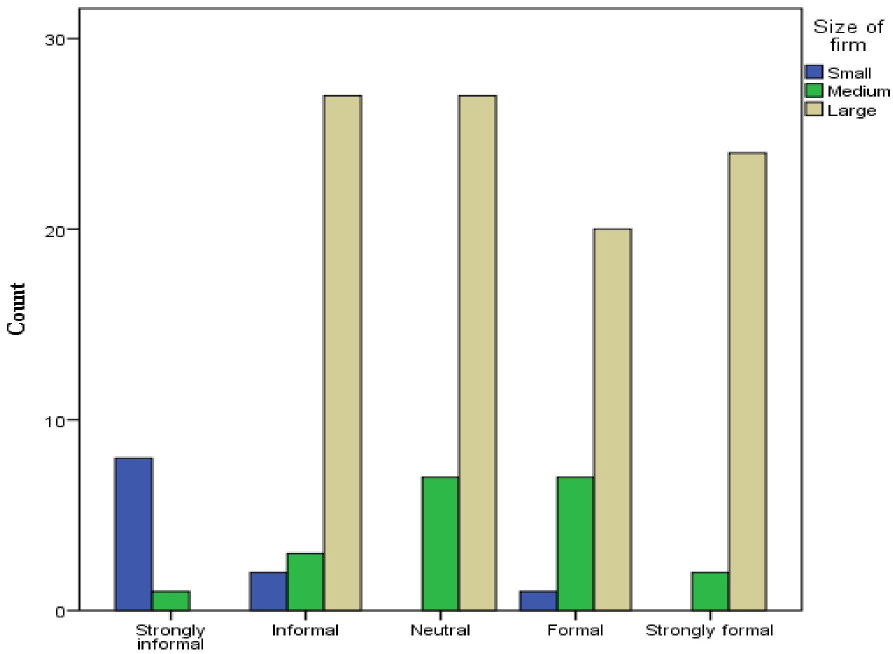

Figure 43 The relationship between firm's size and the RM Maturity

Local and regional contractors rarely participate in international construction markets. In addition, international construction projects are typically larger in size and more complex technologically and organisationally. Due to the distribution of projects around world, the international contractor is more projects oriented, more mobile, and subject to more environmental influences (Han et al., 2005).

In order to check whether the above result did not happen by chance and to test whether or not a significant statistical difference did exist between the different size categories, chi- squared test was conducted. The chi- squared statistical test showed that the difference was statistically significant: $x^2 = 80.630$, $p = 0.000 < 0.05$. Hence there is a relation between the size of the construction company and the expansion of company. This may, to some extent, explain why small companies rarely operate projects overseas.

Table 29 Size of firm and Expansion of firm Cross-tabulation

			Expansion of firm			Total
			Local	Regional	Overseas	
Size of firm	Small	Count	9	0	2	11
		% within Size of firm	81.8%	0.0%	18.2%	100.0%
		%within expansion of firm	69.2%	0.0%	2.9%	8.5%
		% of Total	6.9%	0.0%	1.5%	8.5%
	Medium	Count	4	3	13	20
		% within Size of firm	20.0%	15.0%	65.0%	100.0%
		%within expansion of firm	30.8%	6.1%	19.1%	15.4%
		% of Total	3.1%	2.3%	10.0%	15.4%
	Large	Count	0	46	53	99
		% within Size of firm	0.0%	46.5%	53.5%	100.0%
		%within expansion of firm	0.0%	93.9%	77.9%	76.2%
		% of Total	0.0%	35.4%	40.8%	76.2%
Total		Count	13	13	49	68
		% within Size of firm	11.1%	10.0%	37.7%	52.3%
		% within expansion of firm	100.0 %	100.0%	100.0%	100.0%
		% of Total	11.1%	10.0%	37.7%	52.3%

Table 30 Chi-Square Test

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	80.630[a]	4	.000
Likelihood Ratio	60.981	4	.000
Linear-by-Linear Association	22.971	1	.000
N of Valid Cases	130		

a. 3 cells (33.3%) have expected count less than 5. The minimum expected count is 1.22.

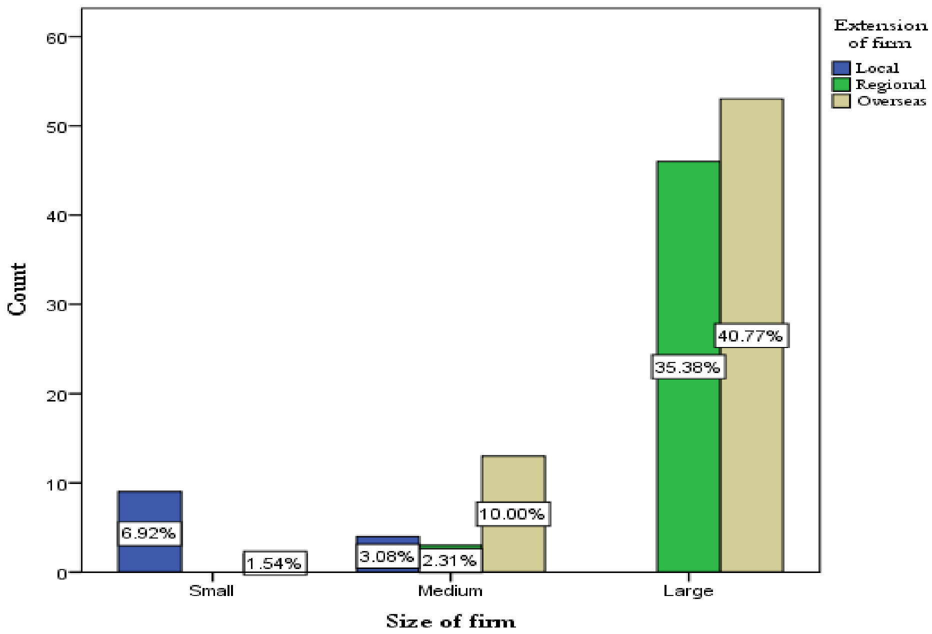

Figure 44 The relationship between firm's size and the expansion of firm

5.4.3 Reliability and validity tests

Questionnaires must be subjected to statistical analysis to confirm their reliability and validity (Ghosh and Jintanapakanont, 2004). To validate the items, reliability and validity tests of the instrument were conducted. According to Cronbach (1951), this is one of the most popular reliability statistics which aimed to determining the internal consistency or average correlation of items in a survey instrument to gauge its reliability. Cronbach's alpha coefficient can range from 0 – 1 and should be at least 0.7 for a scale to be reliable (Nunnally, 1978; Hair et al., 1998). The Cronbach α was found to be .754 for the variables. While the Cronbach α coefficient for the variable was > 0.7, thus indicating a high reliability of scales (Nunnally, 1978), the same study by Nunnally (1978) has pointed out that, lower thresholds are sometimes used in literature. Consequently, all measurement models presented appropriate reliability.

Table 31 Cronbach's Alpha

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.754	.621	127

5.4.4 Validity test: Content validity

A measure has content validity if there is general agreement among subjects and researchers that the instrument has measurement items that cover all aspects of the variable being measured (Love and Irani, 2004). The content validity of the questionnaire was based on the literature review and on the opinions of several experts who examined the items. Thus, we concluded that the maturity attributes and barriers criteria had content validity. According to Nunnally (1978) an instrument has content validity when it contains a representative collection of items and when appropriate methods were used to construct the test (Nunnally, 1978). We concluded that the maturity and barriers criteria section of this survey had content validity because it was approved by the pilot respondents.

5.5 Summary of this chapter

This chapter summarized the data analysis results of the questionnaire surveys. A total of 62 risk factors were assessed and ranked in the first questionnaire survey. Also, a total of 28 RM maturity criteria and 15 barriers to RM were validated by the second questionnaire. The results reported a low level overall RM maturity of local firms, as well as positive association between RM maturity and firms' characteristics. Larger, older and expanded firms tend to have better RM practices.

Chapter Six
Case Studies from the GCC Countries

6.1 Introduction

This chapter presents six case studies to investigate RM implementation in construction firms in the GCC countries. They were seven overseas, two regional, and three local firms. Table 40 shows a profile of the six case studies in this research. RM plans, past documents, including the internal documents about RM and the reports which were also reviewed. Also, this Chapter presents the cross - case comparisons, which is substantiated the association between RM maturity and firms' characteristics.

Yin (2003) describes the case study as an "empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident". In order to explore all those issues, case studies can include the collection of data from several different sources, to allow for triangulation, and in this research project, the case studies involved the researcher conducting personal interviews. The case studies aim to investigate the existing status of RM implementation, risk culture, risk communication, critical risks in project, and RM process implementation.

Table 32 Case studies description

No.	Project type	Project cost (US$)	Project location	Firm nationality
Case study 1	Metro project	6.4 Billion	KSA	Consortium
Case study 2	Rail project	1.4 Billion	KSA	KSA
Case study 3	Hotel	70 Million	KSA	KSA
Case study 4	Skyscraper building	830 Million	Kuwait	Kuwait
Case study 5	Commercial tower	178 Million	Qatar	Qatar
Case study 6	Port warehouses	70 Million	Dubai	UAE

Table 33 Interviewees' profile

No	Role in firm	Exp. (Years)	Interviewee's nationality	Firm	Firm location	Firm size
1	Project director	35	Germany	Independent	-	Large
2	Project management manager	32	USA	Firm A	Australia	Large
3	Lead risk manager	15	Egypt	Firm A	Australia	Large
4	Project controls manager	28	UK	Firm A	Australia	Large
5	Risk manager	13	Egypt	Firm H	KSA	Large
6	Planning manager	18	Egypt	Firm H	KSA	Large
7	Chairman	15	Saudi Arabia	Firm J	KSA	Small
8	Construction manager	15	Kuwait	Firm K	Kuwait	Large
9	Construction manager	18	Qatar	Firm L	Qatar	Medium
10	Construction manager	15	UAE	Firm M	UAE	Medium

Table 41 exhibits the profile of the interviewees in the six case studies. The interviewees vary in their nationalities and their companies. Seven interviewees represent large construction firms, two represents medium firms, and one represents small firm. All of them have working experience above 10 years in the construction industry. Also, all of them were project managers in their firms.

6.2 Case study 1

6.2.1 Background

A multi-national consortium consists of seven overseas companies. Their original head-offices are in different countries, as shown in Table 42. The consortium currently has been awarded turnkey Engineering Procurement Consultant (EPC) for the design and implementation of a metro project, in Saudi Arabia. The project cost is 6.4 billion USD and the project duration is from 2013 until 2018. In this case study, a project director, manager of the project management, project controls manager, and a lead risk manager who form the consortium were interviewed to collect information and their profiles are shown in Table 43. The four interviewees represent Firm A in the consortium. Firm A is leading the project management for the whole consortium. The project director can attend the board meeting and monthly operating meetings, while the manager of project management and the risk manager cannot attend. All the four involved in the PRM. Thus, the four interviewees were involved in the RM practices at project and firm levels, and competent to provide adequate and reliable information about RM implementation in the consortium.

Table 34 Firms profile in the consortium

No	Consortium 1	Firm origin	Firm size (Employees)	Firm expansion	Firm age (Years)
1	Firm A	Australia	Large	Overseas	45
2	Firm B	Italy	Large	Overseas	57
3	Firm C	Italy	Medium	Overseas	10
4	Firm D	Spain	Medium	Overseas	59
5	Firm E	Turkey	Large	Overseas	35
6	Firm F	India	Large	Overseas	78
7	Firm G	United Kingdom	Medium	Overseas	74

Table 35 Interviewees profile in case study 1

Interviewees	Firm	Interviewee nationality	Experience
Project director	-	Germany	35 years
Project management manager	A	USA	32 years
Lead risk manager	A	Egypt	15 years
Project controls manager	A	United Kingdom	28 years

The board of the consortium consisted of nine members, including:

- Consortium representative: he is representing the consortium for contractual relationships between the consortium and the client (government).
- Project director: he is leading all managers in the consortium, as shown in Figure 43.
- One representative of each firm (total = 7 rep.): they are managing the contractual relationships, between their company and the consortium.

In addition, the information about the RM practices in the consortium was adapted and collected from Firm A which was leading the project management in the consortium. The information was collected from past documents, including internal documents about RM and annual reports.

The internal documents, including operational and management manuals, were not marked confidential and were obtained through networking, while the reports were collected through reviewing the websites of Firm A. Monthly report, quarterly risk review results, and risk workshop reports were provided by the interviewees.

6.2.2 Factors affecting RM implementation

As the interviewees said, one of the main barriers to RM implementation in the GCC is the construction environment. There is a lack of professional subcontractors. Local subcontractors are not able to implement international codes. Another barrier is the hosting country. The local codes were not sufficient and need improving to cope with the complexity and growth in size of projects running in the construction industry.

Moreover, another barrier is lack of historical data of risk trend analysis and insufficient ongoing project information. The absence of historical records made the quantitative risk analysis more difficult. Hence, to determine the value of the impact of risks, the historical data of trend analysis is needed, as well as sufficient and accurate records to illustrate the actual situation of the ongoing projects.

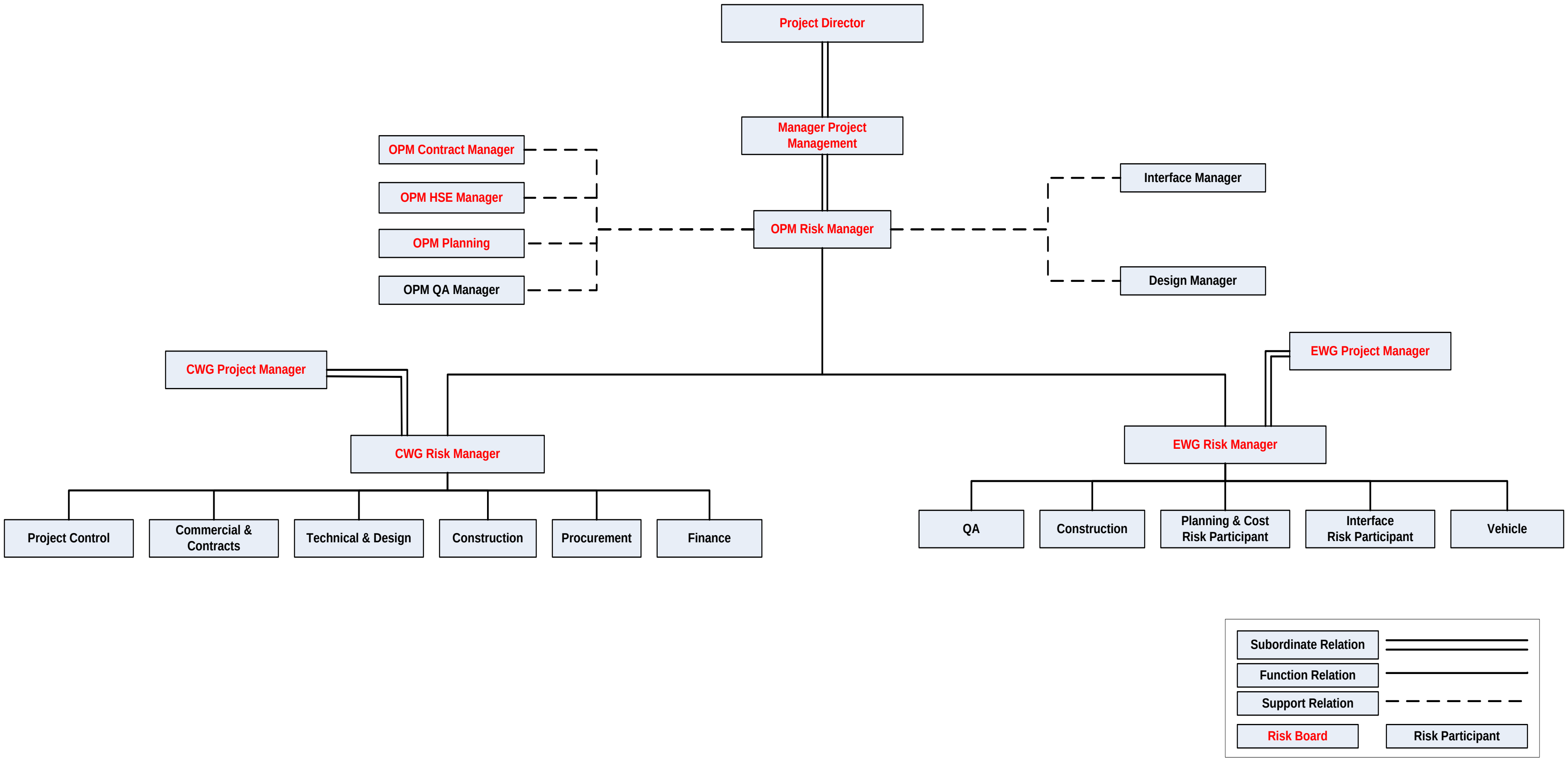

Figure 45 The risk organisation chart

There are different levels of RM maturity in the consortium, which cause difficulties in RM implementation. Also, the language and culture barriers in the hosting country were considered to be other challenges that affect the communication on different levels.

6.2.3 RM framework

The RM framework in Firm A was used as guidance to RM implementation in the consortium included the following components: establish context, risk identification, risk assessment/ quantitative, risk treatment, monitor and control, RM review, and risk aware culture. However, not all the components had been fully fulfilled in the consortium.

The consortium collected risk information from all available resources, such as: international standard ISO, tender documents of the project, company manual, developed process and procedures, risk workshops, lesson learned, and past project risk registers. All this information helped to identify potential risk.

There is a designated department in charge of RM activities in the consortium. This department reports weekly-monthly-quarterly directly to the engineer/client. The RM activities have been undertaken by leading two groups in the department. The first group is responsible for managing risk in the Civil Work Group (CWG) and the second group is responsible for managing risk in Electromechanical and System Work Group (EWG).

The interviewees described their RM approach as strongly formal because all information of RM system was developed, maintained, and reviewed in official manner in accordance with the approved RM plans. Also, the interviewees described their organisations' RM system to be highly standardised system. This was due to all processes, procedures and guidelines were developed in accordance with international standards (ISO 31000).

The interviewees described their organisation RM system to be highly adequate. There is an intention of the consortium board to implement RM system at an adequate level because they believe they cannot achieve project goals without sufficient RM system. This was reflected in many decisions, for instance, implementing Web-Based Tool (WBT), which was not exists neither in the original RM plan nor in the tender documents or contract obligations.

In addition, they increased the RM staff and risk participants (risk owner). Those decisions reflect the risk awareness culture in the organisation. Moreover, the project controls manager pointed out that one of the key motivations to implement RM plan is because the project contractual duration (baseline schedule) was very tight and contains very high percentage of critical activities on the critical path.

6.2.4 Risk communication

Risk communication is one of key success factors in RM implementation in the current project. Figure 44 illustrates the risk communication system in the consortium. The deficiency of risk communication will lead to depreciation in the RM performance. As the lead risk manager mentioned, there are several risk communication levels in this project. The first level is internal risk communication between the lead risk manager and risk participants in the consortium such as other risk managers, RM staff (part and full time), risk owners, and risk mitigation action owners (not necessarily in the RM team).

The second level is between all risk managers in the consortium and their RM departments in the seven origin head offices in different countries. This was for the purpose of risk auditing, reporting to corporate level, improving their RM performance, and lesson learned.

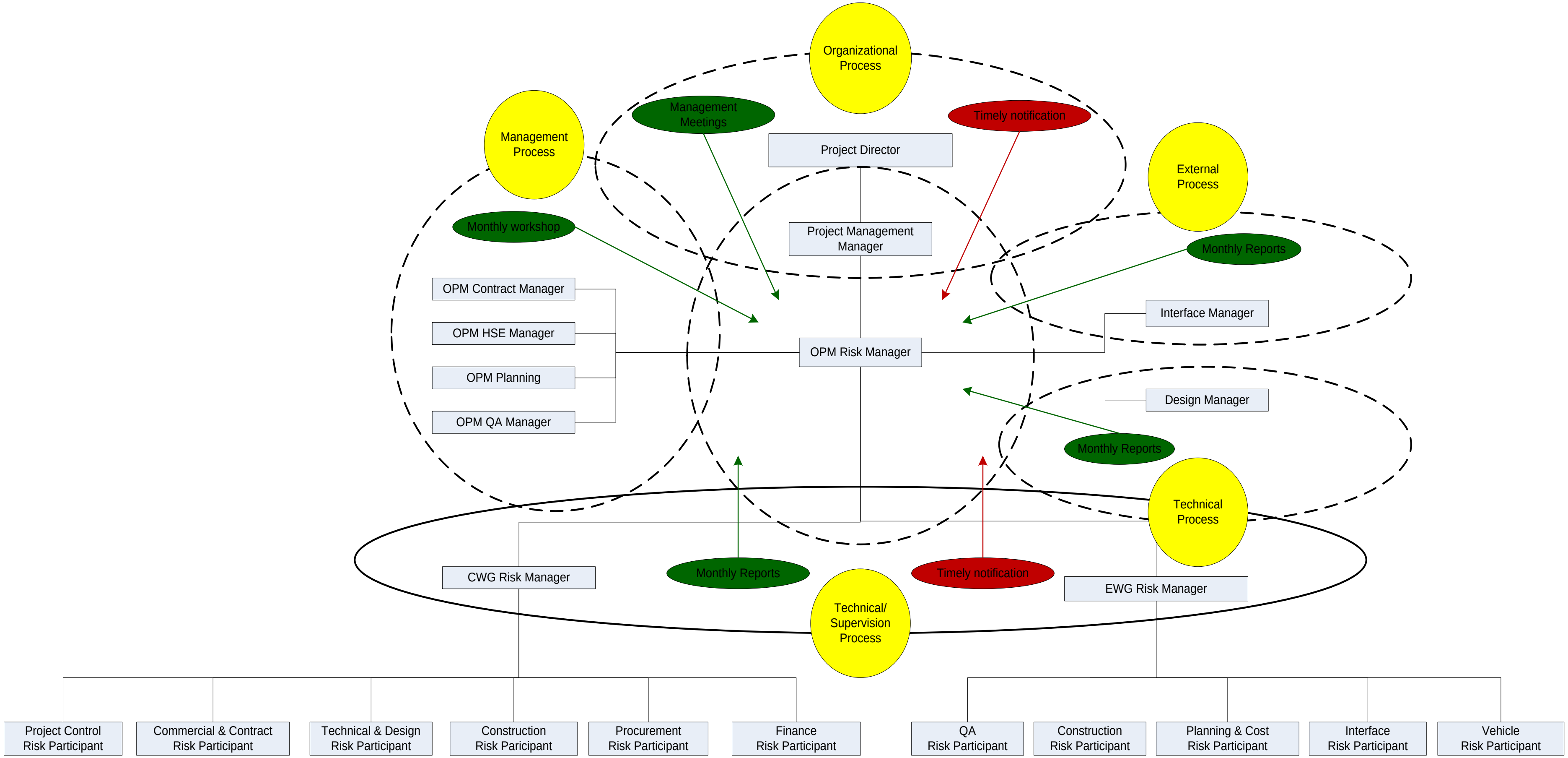

Figure 46 Communication of risk information in case study 1

The third level is between the consortium head office in the host country and relevant offices abroad providing services for the projects, for instance civil designs, electromechanical designs, system designs, and Temporary Traffic Plans (TTP), etc.

In the fourth level, the risk communication is between the consortium, and both suppliers and vendors abroad. As an evidence, there was one risk materialised (issue) and considered as a trigger for upcoming potential risks. The issue was a dramatic event occurred at Tianjin Port in China on August 13th 2015. It was a huge explosion caused much causality and destroyed a significant portion of the port area as well as many containers and equipment stored nearby.

Additionally, the blast caused a fall out of the poisonous particulate that compelled the local authorities to evacuate an area of three kilometres' radius. The effect of this issue was that there will be an impact on the schedule of future deliveries due to the disruption caused to the port activities. Also due to the disruption, the manufacturing company was located nearby the area of the accident and the area has been closed for the time being. Therefore, its factories stopped all the activities for safety reasons.

The supplier in China communicated and reported to the consortium in the host country about this issue and its expected delay for the material delivery. Hence, the consortium worked closely with suppliers in China trying to get additional information to evaluate the expected impact and determine the mitigation actions.

The fifth level is between the RM team in the consortium and the RM team in other consortiums in the metro project in Saudi Arabia. As an example, there are two critical risks in the project that should be managed because it could cause long delay, high cost, and bad reputation to the consortium. The first risk is a delay of arrival Tunnel Boring Machine (TBM) on the planned time in main conjunction station. Consequently, the consortium has to suspend his activities in the conjunction station and wait the arrival of the TBM machine from other consortiums which will cause severe delay in the project. Therefore, the two RM teams in both consortiums have to communicate to manage this risk.

The second risk is a delay from the consortium in the construction activities in the required date of TBM's other consortiums in the main conjunction station. According to that, the other consortium has to shut down his TBM machine, which will cause a very high cost and severe delay in the projects, as well as bad reputation. Then, another consortium will issue claim against the consortium to compensate a very high cost. Based on the risks above, the lead risk manager emphasised that the key mitigation action for both risks was to properly communicate, coordinate, and cooperate with RM departments in other consortiums, to overcome any challenges as soon as possible.

The last level, is between consortium and the Engineer, the PMO (client's representative), and the client. The lead risk manager reported to the Engineer weekly about the progress of mitigation action of top 10 risks in the project. Also, he reported monthly about the updated risk register, and monthly RM reports to the Engineer. Moreover, quarterly risk review report to the Engineer and the client. Mainly, this report shows the performance of RM implementation in the project.

Firm A issued a user manual for using the WBT RM system, to facilitate using the tool across all users. Besides the WBT, regular meetings, face-to-face interviews, skype interviews, conference meetings, emails and telephone calls were the main communication methods across project RM teams and departments in the consortium.

Table 36 Integration methods/tools in case study 1

Project Process	**Integration Method/Tool**		
	Monthly Workshop	Monthly Report	Timely Notify
Organisational Process		×	×
Management Process	×	×	
Technical Process		×	
External Process		×	×
Site Supervision Process		×	×

Regarding the cultural risk, all interviewees felt that there was a big cultural difference between foreigners and local labours. To overcome this risk, the interviewees explained that they spent much time in the firm to know more about the country and to establish relationships with the locals. Through the understanding of their culture, communication becomes more effective and foreigners are more certain of the true intentions of the local staff.

6.2.5 Risk culture within organisation

The interviewees described their RM system to be highly embedded in the organisation's behaviour and practice. This due to several activities to raise the awareness and risk attitude within the consortium through in-house training, mandatory on-line training, and twelve risk workshops planned to cover all project processes in different phases of the project. In addition, the RM team attended several risk workshops/meetings in different locations regionally and overseas. As mentioned earlier, Firm A provide mandatory on-line courses for all employees to increase risk culture. All employees have to attend those courses online and in case of not attending the online courses; the firm will delay his promotion.

6.2.6 RM ownership

In the consortium, the project director was ultimately responsible for the RM, but the lead risk manager actually took charge of RM. The senior management made decisions concerning RM because they were fully aware of all details of the project. However, the project director and the board have the authority in taking decisions relating to increase resources for RM such as people, software and tools. All critical decisions were discussed at regular board meetings. The list of potential risks identified from previous resources, has been tabulated in a risk- register, and reviewed monthly. In the start of the project, the total identified risks were 194. By completing 40% of the project, 216 risk factors have been identified, among which 12 risks occurred within two years (2013 – 2015). Within the first two years, the total number raised to 216, 46 out of the 216 risks were closed, 12 risks were materialized to issues and 34 were expired risks. The current identified number of risks was 170 risks. There were 14 critical risk, 44 moderate risks, and 112 low risks.

The critical risks identified are (in order of importance): (1) delay of power supply from the provider governmental utility; (2) lack of coordinate with another consortium in main conjunction station, which may cause delay of TBM on the planned time; (3) lack of coordinate with another consortium in main conjunction station, which may cause delay in construction; (4) delay in land expropriation; (5) delay to design process completion due to change notice; (6) discovery of unforeseen utilities along work areas; (7) shortage of cash in; (8) traffic detours and truck movement causing fatalities; (9) lack of integration between civil and system; (10) damage to transit system in storage and warehouse; (11) lack of coordination with governmental entities contractors; (12) longer time taken for re-allocation of utilities; (13) lack of integration between rolling stock and system; and (14) difficulties to meet sustainability requirements.

All the risks identified, the response plans for all identified risks, as well as lesson learned were issued to key stakeholders (client, engineer, and main sub-contractors) in the form of monthly report. The lead risk manager has reviewed the progress of mitigation actions weekly with risk owners in the consortium. Furthermore, he reported the results of the review of mitigation action to the engineer. The lead risk manager in charge of managing risks used different software. He used spreadsheet software, Primavera Risk Analysis, and WBT.

The spreadsheet is used for registering all risks, estimating risk scoring, risk classification and risk prioritisation. Also, the spreadsheet is used for registering the risk treatment actions and scheduling the risk mitigation actions. Moreover, it is used for monitoring and tracking the progress of implementing the risk treatment actions during the project life. Finally, it registers the closed risk and the materialised risks (issues). It worth mentioning this spreadsheet was developed in-house.

The Primavera Risk Analysis is mainly used for quantitative risk analysis and modelling. Later, the WBT superseded the spreadsheet software for many reasons. One reason, that the Web-Based Tool facilitates the communication between the risk participants abroad and the lead risk manager in the consortium. More another reason, it is considered as a secured tool and speed up the reporting system for RM. Also, the persons in charge of RM depended on their experience, subjective judgments and Delphi technique for qualitative analysis. Also, they are using Ishikawa diagram in the risk response process, and using it heavily in the monitoring and control process.

Most decisions for developing and implementing risk response plans were made by the senior management, who were very experienced in dealing with risks in similar construction projects. For instance, the delay of power supply from the provider governmental utility is the most critical risk in the project. To clarify, in case of the absence/delay of the required power supply that will cause a delay in commissioning and testing activities of the rolling stock, then the transit system will not work. Consequently, the board of the consortium decided to design alternative electrical generators with capacity that can provide the required power for the testing and commissioning activities.

In parallel with the design phase of the alternative electrical generators, the consortium was monitoring key milestones of the work progress in the provider governmental authority of the power. So, in case of a delay in the key milestone at certain date, which reflects that the power delay will occur, then the consortium can take the next decision to purchase immediately that electrical generators.

Another example for a critical risk is a shortage of concrete segments of the tunnel. The effect of this risk will be very severe because the TBM should not stop under any conditions. So, in case of shortage of concrete segments, the TBM will shut down. The first cause of this risk was shortage of basic materials required for concrete and there is a trigger for that cause. There are many mega projects will be running in the same time and same region, which means increase in basic material demand in GCC region.

The second cause of the risk was delay of Quality Control (QC) approval for fabricated segments, and there were many triggers for that. The project is fast track project, and the required specification is very high. Also, the implemented quality control procedures are complicated, which mean the approval will be very difficult. The decision for mitigating the risk was to contract with additional pre-cast factory to duplicate the production rate of the fabricated concrete segments in the same period. The mitigation action was very effective and did not increase the actual cost for that item. In addition, Firm A provided guidance to risk response, which contributed to better-informed decisions in the consortium.

As shown in Table 45, Firm A reviewed the RM quarterly and reported the review results and plans for improvement to the client. RM implementation in Firm A was also reviewed and audited by the corporate level in Firm A twice a year. The risk monitoring and analysis report issued by consortium also provided lessons learned and some successful RM practices in the other firms in the consortium, which help the seven firms as well as the consortium to improve its RM implementation. Firm A established the WBT, RM plans and guidelines for all risk processes. The WBT used for collecting, storing, analysing, and communicating risk information within the consortium head office, design offices, sub-contractors' offices, vendors, suppliers, and the head offices in the origin of the seven firms. Key performance indicators (KPIs) of RM performance were evaluated and reviewed by consortium and then reported to the Engineer.

Table 37 Risk review and reporting schedule in case study 1

Activity	Frequency	By	Reporting to
Weekly Risk Report – emerging risks	Weekly	All	OPM Risk Manager
Monthly Project Risk Report	Monthly	OPM Risk Manager	Engineer/ Employer
Quarterly Risk Review	Quarterly	Project Director	Engineer/ Employer
RM Review • **Validation of risk controls/ actions** • **Risk performance & compliance** • **Project risk compliance**	Quarterly Quarterly Six Monthly	OPM Risk Manager Mgr. project Mgmt.	Project Director
Risk Workshops	12 workshops for whole project	Project Director Mgr. Project Mgmt. OPM Risk Manager	Engineer

6.3 Case study 2

6.3.1 Background

Firm H and Firm I formed a joint venture and were awarded one contract to build two rail stations (flagship station). The project cost is 1.40 billion US$. The origin of Firm H is Saudi Arabia, while the origin of Firm I is Turkey. The scope of work for both companies is fully separated. So the scope of work for each company is a flagship station. All management plans and procedures were issued, separately. There is no cooperation or integration, even in the resources or implemented management plans and procedures. The focus in this case study will be on firm H. The contract type is lump-sum turnkey.

The project comprises a station building and associated platforms for a number of high speed rail lines. The station itself has a basement with capping slab over which an elevated concourse is situated. This is covered by a steel roof structure. The platforms are of reinforced concrete and covered with a steel and tensile fabric roof canopy structure. In addition to the station there are four additional buildings (Design and Build Scope): long stay car park, helipad, civil defence fire station, and a mosque.

A risk manager and a planning manager were interviewed to collect information. The interviewees' profile is shown in Table 46. The project director according to the RM plan was fully in charge of RM responsibilities. However, he is not involved in this interview. The project director cannot attend the board meeting. Mainly, the project director is responsible for monitoring risk action effectiveness and participating in risk escalation. He also, has the responsibility to communicate to certain project stakeholders, on an as needed basis.

Table 38 Interviewees profile in case study 2

Interviewees	Firm	Interviewee nationality	Experience
Risk manager	H	Egypt	13 years
Planning manager	H	Egypt	18 years

The board of firm H consisted of just seven members. However, the project director is a member but he reported directly to the board. Project director, project manager, development director, and risk manager were involved in the RM activities at the project level, and competent to provide adequate and reliable information about RM implementation in the company. As the interviewee explained, the main driver to implement RM was a contractual obligation in this project.

6.3.2 Factors affecting RM implementation

The interviewees explained that the main barriers to implement RM are: (1) increased additional costs and administration; (2) lack of commitment of the top management; and (3) lack of awareness and interest. In the interview, the senior management in the company believed that they are practicing RM, so that there is no need for official RM implementation which required more resources and more costs.

On other hand, the main driver to RM implementation at the enterprise level was that, the new projects awarded were required to implement the RM in a formal approach. Also, the company was seeking to be award new projects in other country at regional level and RM was required as one of tender requirements. In addition, the company was studying strategic decisions to convert from a private company limited to public sharing stock.

Therefore, these drivers raise the interest of the company board to implement RM. This interest leads the company to take different decisions. First, they formed permanent committee under the responsibility of the development director to implement the RM activities on a wide scale in the company.

Second, they provide the company with necessary resources for RM implementation. Third, they invite the top international consultant of project management to raise the level of awareness and culture in the company. Also, they conducted several PMP/ RMP courses at different levels for employees in the company.

In addition, information about the RM practices was adapted international codes. Despite that this company is one of the largest construction companies in the GCC region; this is the first formal RM plan in the company. The purpose of this RM plan is to describe the methodology for identifying, tracking, mitigating, and ultimately retiring project risks. Also, the plan defines the RM roles and responsibilities of the Team.

The interviewee explained that the RM activities in the company were undertaken in informal manner by senior management and project managers. Also, there was an initial work related to RM in some previous projects. For example, there was some risk registers, mitigation actions, and some records for the issues. The purpose of that was for lesson learned. The interviewee considered the previous work on RM to be useless because they did not document or record the RM work in proper way as per the concepts or the RM processes.

6.3.3 RM framework

The RM framework in this firm to RM implementation included the following components: risk identification, risk assessment, risk response plan, implement risk response, and monitor and control. However, not all the components had been fulfilled in this project. Firm H collected risk information from international standard, project documents, and different management plans. All this information helped to identify potential risk. There was no evidence about conducting and RM meeting or risk workshop in the firm. However, the risk manager was attending the progress bi weekly meeting.

There is no designated department in charge of RM activities in the firm. The risk manager reported monthly and directly to the engineer. However, the report was just including the risk register, and there is no any risk report explaining the RM activities in the project. The RM activities have been undertaken as an individual exercise by the risk manager only. He was just responsible for maintain and update the risk register.

The interviewees described their RM approach as semi-formal approach, because RM processes were partially fulfilled. Also, the interviewees described their organisations' RM system to be moderate standardised system. Despite the RM system was developed based on international standard, it was partially fulfilled.

The interviewees described their organisation RM system as semi- adequate. This is due to the main procedures implemented of RM were only the risk identification and qualitative risk analysis. Also, neither quantitative assessment nor risk modelling analysis was used. In addition, there were risk treatment actions but with very few details about cost or schedule, which leads to making the risk monitoring and control to be impossible to implement.

Reviewing the project documents and the developed project management plans were the main source to identify the list of risks. The total identified risks were: (303). The total identified risks were assessed and classified to 38 significant; 217 moderate; and 48 low risks. 14 out of the 38 risks were considered the most critical risks.

The critical risks are: (1) delay of land expropriation due to delay in land acquisition; (2) delay of disconnect and remove portable water, fuel sewer surface water systems by general directorate of water; (3) delay of diversion of utilities of water and fuel water by general directorate of water; (4) delay of final connections of water and fuel water by general directorate of water; (5) delay of disconnect and remove surface water systems by municipality; (6) delay of diversion of utilities of storm water by municipality; (7) delay of final connections of storm water by municipality; (8) delay of diversion of electricity by electric company; (9) delay of final connections of electricity by electric company; (10) delay of road works by the landowners and local highway authorities; (11) delay of traffic management plan by local highway authority;

(12) delay of blasting for excavation including the hours of blasting by police authority; (13) delay of construction permit by municipality; (14) delay of properties acquisitions / full site handover; (15) delay of adjusting the electric poles, electric transformer, lamp post, medium voltage (MV) and low voltage (LV) cables, etc., by electric company.

In the early stage of the project, in the planning phase, the risk manager expected an extreme risk that will occur and effect on the project schedule. The risk was a delay in land acquisition. The owner of this risk was the client not the contractor. It is worth mentioning, the first risk materialised to issue. It leads to delaying 50 percent of the total contractual duration of the project.

So, the risk manager in Firm H considered the risk as an opportunity. To clarify, if the client delay in handing over the required land as per the approved schedule, then the contractor can claim expansion of time and a financial compensation from the client. This expansion of time will be equivalent to the same period of client's delay.

They used only excel spreadsheet to develop the project risk register. The risk factors, and risk response plans were issued and regularly updated to the Engineer. The risk manager was only in charge to assess risks. He only conducted qualitative risk analysis. He used the P-I Matrix to assess risks. Most of the risk mitigation actions were taken by the project director him-self, while few risk mitigation actions were taken by the project director and the risk manager.

The project director did not depend mainly on the risk register or the qualitative risk assessment. He mainly depended on his experience, intuition, and subjective judgments in managing risks. In addition, the project director considers that decision and the interpretation beyond his decision are confidential, so he did not like to share the risk manager in his decisions. Firm H doesn't review the RM implementation at any level. There is no evidence about any reports related to RM implementation and performance reported to board level.

6.3.4 Risk communication

Risk communication is considered low between risk manager and other parties. It was mainly depended on emails, and some face-to-face interviews, which was not conducted regularly. In addition, another sort of communication between

Firm H and the Engineer was the risk manager reporting monthly to the Engineer the updated risk register.

6.3.5 Risk culture within organisation

The interviewees described their RM system to be neutral embedded in the organisation's behaviour and practice. This is due to lack of awareness and interest in RM within the organisation. Many RM seminars and presentations were conducted for project management managers/directors as well as senior management team to raise the level of awareness of the RM.

6.3.6 RM ownership

In Firm H, the project director was ultimately responsible for the RM. He also, conducted arrangements with the development director about needed resources for RM.

6.4 Case study 3

6.4.1 Background

Firm J is member of investment group. One of the companies in this group owns the project. The contractor is considered the owner of the project. Firm J is a local company, it was awarded the project from the sister company to design and build an eleven stories hotel in Saudi Arabia. The site area is 3500 meters' square. The cost of the project was 70 M US$. The project was completed in 2014.The chairman of the company was interviewed. The board consists of five members, and they are members in the investment group.

Table 39 Interviewee profile in case study 3

Interviewees	Firm	Country	Experience
Chairman	J	Saudi Arabia	15 years

The profile of the interviewee is shown in Table 47. According to him, there is no RM department or staff in the company. The chairman of the company and the project director were responsible for the RM. However, actually the RM has been practiced by the senior management. There is no documentation or records about RM activities. They depended on their experience and self-judgment to manage RM.

The interviewee considered the RM system in the firm as non-standardised and informal. The project director and senior management in the project were responsible to identify the potential risks. Risk identification was conducted based on the requirement of each project phase. Sometimes, if there is any major change in the surrounding business environment, internal company or project level, then the risk identification is held. The interviewee explained that they conducted meetings to discuss that changes and the potential impact to find out some mitigation actions or solutions.

The interviewee explained that the main barriers to formal RM implementation were lack of commitment of the top management, lack of interest, limited resources for overall management, and there is no contractual obligation to implement formal RM. One of the major risks, the subcontractor delay to achieve their scope of work. As the interviewee said, the main reason of this risk is the deficiency of credibility. The action to mitigate this risk was to decrease the number of subcontractors to the minimum. The chairman has a master degree in RM. He was aware about RM; however, he believed that the size of construction projects and the nature of these projects does not require RM plans. Also, he has no interest in RM because they aim to decrease the administration expenses.

6.5 Case study 4

6.5.1 Background

Firm K was a general contractor for the tallest building in Kuwait City, and the tallest carved concrete skyscraper in the world. The height of the building is 412 meter and consisted of 84 stories. The site area is 10,000 meters' square. The construction of the skyscraper building started in 2005 and was completed in 2011. The contract was a cost plus contract. The cost of the project was 830 Million US$. The board of the firm consists of seven members. The construction manager of the project was interviewed.

The profile of the interviewee is shown in Table 48. According to the interviewee, there was no RM plan for the project and the RM system in the firm was inadequate. He added that, in 2008, when the economic crisis happened, they could not face the problem. Also, he described the RM approach used in the firm as informal, and this lead to many risks. Thus most of the problems that are dealt with were through issue management more than RM. Moreover, he described their RM approach as non-standardised, because originally they do not have a documented system for RM and consequently there is no relationship between the implemented system and the international standards.

The interviewee explained that the major barriers and challenges to RM implementation in the firm were low interest and low awareness about RM within multi levels in the firm such as, the board, the senior management, and project staff. There is no designated department or staff in charge of RM activities in the firm. The RM activities have been undertaken by the project director as an individual exercise. The project director as well as the project manager was ultimately responsible for managing risks in the company.

Table 40 Interviewee profile in case study 4

Interviewees	Firm	Country	Experience
Construction manager	K	Kuwait	15 years

The project director reported to the board about RM status through regular meeting and reports. Mails, phone calls and meetings were the most used communication tools between different departments. The interviewee explained that RM was not embedded in the firm's behaviour and practice, and they do not take any actions towards raising the culture and awareness about RM. There was no training courses, workshops, or conferences about RM.

6.5.2 RM framework

There is no standard or framework followed to implement RM. The risks are identified through brainstorming technique. The critical risks in this project were: (1) accidents; (2) sudden inflation; (3) delay of progress payment; (4) strike of labour; (5) fighting between labours. However, they do not have any checklist of risks.

For instance, the firm purchased 40 percent of the project shares to avoid the delay in progress payment. Also, they do not have any reviewed or updated risk register. They manage risks through discussions and self-experience. The interviewee explained, because there is no existence for a RM plan or a systematic system in the firm, it leads them to face many issues and problems. He emphasized that RM could contribute to enhance the performance and decision making in their firm.

6.6 Case study 5

6.6.1 Background

Firm L is a Qatari construction firm. The board of the firm consisted of 6 members. The project is a commercial tower consisted of 16 stories. The cost of the project was 178 Million US$. The project contract was a lump sum. The interviewee profile is shown in Table 49. According to him, there is no designated department and staff in charge of RM in the company. RM activities have been undertaken by individual exercise not as group exercises. The interviewee considers their RM system in the firm as inadequate. Also, there is no formal approach for RM. Moreover, there was non-standardised RM approach in the firm.

6.6.2 Factors affecting RM implementation

Regarding the factors driving to implement RM in the company, the interviewee indicated that the major reason was to achieve project objectives. On the other hand, he indicated that the main barriers to RM implementation were: absence of contractual requirements, the people and staff in the company were not qualified; no interest from the board in RM, and to decrease the administration costs.

6.6.3 RM framework

There was no framework or standard followed for a RM framework. Usually they identify risks through brainstorming technique. Also, they collect some information about risks through project documents, drawings and internet.

Moreover, there was no risk register used. The interviewee mentioned few risks in the project, such as, approval delay of submittal, delay of permits, and complexity of civil defence requirements. The latter risk, as the interviewee described, was mitigated through forming committee to coordinate and manage all civil defence requirements. However, they do not have any risk checklist or risk indicators in place to help identifying risks.

Table 41 Interviewee profile in case study 5

Interviewees	Firm	Country	Experience
Construction manager	L	Qatar	18 years

Of course, there was no updated or reviewed risk register within the company. Also, within the regular meetings in the company, or arranging specific workshops, they identify some potential risks and discussed the ways to deal and mitigate the risks. In addition, they review and monitor risks through meetings. The interviewee added that adopting formal RM could enhance their RM practice, because the absence of RM system was an evidence for the low performance of their projects.

6.6.4 Risk communication

Risk information was communicated and distributed in the company through E-mails, regular meetings and phone calls. They reported about the RM implementation status to the board or project director through monthly meetings, quarterly meetings and special workshops.

6.6.5 Risk aware culture

RM was not embedded in their organisation behaviour and practices, and the firm does not take any actions to raise the culture and awareness about RM. There was no training courses, workshops, or conferences about RM.

6.6.6 RM ownership

The board and the project manager were ultimately responsible for RM implementation in the company. The project manager was actually in charge of RM in the company.

6.7 Case study 6

6.7.1 Background

The board of Firm M consisted of five members. The interviewee profile is shown in Table 50. The project is a steel structure warehouse in Dubai port. The cost of the project was 70 million US$. There was no department in the company in charge of RM activities. Senior management in the firm was ultimately responsible for RM implementation. However, RM was considered as individual exercise, and the project manager was actually in charge of RM.

According to the interviewee, RM approach was considered informal and inadequate. There was no standard or documented system to implement RM. There were difficulties in the project management because the decision maker was lack of a clear plan for RM implementation.

6.7.2 Factors affecting RM implementation

According to the interviewee, the main barriers to successful RM implementation were lack of interest of the board in RM, lack of awareness about the importance of RM, people and staff were not qualified in RM, and there was no contractual requirement to implement RM plan. They communicated and distributed risk information through daily communication channels such as, emails, meetings, and phone calls. They identify risks through brainstorming technique.

6.7.3 RM framework

The construction manager collects information about risks through reviewing project documents. There was no risk register in the project. Inflation of steel structure, difficulties of material storage, and delays in procurement of critical items were considered key risks in the project. The delay in material procurement leads to a severe delay in the project. The delay caused them to find other faster shipping methods which were more expensive. They do not review or update any risk register, because they do not have one. Also, they do not use any technique or software to analyse risks. Senior management take decisions about mitigating risks in the project.

Table 42 Interviewee profile in case study 6

Interviewees	Firm	Country	Experience
Construction manager	M	UAE	15 years

6.8 Cross-case comparisons and discussions

As shown in Table 43, comparisons were conducted to explain the differences and similarities in RM implementation between the six case studies as shown in Table 53. Only the consortium has formally initiated a RM system although the project was in a GCC country. Although Firm H did not has formal RM system, some of their RM practices were consistent with the RM fundamentals.

Case study 1 reflects the highest maturity of construction firms in the GCC countries, because it is the world's largest infrastructure project. In the consortium, the RM implementation was primarily driven by several factors, such as: the requirements from the seven firms which consisting the consortium, the increasing and complicated risks in the project, encouragement from the board and senior management, and a contractual obligation from the client. Thus, in order to meet the compliance requirements from the client, the consortium implemented a high maturity RM plan. However, in Firms K, L and M there was no contractual obligation to implement an RM plan. Also, there was no interest or awareness about RM within the board and the senior management levels.

The consortium implemented WBT to enhance communication of risk information between people and staff in the consortium. This indicated that there was a strong RM information system in the consortium. Besides the formal communication channel in Firms K, L, and M, emails and telephone calls were the main communication methods across project teams and departments and there was neither an interaction nor a RM information system in the firms.

To embed a risk aware culture, Firm A provided in-house training, workshops, and mandatory on-line training courses to raise the awareness and attitude for RM. The training programs involved all levels of staff. Compared with Firm A, Firm H conducted seminars and presentations for project management directors as well as senior management. However, RM was considered low embedded in their organisation behaviour and practices. In Firms J, K, L, and M there is absence of RM and the firms does not take any actions to raise the culture and awareness about RM. There was no training courses, workshops, or conferences about RM. Also, these firms do not have a shared understanding of the project risk and consequently they are unable to implement effective early warning measures and mitigating strategies to adequately deal with problems.

For the RM framework, Firm A implemented a systematic RM framework adopted from international standards. Similarly, Firm H implemented the first RM plan with reference to international standards but it did not have a formal RM process. In comparison, in Firm J, K, L, and M, there was no framework or standard followed for a RM framework. In addition, Firm J, K, L, and M dealt with issue management more than RM. None of the latter firms have clearly defined RM plans or procedures in place.

Since risk identification, assessment, and response are the most important steps in various RM frameworks, this section focuses on the similarities and differences in these three phases among the six case studies. For risk identification, Firms A and H used risk registers and regularly update and reviewed them. In comparison, Firms J, K, L, and M just used brainstorming technique to identify risks, and they did not formally initiate RM system. Also, they collected risk information through project documents. There was no risk register.

In terms of risk analysis, Firms A and H used P-I Matrix to assess risks. Also, Firm A used Primavera Risk Analysis, Delphi technique and a spreadsheet tool to analyse and quantify risks. In contrast, Firms J, K, L, and M depended on their experience and subjective judgments to analyse risks. This was consistent with the findings of previous studies that most RM practices in the construction industry depended on their experience, intuition, and subjective judgments instead of using risk analysis software (Kartam and Kartam, 2001; Wang and Yuan, 2011; and Taroun, 2014).

Regarding risk response, in Firm A, risk response plans and actions were made by the senior management. In Firm H, the project director was mainly responsible for developing risk response actions. While in Firms J, K, L, and M, the project director selected the risk response actions based on their experience and subjective judgments and mainly dealt with issue management more than RM.

Among the six case studies, only Firm A reviewed RM monthly and developed plans for RM improvement. The review results and plans were included in the annual report of the firm and their successful practices were referred to their parent company for lesson learned. In comparison, the other Firms H, J, K, L, and M did not review their RM status or improve their RM practices.

Table 43 Cross-case comparisons

Characteristics	Case studies		
	Case 1	Case 2	Case 3
Company name	A	H	J
Project type	Metro project	Rail station	Hotel 11 stories
Project location	Saudi Arabia	Saudi Arabia	Saudi Arabia
Project cost (USD)	6.4 Billion	1.4 Billion	70 Million
Contract type	Turnkey EPC	Lump sum turnkey	Unit rate
Company nationality	7 Multi-national firms	Saudi Arabia-Turkey	Saudi Arabia
Company age	45 years	85 years	13 years
Company size	Large	Large	Small
Company expansion	Overseas Expanded in 45 countries	Regional Expanded in 6 GCC countries	Local No expansion
RM department	Exists	Non - exists	Non - exists
RM activities	Group exercise	Individual exercise	Individual exercise
RM approach	Highly formal	Neutral	Informal
Existing RM system	Highly adequate	Moderate	Inadequate
Factors affecting RM implementation			
• Drivers	-Requirement from parent Company; -Increasing and more complicated risks; -Request and encouragement from the board and senior management; -Contractual obligation;	-Contractual obligation	-None
• Barriers	-Hosting country; -Lack of professional sub-contractors; -Lack of historical data; -Language barrier;	-Increased additional costs and administration; -Lack of commitment of the top management; -Lack of interest; -Lack of awareness;	-Lack of commitment of the top management; -Lack of interest; -Limited resources for overall management;
RM ownership	Board, project director, and senior management	Project director	Chairman and project director
Risk communication	Weekly, monthly, quarterly meetings and reports Web-Based Tool, workshops, seminars	Interviews, monthly reports	No common risk language
RM tools/ techniques	PI Matrix, Primavera Risk Analysis	Reviewing project documents	None
Risk aware culture	Highly embedded	low embedded	Not-embedded
RM framework	ISO standard	ISO standard	None

Table 43 Cross-case comparisons – continuation

Characteristics	Case studies		
	Case 4	Case 5	Case 6
Company name	K	L	M
Project type	Skyscraper 84 stories	Commercial Tower 16 stories	Steel structure for Port Warehouses
Project location	Kuwait	Qatar	Dubai
Project cost (USD)	827 Million	178 Million	70 Million
Contract type	Cost plus	Lump sum	Lump sum
Company nationality	Kuwait	Qatar	UAE
Company age	62 years	45 years	18 years
Company size	Large	Medium	Medium
Company expansion	Regional Expanded in 6 GCC countries	Local No expansion	Local No expansion
RM department	Non - exists	Non - exists	Non - exists
RM activities	Individual exercise	Individual exercise	Individual exercise
RM approach	Informal	Informal	Informal
Existing RM system	Inadequate	Inadequate	Inadequate
Factors affecting RM implementation			
• Drivers	-None	-Achieve project objectives	-None
• Barriers	-Lack of interest; -Lack of awareness	- No contractual requirements; - No qualified people; - No interest of the board; - Decrease the administration costs	-Lack of interest; -Lack of awareness
RM ownership	Project director	Board and project manager	Senior management
Risk communication	Monthly meetings	Monthly general meetings, and workshops	Monthly meetings
RM tools/ techniques	Brainstorming	Brainstorming	Brainstorming
Risk aware culture	Not-embedded	Not-embedded	Not-embedded
RM framework	None	None	None

6.9 Implications

Several implications emerge and can be drawn from the cross-case comparisons. This comparison shows that some problems causing poor performance of construction projects and low maturity of construction firms are recurring. Also, there seems to be a similar pattern of problems in all local firms. The implications are:

- Key characteristics of a project participant undertaking RM include the participant's capability and experience in RM, and the participant's perception of their responsibilities for undertaking RM (Ward, 1999). The absence of RM implementation in local and regional construction firms has led to a poor performance in their projects. It may be beneficial for the governments in different GCC countries to offer greater encouragement for local and regional firms to cooperate with overseas firms with more experience to improve the level of local experience.

- A strong RM culture championed by the board is a crucial element in increasing the efficacy of the RM process (Karlsen, 2011; Mongiardino and Path, 2010; Sanchez et al., 2009). However, the level of involvement of the board and senior management in the local and regional firms is low. The majority of the interviewees in the six case studies agreed that implementing systematic RM systems and the involvement of the board and senior management could avoid many overwhelming issues in project.

- Discussion with interviewees also suggested that the poor understanding of RM was mainly due to apathetic attitude towards RM, lack of commitment of the top management, lack of resources, lack of interest and awareness, and insufficient knowledge and skills. This seemed to coincide with Uher and Toakley (1999) who found that lack of knowledge and inadequate skill were the most two important obstacles to applying RM to work processes.

- The comparisons implied that firm size and age does not influence RM implementation. The comparison implied that ‘firm expansion’ influenced RM implementation thus confirming the findings of the survey that there was association between RM maturity and ‘firm expansion’.

- Even if Firm H did not have formal RM implementation it still had some practices consistent with the RM fundamentals. For instance, Firm H initiated the first RM plan in the firm with reference to the international guidelines. This practice was more or less consistent with the RM fundamentals. In this firm, a formal RM system could be initiated based on the existing RM practices, and the maturity of the RM in the firm could be enhanced to the next level through RM guidelines and actions.

- RM culture incorporates risk awareness (Ropponen and Lyytinen, 2000). To make an effective and efficient RM, it is necessary to have a proper and systematic methodology and, more importantly, knowledge and experience of various types. For example, it requires at least the knowledge of PMP courses to get a job in these firms.

6.10 Summary of this chapter

This chapter presented six case studies among GCC countries. The results revealed successful and unsuccessful RM practices within construction firms. Also, this chapter presented cross – case comparisons and several implications.

Chapter Seven
Development of RM framework for construction firms in the GCC region

7.1 Introduction

This chapter describes the development of a RM framework for construction firms and builds upon the findings of the literature review, the results of the questionnaire and the case studies. It incorporates velocity of risk as a third dimension to the P – I risk model. Also this chapter presents RM capability actions in a matrix format to enhance the RM implementation in construction firms. This framework is mostly applicable to construction projects in the GCC region.

7.2 Development of RM framework

Based on literature review, the analysis data, and the case studies reported in this thesis, a RM framework has been developed. The conceptual model of the proposed RM framework is illustrated in Figure 45. The development of RM framework included five primary phases, namely: (1) establishing context, (2) risk identification, (3) risk analysis, (4) risk treatment, and (5) risk monitoring and control. The first phase is establishing context which is about setting the parameters or boundaries around the organisation risk appetite and RM activities. The company puts into consideration of the external factors such as social, political and economic and the alignment with internal factors such as strategy, resources and capabilities. In the risk identification phase, triggers should be identified and distinguished from risk factors.

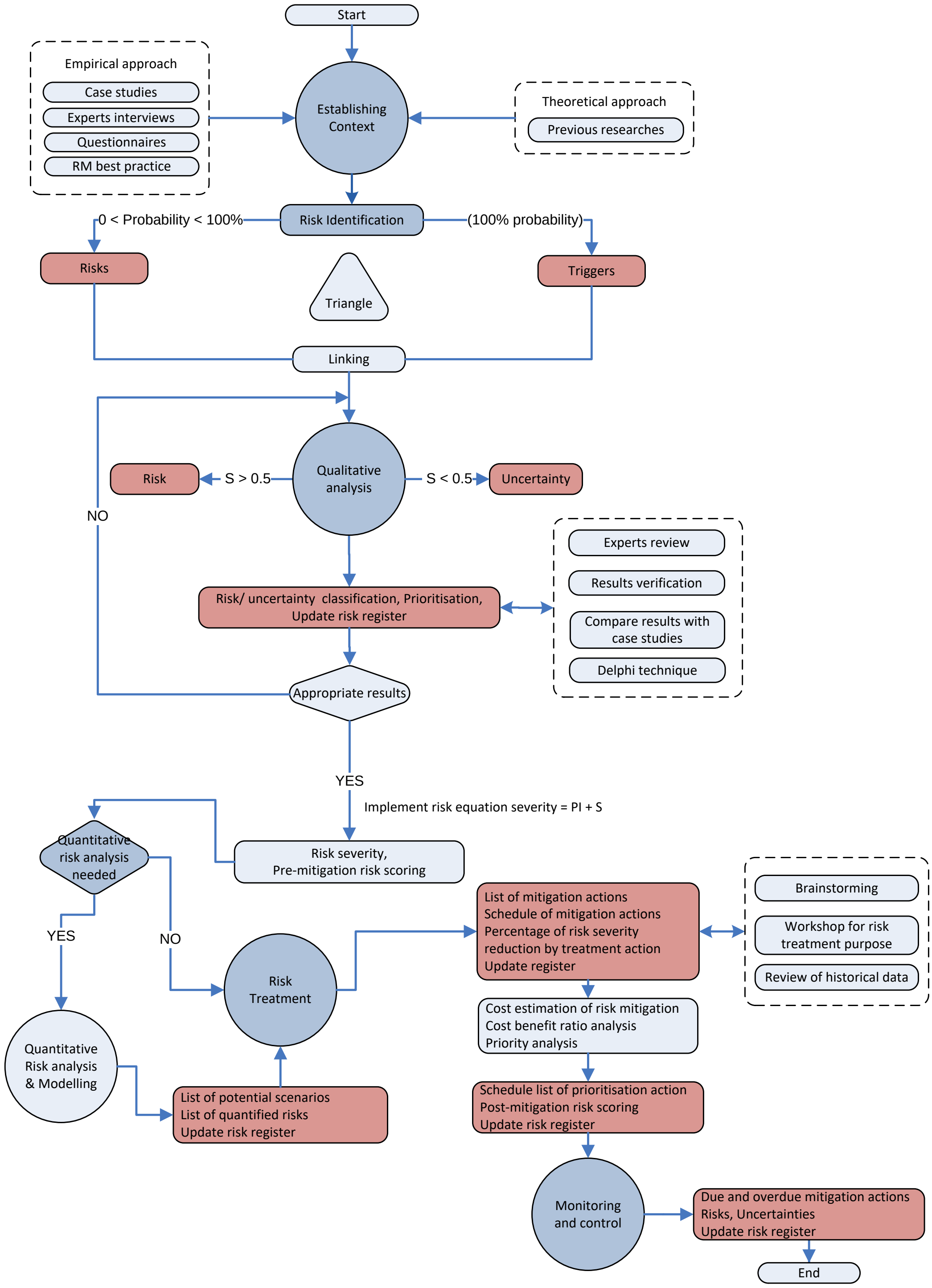

Figure 47 The proposed RM framework for construction firms

A risk is any potential event that could prevent the project from progressing as planned, or from successful completion. Risks can be identified from a number of different sources. Some may be quite obvious and will be identified prior to project kick-off. Risk identification and assessment phases are considered as most important phases of systematic RM process by several researchers (e.g. Al-Bahar and Crandall, 1990; Bajaj et al., 1997; Ward, 1999; Zoysa and Russell, 2003; Wang et al., 2004; Maytorena et al., 2007; Baston, 2009; Edwards et al., 2009).

On the other hand, subsequent phases of RM process (assessment, analysis and responding) are carried out based on the identified risk factors (Al-Bahar and Crandall, 1990; Akinci and Fischer, 1998; Wang et al., 2004). Therefore, RM practices will be beneficial for the companies only if the products of its initial stages (identification and assessment) are reliable and inclusive (Bajaj et al., 1997; Chapman, 1998).

One of the most common failing in the RM process is for the risk identification step to identify things which are not risks (Hillson, 2005). According to Hillson (2005), risk differs from its cause and its effect according to the following criteria:

- Causes are definite events or facts, and should not be managed through the RM process;
- Risks are uncertainties that should be managed proactively through the RM process;
- Effects are unplanned variations from objectives and they cannot be managed through RM process.

In light of the above, the definite events or facts that have been described earlier by Hillson (2005), are called “triggers” in this research. Also, this research uses the term “issues” to describe the effects of risk. Trigger (sometimes called early warning or symptoms) is an indication that a risk has occurred or is about to occur (PMBoK, 2008). Before the onset of a risk, there are early warning signs that can be used as triggers for actions. The trigger can cause one or multiple events in different activities. Triggers are ‘signs’ that a risk event is about to occur, it signals that something more relevant to the project is on the horizon.

In the context of management, Ansoff in (1975) was the first who discussed the concept of early warning. He stated that it is possible to predict the occurrence of strategic surprises by the aid of signs which are called weak signals. Ansoff (1984) defined a weak signal as ‘‘imprecise early indications about impending impactful events .. all that is known is that some threats and opportunities will undoubtedly arise, but their shape and nature and source are not yet known’’. However, Nikander (2002) defined early warning as ‘‘an observation, a signal, a message that can be seen as an expression, an indication, a proof, or a sign of the existence of some future or incipient positive or negative issue. It is a signal, omen, or indication of future developments’’. The relationships between the three events can be visualized using the risk triangle below:

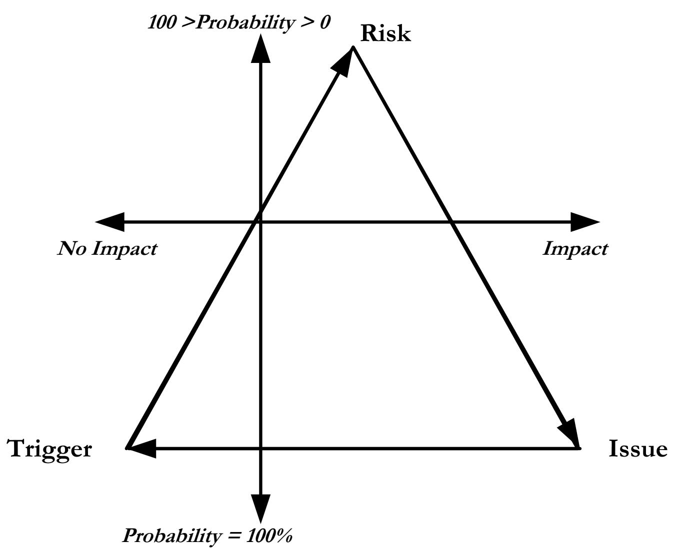

Figure 48 Relationship between three events (trigger, risk, and issue)

The Triangle shows iterative process for the three events. Trigger acts as indicator for a risk about to occur. Risk may happen or it may not. We can plan for risk based on its probability and impact. When a perceived risk is certain to occur, it is called an issue. An issue is present problem influencing project objectives. In management terms it should be treated exactly like any other risk but with a probability of 100 percent (Dallas, 2008). In other words, an issue is raised when something has gone wrong and will impact project success. A risk can become an issue, but issue is not risk, it has already happened. The next stage in the proposed framework is risk analysis. There are two main types of risk analysis, qualitative and quantitative analysis. Qualitative analysis is the process of assessing by qualitative means the probability and impact of each risk. It assists in risk comparison and prioritization. It is applied when parameters are difficult to calculate, using qualitative scales. Quantitative analysis is the possibility to give a quantitative value to a risk, regarding its probability and/or its impact.

Therefore, this research suggests extending the P-I model and consider incorporating other attributes, in addition to probability and impact. Other researchers have suggested new quantifying criteria to reflect the nature of the risk and the experience of risk analysts (Han et al., 2008; Taroun, 2014; CII, 2003). In a research survey conducted by Deloitte Risk Integration Strategy Council (2007), while 70 percent of finance executives agree that risk velocity is a core consideration, only, 11 percent have introduced it into their assessments. In this research, the risk quantification method will include velocity of risk, along with probability and impact, in contrast to the existing P – I model. By considering the velocity of risk, various attributes of risk can be reflected in the risk quantification and management prioritisation. Also, incorporation of velocity of risk in the assessment of risk events helps to improve the risk prioritisation process and subsequent development of adequate response planning (Osundahunsi, 2012).

In three- dimensional coordinates consisting of probability of risk, impact of risk, and the velocity of risk. The risk magnitude is computed by adding the value of risk velocity to the P – I matrix score, shown in Figure 47.

$$Risk = (Probability \times Impact) + Velocity$$

According to Curtis and Carey (2012), every organisation is different and the scales should be made to fit the industry, complexity, size, and culture of the organisation in question. For simplicity, this research will adopt a five-point scale.

Probability of risk

The probability of a risk that may occur can range from above 0 percent to just below 100 percent. The probability cannot be 100 percent exactly because it would be a certainty (or issue). Also, it cannot be 0 percent exactly or it would not be a risk. Using qualitative terms, this research defined the probability as very low = 1, low = 2, moderate = 3, high = 4, and very high = 5.

Table 44 Risk probability scale

Probability	Score	Min	Max	Description
Very low	1	>0%	10%	Very low probability of the risk event actually occurring
Low	2	11%	30%	Low probability of the risk event actually occurring
Moderate	3	31%	50%	Moderate probability of the risk event actually occurring
Significant	4	51%	80%	Significant probability of the risk event actually occurring
Very high	5	81%	<100%	Very high probability of the risk event actually occurring

Impact of risk

Impact of risk or called consequence refers to the extent to which a risk variable would affect the company. The size of impact varies in terms of cost, time, performance, and reputation. This research assigned an impact rating to a risk in a five-point scale. Using qualitative terms, this research defined the probability as very low = 1, low = 2, moderate = 3, high = 4, and very high = 5.

Table 45 Risk Impact scale

Impact	Score	Cost impact	Time impact	Performance impact	Reputation impact
Very low	1	Cost < 1% Original budget	Time <1% Original duration	No impact on technical specification requirements	No impact on reputation
Low	2	1% Original budget ≤ Cost < 5% Original budget	1% original duration ≤ Time < 5% Original duration	High compliance with technical specification requirements	High compliance with reputation features
Moderate	3	5% Original budget ≤ Cost <15% Original budget	5% Original duration ≤ Time <15% Original duration	Partial compliance with technical specifications requirements	Partial compliance with reputation features
Significant	4	15% Original budget ≤ Cost <35% Original budget	15% Original duration ≤ Time < 35% Original duration	Severe discrepancies with the technical specification requirements	Severe discrepancies with the reputation features
Very high	5	35% Original budget < Cost	Time ≥ 35% Original duration	Non-compliance with technical specifications requirements	Non-compliance with the reputation features

Velocity of risk

Velocity of risk (or speed) parameter was added as a third dimension to the calculation of risk magnitude. The velocity of risk refers to the time it takes for a risk to manifest itself. According to Curtis and Carey (2012), velocity of risk is "the time that passes between the occurrence of an event and the point at which the company first feels its effects".

Table 46 Scale of the velocity of risk

Velocity	Score	Description
Very low	0.1	Very slow onset, occurs over 6 months or more
Low	0.3	Onset occurs in a matter of 4-6 months
Moderate	0.5	Onset occurs in a matter of 2-4 months
Significant	0.7	Onset occurs in a matter of 1-2 month
Very high	0.9	Very rapid onset, in a matter of <1 month

Probability			0.9		0.9		0.9		0.9		0.9
			0.7		0.7		0.7		0.7		0.7
	5	5	0.5	10	0.5	15	0.5	20	0.5	25	0.5
			0.3		0.3		0.3		0.3		0.3
			0.1		0.1		0.1		0.1		0.1
			0.9		0.9		0.9		0.9		0.9
			0.7		0.7		0.7		0.7		0.7
	4	4	0.5	8	0.5	12	0.5	16	0.5	20	0.5
			0.3		0.3		0.3		0.3		0.3
			0.1		0.1		0.1		0.1		0.1
			0.9		0.9		0.9		0.9		0.9
			0.7		0.7		0.7		0.7		0.7
	3	3	0.5	6	0.5	9	0.5	12	0.5	15	0.5
			0.3		0.3		0.3		0.3		0.3
			0.1		0.1		0.1		0.1		0.1
			0.9		0.9		0.9		0.9		0.9
			0.7		0.7		0.7		0.7		0.7
	2	2	0.5	4	0.5	6	0.5	8	0.5	10	0.5
			0.3		0.3		0.3		0.3		0.3
			0.1		0.1		0.1		0.1		0.1
			0.9		0.9		0.9		0.9		0.9
			0.7		0.7		0.7		0.7		0.7
	1	1	0.5	2	0.5	3	0.5	4	0.5	5	0.5
			0.3		0.3		0.3		0.3		0.3
			0.1		0.1		0.1		0.1		0.1
		1		2		3		4		5	
Impact											

Figure 49 The proposed P-I-V Matrix

The next stage in the proposed framework is risk treatment. The process of risk treatment aims to choose actions in order to reduce risk exposure with least cost. It addresses project risks by priority, defining actions and resources, associated with time and cost parameters. Almost every method mentions the same possible treatment strategies, including the following:

- Avoidance,
- Probability or impact reduction (mitigation), including contingency planning,
- Transfer, including subcontracting and insurance buying, and
- Acceptance

The last stage in the proposed framework is the risk monitoring and control. According to the PMBOK, the ongoing process of "identifying, analysing and planning for newly arising risks, keeping track of the identified risks and those on the watch list, re-analysing existing risks, monitoring trigger conditions for contingency plans, monitoring residual risks, and reviewing the execution of risk responses as well as evaluating their effectiveness" (PMI 2008).

7.3 Framework matrix for improving RM practices in the GCC countries

In order to ascertain the extent to which the current RM practices were used by construction companies in the GCC countries, a project RM capability framework matrix was employed. The framework matrix was intended to facilitating measuring each of the series of steps for the RMC attributes. Thus, a construction firm can determine how it was following construction industry best practices. Therefore, based on the previous literature described in Chapter 4, assessing RM capability focused on the following variables:

1- Risk attitude
2- Risk ownership
3- Risk identification
4- Risk assessment
5- Risk response
6- Risk monitoring
7- Risk implementation and standardisation

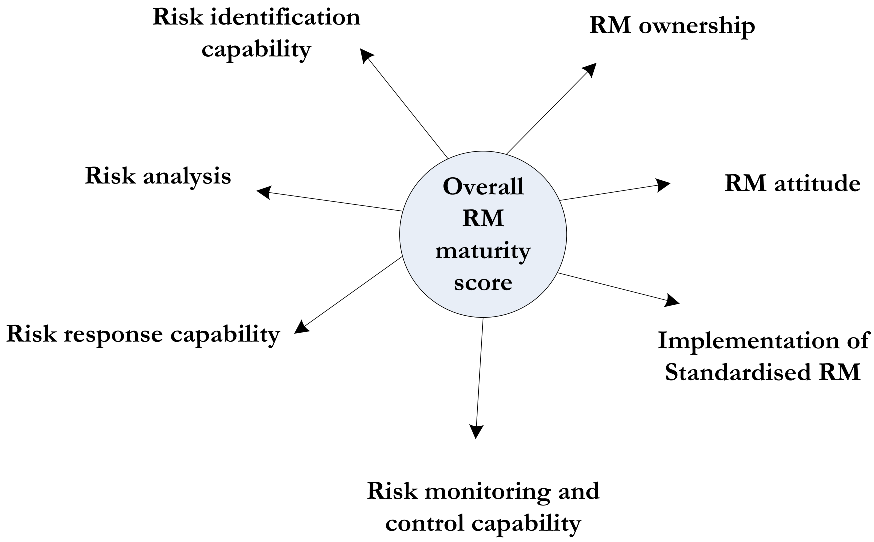

Figure 50 RM maturity attributes

As shown in Figure 48, the assessment criteria were firstly acquired through the comprehensive literature review (Zou et al., 2010; Mu et al., 2014; Zhao et al., 2014). These studies also include the statements relating to the best practices that were recognised to constitute a successful or advanced RM system.

As shown in Table 55, the framework matrix provides detailed description of every criterion at different maturity levels. The framework not only helps to position an existing company on the maturity scale but also helps to identify areas where improvement is needed to achieve a higher maturity.

The preliminary set of assessment criteria was presented to four industry interviewees, who were originally included in the samples of second questionnaire. These interviewees were involved in RM in their firms and had over 10 years' work experience in the construction industry. According to the interviewees' comments and inputs, the assessment criteria were revised and updated. The finalised set consisted of 112 assessment criteria for improving the implementation of the 28 RM best practices.

Table 47 Maturity Matrix for RM implementation

Main criteria and sub-criteria	Maturity level			
	Level 1	Level 2	Level 3	Level 4
Criteria 1: Risk attitude				
(1) There is formal report submitted to board level in your firm at least annually on the current state of risk and effectiveness of RM	The firm has no interest to produce any annual report on the current state of risk and effectiveness of RM	The firm understand the importance of producing formal annual report on the current state of risk and effectiveness of RM but has not done so	The firm partially produces formal annual report on the current state of risk and effectiveness of RM	The firm always produces formal annual reports on the current state of risk and effectiveness of RM
(2) The senior management fully engage with and commit to the RM meetings	The senior managers in the firm never engage and commit to the RM meetings	The senior managers in the firm understand the importance of engaging and committing to the RM meetings but have not done so	The senior managers in the firm partially engage and commit to the RM meetings	The senior managers in the firm always engage and commit to the RM meetings
(3) The department managers fully engage with and commit to the RM meetings	In firm, the department managers have no interest to engage with and commit to the RM meetings	In firm, the department managers understand the importance of engaging with and committing to the RM meetings but have not done so	In firm, the department managers partially engage with and commit to the RM meetings	In firm, the department managers always engage with and commit to the RM meetings
(4) The RM team appropriately resourced	The firm has not any interest resourcing the RM team	The firm understand the importance of appropriately resourcing the RM team but has not done so	The firm partially appropriately resourcing the RM team	The firm always appropriately resourcing the RM team
(5) Sufficient resources dedicated to projects	The firm has no interest in dedicating sufficient resources to projects	The firm understand the importance of dedicating sufficient resources to projects but has not done so	The firm partially dedicates sufficient resources to projects	The firm always sufficient dedicates resources to projects
(6) Team members are taking risk ownerships during project implementation	The firm's team members have no interest in taking any risk ownerships during project implementation	The firm's team members understand the importance of taking risk ownerships during project implementation but has not done so	The firm's team members partially take risk ownerships during project implementation	The firm's team members always take risk ownerships during project implementation

Table 47 Maturity Matrix for RM implementation - continuation

Main criteria and sub-criteria	Maturity level			
	Level 1	Level 2	Level 3	Level 4
Criteria 2: Risk culture				
(7) RM information is distributed and communicated to all project participants within the firm	The firm has no interest for distributing and communicating RM information to all project participants within the firm	The firm understands the importance of distributing and communicating RM information to all project participants within the firm but has not done so	The firm partially distributes and communicates RM information to all project participants within the firm	The firm always distributes and communicates RM information to all project participants within the firm
(8) RM system embedded in the firm's behaviour and practices	The firm has no interest to embed RM system in the firm's behaviour and practices	The firm understands the importance of embedding RM system in the firm's behaviour and practices but has not done so	The firm partially embeds RM system in the firm's behaviour and practices	The firm always embed RM system in the firm's behaviour and practices
(9) The organisation board reviews the risk process on a regular basis	The board of firm never reviews the RM process on a regular basis	The board of firm understands the importance of reviewing the RM process on a regular basis but has not done so	The board of firm partially reviews the RM process on a regular basis	The board of firm always reviews the RM process on a regular basis
(10) RM is widely implemented and practiced in all levels within the firm	RM is not implemented and practiced in all levels within the firm	The firm understands the importance of RM implementation in all levels within the firm but has not done so	RM is partially implemented and practiced in all levels within the firm	RM is always implemented and practiced in all levels within the firm
Criteria 3: Risk identification capability				
(11) Potential risks are identified each time for new projects	The firm has no interest in identifying potential risks for new projects	The firm understand the importance of identifying all potential risks for new projects but has not done so	The firm partially identifies all potential risks for new projects	The firm always identify all potential risks for new projects
(12) You are aware of triggers in project causing risks to occur	The firm has no awareness of triggers in project causing risks to occur	The firm aware of the importance of triggers in project causing risks to occur but has not identify any	The firm partially aware of identifying triggers in project causing risks to occur	The firm always aware of identifying triggers in project causing risks to occur
(13) You can identify and these recognise triggers easily	The firm has no interest in identifying triggers	The firm understands the importance of identifying triggers but has not done so	The firm partially identifies triggers	The firm always identifies triggers
(14) A systematic identification method is used to ensure risks are identified	The firm has no interest using systematic identification method to ensure risks are identified	The firm understands the importance of using systematic identification method to ensure risks are identified but has not done so	The firm partially uses systematic identification method to ensure risks are identified	The firm always used systematic identification method to ensure risks are identified

Table 47 Maturity Matrix for RM implementation - continuation

Main criteria and sub-criteria	Maturity level			
	Level 1	Level 2	Level 3	Level 4
Criteria 4: Risk assessment capability				
(15) All project participants are capable of basic risk analysis skills such as qualitative or quantitative analysis	The firm project participants are not capable of basic risk analysis skills such as qualitative or quantitative analysis	The firm project participants understand the importance of basic risk analysis skills such as qualitative or quantitative analysis but have not done so	The firm project participants are partially capable of basic risk analysis skills such as qualitative or quantitative analysis	The firm project participants are always capable of basic risk analysis skills such as qualitative or quantitative analysis
(16) Qualitative and/or quantitative risk analysis tools and applications are used to assess identified risks	The firm has no interest in qualitative/ quantitative risk assessment tools and no applications are used to assess identified risks	The firm understands the importance of using qualitative/ quantitative risk assessment tools and the applications used to assess identified risks but has not done so	The firm partially uses qualitative/ quantitative risk assessment tools and partially used applications to assess identified risks	The firm always used qualitative/ quantitative risk assessment tools and the applications to assess identified risks
(17) The results of risk analysis is used as a basis for resource allocation and distribution to projects	The firm has no interest in the results of risk analysis that used as a basis for resource allocation and distribution to projects	The firm understands the importance of the results of risk analysis used as a basis for resource allocation and distribution to projects but has not done so	The firm partially uses the results of risk analysis that used as a basis for resource allocation and distribution to projects	The firm always uses the results of risk analysis that used as a basis for resource allocation and distribution to projects
(18) You conduct intensive analyses of causes in terms of the sources of risk	The firm has no interest in conducting intensive analyses of causes in terms of the sources of risk	The firm understands the importance conducting intensive analyses of causes in terms of the sources of risk but has not done so	The firm partially conduct intensive analyses of causes in terms of the sources of risk	The firm always conduct intensive analyses of causes in terms of the sources of risk
Criteria 5: Risk response capability				
(19) You have enough freedom of action to react to risks adequately	The firm has no interest or freedom of action to react to risks adequately	The firm understands the importance of action to react to risks adequately but has not done so	The firm has partially freedom of action to react to risks adequately	The firm always has freedom of action to react to risks adequately
(20) You take many actions at the sources of risk	The firm has no interest of taking many actions at the sources of risk	The firm understands the importance of taking many actions at the sources of risk but has not done so	The firm partially takes many actions at the sources of risk	The firm always take many actions at the sources of risk
(21) You can react to identified risks and carry out the necessary adaptive measures quickly	The firm has no interest to react to identified risks and carry out the necessary adaptive measures quickly	The firm understand the importance of reacting to identified risks and carry out the necessary measures quickly	The firm partially reacts to identified risks and carry out the necessary adaptive measures quickly	The firm always react to identified risks and carry out the necessary adaptive measures quickly

Table 47 Maturity Matrix for RM implementation - continuation

Main criteria and sub-criteria	Maturity level			
	Level 1	Level 2	Level 3	Level 4
Criteria 6: Risk monitoring capability				
(22) Risks are consistently identified, analysed, responded, and continuously monitored throughout the project life cycle	The firm has no interest to consistently identifies, analyses, responses, and continuously monitors risks throughout the project life cycle	The firm understands the importance to consistently identifies, analyses, responses, and continuously monitors risks throughout the project life cycle but has not done so	The firm partially consistently identifies, analyses, responses, and continuously monitors risks throughout the project life cycle	The firm always consistently identifies, analyses, responds, and continuously monitors risks throughout the project life cycle
(23) Risks occurred are compared against to initially identified risks	The firm has no interest to compare risks occurred against initially identified risks	The firm understands the importance to compare risks occurred against initially identified risks but has not done so	The firm partially compares risks occurred against initially identified risks	The firm always compares risks occurred against initially identified risks
Criteria 7: Development and implementation of standardised RM system				
(24) RM process reviewed to ensure the process is effective	The firm has no interest to review RM process to ensure the process is effective	The firm understands the importance to review RM process to ensure the process is effective but has not done so	The firm partially reviews RM process to ensure the process is effective	The firm always reviews RM process to ensure the process is effective
(25) The RM plan & procedures are fully developed	The firm has no interest to fully develop RM plan and procedures	The firm understands the importance of fully develop RM plan and procedures but has not done so	The firm partially develops RM plan and procedures	The firm always fully develops RM plan and procedures
(26) A standardized RM process is applied to all projects with the firm	The firm has no interest to apply standardized RM process to all projects	The firm understands the importance to apply standardized RM process to all projects but has not done so	The firm partially apply standardized RM process to all projects	The firm always apply standardized RM process to all projects
(27) Formalized RM system	The firm has no interest in applying any formalised RM system	The firm understands the importance of applying formal RM system but has not done so	The firm has partially formalized RM system	The firm has always formalized RM system
(28) RM tools and techniques are integrated and used in projects	The firm has not any interest in using any RM tools and techniques in projects	The firm understands the importance of RM tools and techniques in projects but has not used any	The firm partially uses RM tools and techniques in projects	The firm always uses RM tools and techniques in projects

7.4 Summary of this chapter

This chapter presents the proposed RM framework for construction firms in GCC countries. The aim of the framework is to facilitate the implementation of RM in these firms. This chapter also presents a RM maturity framework to enhance RM implementation and to help identify the areas which needs improvement. The following chapter is to validate the framework with industry experts. The developed framework was distributed among 15 experts who participated before in the questionnaire survey to obtain their final comments for the purpose of validation of framework. The majority of experts agreed with the proposed framework, in some cases with minor comments. The comments were applied to the proposed framework to constitute the final framework.

Chapter Eight
Validation of the Model

8.1 Introduction

Validation is "a main part of model development process which increases confidence in the model and make it more valued" (Braimah, 2008); Choosing validation methods in construction research was considered as challenging task (Liu et al., 2014). The proposed RM framework was validated for application through a questionnaire survey among 15 experts across the GCC construction industry, as shown in Table 56. The questionnaire survey was developed to seek the opinions and views of experts in order to improve the framework to better meet the needs of the construction firms. The experts filled in the questionnaire after explaining for them the idea of the framework as well as the validation criterion. The questionnaire required the experts to choose one of the answers offered using Likert scale (1= very low and 5= very high). Of the experts' contacted, 15 responded to participate in the validation questionnaire.

Table 48 Experts profile

No	Role in firm	Experience	Expert nationality	Method	Firm nationality
1	Lead risk manager	16 years	Egypt	Face-to-face	Australia
2	Lead risk manager	17 years	Jordan	Face-to-face	Italy
3	Risk manager	35 years	USA	By phone	Saudi Arabia
4	Tender director	30 years	UK	By phone	Austria
5	Project manager	32 years	Egypt	By phone	UK
6	Risk manager	22 years	Sudan	Face-to-face	USA
7	Risk manager	18 years	Malaysia	Face-to-face	Turkey
8	Construction director	36 years	India	Face-to-face	India
9	Contract manager	34 years	UK	Face-to-face	Italy
10	Head dep. of RM	15 years	Palestine	By phone	China
11	Construction manager	15 years	Egypt	By phone	Multi-national
12	Risk manager	18 years	Pakistan	Face-to-face	UK
13	Transportation regional manager	30 years	Australia	By phone	USA
14	Project control manager	16 years	Italy	By phone	France
15	Project management director	37 years	USA	By phone	Australia

As mentioned earlier, the respondents were asked to give their comments on the framework in a structured questionnaire. All responses were received to a large extent positive. A summary of the responses to the various questions are shown in Table 57. The risk triangle, the P-I-V Matrix, and the RM framework were presented to the participants in the validation process to survey their opinion about the findings. The participants have been asked about their opinion on the risk triangle. There was general agreement among participants about the role of the risk triangle in enhancing their understanding of the nature of risk. They agreed that it helped to understand the differences between risk events.

Also, 12 out of 15 participants agreed that the conceptual model was easy to understand and follow. The majority of the participants believed that the risk identification process in their projects could be improved. All experts were satisfied with the proposed approach and it can be useful for RM in construction projects. All experts agreed that they do not have any similar approach used in their company to differentiate between the three events. The participants in the validation process were asked about the P-I-V Matrix. All participants indicated that they do not have any tool or approach to assess uncertainties in construction projects in their firms. Also, they do not have similar of the proposed Matrix in their firms. The majority of the participants believed that the proposed matrix could help them more to understand the risk assessment process in construction projects.

They agreed that the proposed matrix was easy to follow and implement. Also, they agreed that it could improve the risk assessment stage in their firms. The majority of the participants were generally satisfied with the proposed matrix they think it could be useful for risk management in construction projects. Regarding the RM framework presented in this research, the majority of the participants believed that the proposed RM framework addressed the activities necessary for managing risks. Also they agreed that the steps identified in the framework can help in the management of risks. The majority of the participants believed that the steps and procedures are easy to follow and implement.

Generally, the participants were highly satisfied with the proposed RM framework. Also, they believed that the proposed framework could be useful for RM in construction projects. Moreover, they agreed that the inputs and outputs were easy to understand. To a high extent, the participants have willingness to implement the proposed RM framework in their firm. Also, they agreed that they have the capability to implement the proposed RM framework in their construction firms.

The majority of the participants believed that the presented framework could enhance the project performance in their firms. Also, they explained that the risk identification process presented in the RM framework differs from the one they use in their firms. Also, the risk assessment and risk response stages were different from the one they used in their firms. The majority of the participants believed that the proposed RM framework improves their understanding of RM process. Also, they believed that the presented framework could improve the RM for construction projects in the GCC countries.

According to the participants, the presented framework could improve the maturity of RM in their firms. All participants explained that they do not have RM framework similar to the one presented in this research in their firms.

Table 49 Summary responses from experts about the Risk Triangle

No	Validation criteria	Experts response														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	To what extent does using the Triangle improve your understanding about triggers, risks, and issues in construction projects?	5	5	5	5	4	5	5	4	5	4	5	4	5	3	5
2	To what extent the Triangle helped you to differentiate between the events (trigger, risk, and issue)?	5	4	5	5	4	5	5	4	5	5	5	4	5	3	5
3	To what extent the Triangle could help you to more understand the risk identification process in construction projects?	5	4	5	4	4	5	5	4	5	5	4	5	5	3	5
4	To what extent the Triangle easy to follow and implement?	5	3	5	4	3	5	4	5	5	5	4	5	4	3	5
5	To what extent the Triangle could improve the risk identification process?	5	4	5	4	3	5	5	5	5	5	5	5	5	4	5
6	How generally are you satisfied with the proposed approach the (Triangle)?	5	4	5	5	4	5	5	5	4	4	5	5	5	4	5
7	Do you think the proposed Triangle useful for RM in construction projects?	5	5	5	5	5	5	5	4	4	4	4	5	5	4	5
8	Is there any tool or approach similar to this triangle in your company used to differentiate between triggers, risks, and issues?	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No

*Likert scale (very high =5 and very low = 1)

Table 50 Summary responses from experts about the Risk Matrix

No	Validation criteria	Expert response														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Is there any tool or approach to assess the uncertainties in construction projects in your firm?	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
2	Do you have similar of the proposed Matrix in your firm?	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No
3	Do you think the proposed Matrix could help you to more understand the risk assessment process in construction projects?	5	4	5	5	4	5	5	4	4	4	4	5	5	3	5
4	Do you think the proposed Matrix easy to follow and implement?	5	5	5	5	4	5	5	4	5	4	4	5	4	3	5
5	Do you think the Matrix could improve the risk assessment process?	5	5	5	4	4	5	5	5	5	4	4	5	5	3	5
6	How generally are you satisfied with the proposed Matrix?	5	4	5	4	3	5	4	5	4	4	5	5	5	3	5
7	Do you think the proposed Matrix useful for RM in construction projects?	5	5	5	5	5	5	4	4	4	4	4	5	5	3	5

*Likert scale (very high =5 and very low = 1)

Table 51 Summary responses from experts about the RM Framework

No	Validation criteria	Expert response														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	The model addresses the activities necessary for managing risks	5	5	5	5	4	4	5	4	4	5	5	5	5	3	5
2	The steps identified in the model can help in the management of risks	5	5	5	5	4	4	5	4	4	5	5	5	5	3	5
3	The steps and procedures are easy to follow and implement	5	4	5	5	4	4	5	4	4	5	5	5	5	3	5
4	How generally satisfied are you with the proposed RM framework?	5	5	5	5	5	3	5	5	5	4	5	5	5	4	5
5	To what extent the proposed framework useful for RM?	5	5	5	5	3	3	5	4	5	4	4	4	5	4	5
6	To what extent do the inputs and outputs easy to understand?	5	4	5	5	4	3	5	4	5	4	4	4	5	3	5
7	Willingness to implement the proposed RM framework in your firm	5	5	5	5	4	4	5	4	5	4	4	4	5	3	5
8	Capability to implement the proposed RM framework in your firm	5	4	5	5	4	4	5	4	4	5	4	5	5	4	5
9	The present framework could enhance project performance in your firm	5	4	5	5	4	4	5	4	5	5	4	5	5	4	5
10	Risk identification in the framework differs from the one you use in your firm	5	3	5	4	5	4	5	4	5	5	4	5	5	3	5
11	Risk assessment in the framework differ from the one you use in your firm	5	3	5	4	5	3	5	5	5	5	5	5	5	3	5
12	Risk response in the framework differ from the one you use in your firm	5	3	5	5	5	3	5	5	5	5	4	5	5	3	5
13	The framework improves your understanding of RM process	5	4	5	5	4	4	5	5	4	4	4	5	4	4	5
14	The framework can improve the RM for construction project in the GCC	5	5	5	5	4	3	4	4	5	4	4	5	4	4	5
15	The proposed framework could improve the maturity of RM in your firm	5	5	5	5	5	4	5	4	5	4	5	5	4	4	5
16	Have your firm been using a RM framework similar to the one presented to you?	No	No	No	No	No	No	No	No	No	No	No	No	No	No	No

*Likert scale (very high =5 and very low = 1)

8.2 Summary of this chapter

This chapter reports on the validation of the proposed RM framework. The proposed framework was presented to 15 experts in the GCC construction industry using a questionnaire survey. The majority of the experts indicated positive agreement about the proposed RM framework.

Chapter Nine
Discussions, Conclusions and Recommendations

9.1 Introduction

This research study firstly presents a literature review on risks, RM, the types of risks that normally accompany construction projects, the barriers to RM implementation, and the RM maturity levels. Then, the research study presented and discussed primary data collected (through survey and case studies) in respect of current RM practice in the GCC countries. In the previous chapter, the validation process and results were presented. This chapter discusses the obtained results and the research findings in relation to the existing literature. Also, it summarises the research findings and conclusions, presents research contributions, and limitations of the research study.

9.2 Discussion of research findings

The premise of this study was to undertake an evaluation of the status of RM implementation within construction companies in the GCC countries. The findings and responses to the research questions were established from the literature review, responses to the survey questionnaires, and six case studies. The relationship of the research findings to the existing literature is discussed next.

- The mainstream view of RM studies in construction management literature includes: (1) the investigation into RM barriers, benefits, and usage of RM tools and techniques; (2) studies focusing on risk identification, assessment, mitigation and allocation; (3) RM as practiced in both developed and developing nations; (4) the development of RM processes, frameworks, and maturity models.

- The results revealed that the following ten key risks are responsible for project delay in the Kuwaiti construction industry: (1) shortage of skilled labour; (2) inadequate contractor experience; (3) poor labour productivity; (4) variation orders; (5) delay in preparation of shop drawings; (6) financial difficulties; (7) underestimation of costs; (8) inaccuracy of materials estimate; (9) poor planning for the project; (10) conflicts between contractor and subcontractor.

- About 86.6 percent of the construction organisations participated in the initial questionnaire do not have designated department or staff in charge of RM. Also, 82.9 percent indicated that it is essential to have a RM department in their organisations.

- Regarding knowledge in RM, the results shows that 12.2 percent, 54.9 percent, and 24.2 percent of the respondents evaluated their RM knowledge level to advanced, fair, and low, respectively.

- Regarding the fair - low level of RM knowledge, about 57.3 percent of the respondents have not been involved in RM training courses with the remaining 42.7 percent claiming they have participated in one or two RM training course.

- About 87.6 percent of the construction firms participated in the main questionnaire have a designated department or staff in charge of RM, whereas 12.4 percent of them do not have RM department.

- About 57.7 of the respondents indicated that RM activities in their firms undertaken as individual exercise, whereas 42.3 percent of the respondents indicated the activities to be undertaken through group exercises. Therefore, it is recommended to define clear responsibilities or make compulsory duties.

- About 72.3 percent of the respondents were disagreeing about the success of their projects in terms of schedule adherence. The results indicate high time and cost overruns in projects in GCC region. This result was supported by numerous researches in the GCC countries like, Kartam and Kartam (2001) in Kuwait, El-Sayegh (2008) in UAE, Alnuaimi et al. (2010) in Oman, and Assaf and Al-Hajji (2006) in Saudi Arabia.

- It appears that 91.1 percent of the respondents agreed that there is a difference between the concepts risk and uncertainty. However, 8.9 percent of respondents suggest that the concept of risk is not differentiated from the concept of uncertainty. Dikmen et al. (2007) argued that major challenges of RM are mainly due to poor definition of risk and vagueness about how and why risks should be managed in construction projects. This means that the industry practitioners may need some further education to help in differentiating between risk and uncertainty.

- The research confirmed the findings of relevant research projects that past experience and personal judgment are the key elements in analysing risks and making decision (Shen, 1997; Baker et al., 1999a; Wood and Ellis, 2003; Dikmen et al., 2004; Lyons and Skitmore, 2004; Uher and Toakley, 1999; Akintoye and Macleod, 1997; Taroun, 2014). Moreover, the second questionnaire results showed a high reliance of the GCC construction experts in regional and local firms on previous experience in the risk analysis and response processes. Similar results were obtained from the six case studies.

9.3 Research validation

The mixed-method approach was adopted and data was collected through questionnaires, interviews and case studies. Using the SPSS statistical analysis package, made the quantitative data easier to manage and analyse. However, the research has some limitations which are discussed in the next chapter.

9.4 Summary of the Research Findings and Conclusions

The key findings and conclusions are summarised and organised in accordance with the research objectives:

a) A comprehensive literature review has led to a good understanding of the characteristics of risk and RM in the construction industry in general, while the survey on RM implementation practice have provided a clear statement of the current practice and attitude of the GCC firms towards RM in particular.

b) This research has identified and ranked 62 key risk factors affecting construction project performance, and were categorised under four levels, namely: country level, industry and market level, firm capability level, and project implementation level.

c) Concerning current RM practices in construction firms operating in GCC countries, this research concludes that there is relatively little implementation of formal RM methods in practice by the majority of construction firms, especially those within the SMEs category which could explain why the construction industry consistently suffer from poor project performance. On the other hand, overseas companies operating in this industry have a high level of RM maturity in their organisations.

d) It was found out that the size, the history of a construction firm, the ext of the firm, and the ownership of the firm, are key characteristics of construction organisations that affect their RM maturity. The larger and older a firm, the more mature it tends to be in RM. Also, expanded and joint-venture firms appeared to exhibit high RM than firms without such features.

e) The results of the case studies showed that construction experts in the regional and local firms mainly dealt with management issues more than RM. On the other hand, overseas firms tend to follow a more mature practice in RM than the regional and local firms.

f) This research has developed a RM maturity model in a matrix format, consisting of four maturity levels and 28 detailed maturity criteria. The model will help construction firms identify areas needing improvements to achieve higher maturity thereby enhancing their RM practice.

g) The overall rating on the extent to which construction firms apply RM techniques in practice is moderate. The qualitative techniques are used much more often than quantitative techniques by construction firms. “Brainstorming”, “board and review meetings”, “avoid risk”, and “incident investigation” are the most frequently used techniques for, respectively, undertaking risks identification, risk analysis, risk response, and risk monitoring exercise.

h) The results show that there are 15 barriers preventing GCC construction firms from properly implementing RM in practice. Ten of these barriers are considered “important”, and the rest as “averagely important” by practitioners. The important barriers are: (1) political environment; (2) bureaucratic attitudes; (3) lack of required knowledge and skills in RM; (4) lack of interest and motivation; (5) cultural differences; (6) employees not empowered to implement RM process; (7) RM responsibilities not clearly defined; (8) lack of joint RM mechanism by parties; (9) lack of historical data for risk trend analysis; (10) project participants do not regard RM as an integral part of the project management.

i) In addition, this research has proposed a comprehensive RM framework for improving this management facet in construction firms operating in GCC countries. The framework consists of five main stages, mainly: (1) establish the context; (2) risk identification; (3) risk assessment; (4) risk treatment; (5) risk monitoring and control. The proposed RM framework has been evaluated through a series of experts' interviews. The majority of experts have a positive agreement about the proposed RM framework.

9.5 Generalisation of research findings and conclusions

The combination of varied data collection methods used in this research and the different experiences and project types covered give the obtained results and the conclusions a high level of generalisability. The questionnaire surveyed the attitudes of industry professionals who represent a wide spectrum of construction firms in the GCC countries. In addition, the interviewees provided deep insights into actual RM practice, which help to complement the questionnaire and case studies results. Moreover, the validation cases further enrich the interviews' findings and enhance their validity as to practical implications. In fact, one can appreciate a clear consistency between the obtained results from different sources in the vast geographic area investigated in GCC.

9.6 Research contribution

The research contributed to the theory and practice of construction management literature by the following:

9.6.1 Contribution to the knowledge

This study has contributed significantly to the existing body of knowledge and literature on RM in general and the GCC region in particular. The research findings, obtained empirically through robust mixed method research approach, offer contributions and benefit to knowledge by way of the following outcomes:

I. A number of studies have focused on examining project RM implementation in various countries. However, this study, to the best of the researcher's knowledge, is the first study being undertaken in the GCC construction industry on RM implementation, barriers affecting practice and organisations' capabilities. Thus, the results of this research do not only fill a major gap in the literature on the subject of RM practice in this industry, but also offer greater awareness and understanding of RM implementation in construction firms.

II. Presently, there is no known standard framework for improving the management of project risk in GCC countries which has an exceedingly long history of poor project performance. Thus, a major contribution of this research is a scientifically developed RM framework for facilitating effective RM implementation in GCC construction organisations. No such framework currently exists in GCC countries. Thus, this development has the potential of making a positive contribution to the body of knowledge.

III. This research investigated and analysed construction organisations and projects in the GCC region, through comprehensive surveys and case studies. The case studies provide rich in-depth qualitative data that explains, among others, the status of RM implementation in practice and the level of maturity displayed by GCC construction organisations on this subject. The data also provides valuable contextual evidence on the most effective RM practices and recommendations that should be adopted, if successful executions of construction projects in this region are to be ensured.

9.6.2 Contribution to the practices

This research also contributes significantly to the enhancement of RM practice in a number of ways, as follows:

6 The research has identified 28 RM maturity criteria and critical barriers to RM implementation. These were used to develop a comprehensive RM maturity system, which can serve as a guide for determining the RM capability of construction organisations to enable them decide on the most appropriate implementation strategies.

7 At local organisational level, the findings of this research provide construction firms with an informed knowledge which will enable them to understand their current weaknesses, strengths, and their status quo with RM practice, and hence, the best measures to be taken to diminish the negative influences of existing barriers to effective RM.

8 At regional level, the research contributes rich empirical data that can form the basis of developing guidance and policy regulatory documents about how a mature RM system in the construction industry could or should be implemented.

9 At international level, the research findings offer overseas companies with a clear view on the RM capability level of local companies they might be venturing with. Also, the findings serve as a case-study from GCC countries from which other countries in the Middle East and developing world can benefit immensely from the lessons learnt, since these countries share a lot in common as far as RM practices are concerned. For instance, the case studies performed have uncovered how RM is implemented and the associated managerial implications which will allow practitioners to understand the real implementation issues in practice and the experience of firms that is worth learning from.

10 The proposed RM improvement framework from this research consists of a model for determining RM maturity level of GCC construction organisations

and an informed list of best practice recommendations, all of which aid as a road map for implementing an effective RM system, thereby contributing to the enhancement of practice.

9.7 Research limitations

Although the research findings are validated and could be generalised, this dissertation has identified some limitations of the research which need further investigation in future. These limitations are summarised as follows:

1. Although the risk factors, the RM maturity criteria and the barriers to RM implementation were identified from an extensive and comprehensive literature review, they may not be exhaustive with the passage of time.

2. Also, one of the limitations in this research was the difficulty in getting more project experts to participate in the case studies. Also, the number of interviews and validation cases could have been higher. It is thus recommended that future studies should involve the use of more cases from other types of projects and expert practitioners.

3. It may be argued that RM practices are generic and there is no need to study individual countries. However, the detailed case studies revealed that there are unique features in GCC countries, due to political, cultural, and social conditions, that make RM practices unique. For example, this research found that construction firms do not readily adopt RM systems in their organisations, but tend to rather rely on risk insurance and issue management.

4. With time, the developed RM framework and maturity model are going to be less applicable as they are based on data from current RM practices. To ensure these research outcomes stay relevant and provide lasting benefits to RM practice, their continuous improvement is required from time to time through, for example, the evaluation of real case applications. The model could be further

improved using standard and comprehensive assessment methods and providing action steps for advancing the company across maturity levels.

9.8 Recommendations for future work

The results of this research study suggest future studies on RM to enhance the implementation of RM in construction industry, which include the following:

1. The absence of RM implementation in local and regional construction firms has led to a poor performance in their projects. Also, the overall rating on the application of RM techniques is not high, and is quite formal and inadequate to deal with project risks. Future research could be conducted on different approaches of RM to increase both the organisations and individual's knowledge on RM, especially on quantitative techniques.

2. Future studies would be conducted to assess the RM maturity in other projects or in other countries and to investigate the relationship between the RM maturity and improvement in performance (e.g. quality, budget, safety, and sustainability).

3. The conclusions of this research study were obtained from an empirical and case studies conducted in the GCC construction industry to develop RM framework. Further study investigations would be required to test this framework in other industries elsewhere in the world.

4. Future studies can include more case studies for other type of construction projects and involve more companies in the sample size.

9.9 Summary of this chapter

This chapter reviewed the research topic and discussed the obtained results and their relationships with the existing literature. Also, this chapter has reviewed the thesis and given a summary of this research study's findings. Furthermore, a number of practical and theoretical implications have been discussed in terms of the contribution to the field of RM in general and the GCC region in particular. Finally, some limitations and directions for future work were presented for a thorough investigation into this interesting topic.

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Appendices

Appendix 1 RM studies in high rank journals in construction management literature

Year	JCEM	ECAM	JME	CME	IJPM
1983					2
1984					0
1985	1				1
1986	2				4
1987	3		2		1
1988	1		0		0
1989	1		1		0
1990	6		2		7
1991	3		1		3
1992	2		1		4
1993	2		0		2
1994	4		1		6
1995	3		0		7
1996	1		2		4
1997	1		1	4	8
1998	3		8	5	5
1999	6		1	4	6
2000	4		7	1	4
2001	4		1	3	11
2002	7		2	5	8
2003	7	1	1	9	4
2004	17	0	2	6	6
2005	22	2	1	7	6
2006	16	1	1	12	8
2007	13	5	3	6	13
2008	17	4	5	4	6
2009	30	4	0	13	6
2010	16	2	5	15	10
2011	14	4	3	11	9
2012	17	1	3	4	7
2013	21	5	6	4	9
2014	4	1	-	-	-
2015					

Appendix 2 Number of high rank journals used by authors in construction management papers

No	Journal	Abb.	Country	References									Freq.
				Chan A. P. et al. (2004)	Zhou et al. (2013)	Xue et al. (2010)	Ke et al. (2009)	Al-Sherif & Kaka (2004)	Lin G. & Shen Q. (2007)	Chan et al. (2002)	Taroun A. (2013)	Bygballe et al. (2010)	
1	Construction Management and Economics	CME	UK	✓	✓	✓	✓	✓	✓	✓	✓	✓	9
2	International Journal of Project Management	IJPM	UK	✓	✓	✓	✓	✓	✓	✓	✓	✓	9
3	Journal of Construction Engineering and Management	JCEM	U.S.	✓	✓	✓	✓	✓	✓	✓	✓	✓	9
4	Engineering, Construction and Architectural Management	ECAM	UK	✓	✓	✓	✓	✓	✓	✓	✓	✓	9
5	Journal of Management in Engineering	JME	US	✓		✓	✓		✓	✓	✓	✓	7
6	Journal of Construction Procurement	JCP	UK	✓						✓			2
7	Project Management Journal	PMJ	US	✓									1
8	Automation in Construction	AIC				✓			✓		✓		3
9	Building Research and Information	BRI	UK			✓			✓			✓	3
10	Proceedings of the Institution of Civil Engineering	PICE-CE	UK				✓			✓			2
	Total			7	4	7	6	4	7	7	6	6	

Appendix 3 Mapping risk factors in construction industry

No.	Author (Year)	No.	Risks
1	Zhi (1995)	60	1. Interest rate fluctuation 2. Inflation; 3. Foreign currency exchange rate fluctuation; 4. Tax rate increase; 5. Funding/payment shortage; 6. Defects from nominated local subcontractors or materials and equipment suppliers; 7. Late construction site possession; 8. Bad weather; 9. Unforeseen ground conditions; 10. Fluctuations in labour or materials supply 11. Inefficient communications/coordination. 12. Unclear detail design or specification; 13. Incompatibility with local standards and codes; 14. Incomplete design; 15. Lack of interaction with local construction methods. 16. Safety and health-care standards problems; 17. Pollution and nuisances; 18. Poor detail design; 19. Defaults in physical works; 20. Defective materials.
2	Ahmed et al. (1999)	26	1. Acts of God (force majeure) 2. Change in work 3. Change order negotiations 4. Changes in government regulations 5. Contractor competence 6. Cost of legal processes 7. Defective design 8. Defective materials 9. Deficiencies in specifications and drawings 10. Delayed payment on contracts 11. Delays in resolving contractual issues 12. Delays in resolving litigation: arbitration disputes 13. Environmental hazards of the project 14. Financial failure—any party 15. Inflation (lump-sum and unit price contracts) 16. Labour and equipment productivity 17. Labour disputes 18. Labour, equipment and material availability 19. Permits and ordinances 20. Political uncertainty after July 1997 handover 21. Quality of work 22. Safety 23. Site access/right of way 24. Suppliers/subcontractors poor performance 25. Third party delays 26. Unforeseen site conditions
3	Kartam and Kartam (2001)	26	1. Permits and regulations 2. Scope of work definition 3. Site access 4. Labour, material and equipment availability 5. Productivity of labour and equipment 6. Defective design 7. Changes in work 8. Differing site conditions 9. Adverse weather conditions 10. Acts of God 11. Defective materials 12. Government acts

			13. Accuracy of project program 14. Labour disputes 15. Accidents/ Safety 16. Inflation 17. Contractor competence 18. Change order negotiations 19. Third party delays 20. Coordination with subcontractors 21. Delayed dispute resolutions 22. Delayed payment on contract 23. Quality of work 24. Financial failure 25. Actual quantities of work 26. War Threats
4	Shen et al. (2001)	58	Financial risk 1. Bankruptcy of project partner 2. Difficult convertibility of RMB 3. Loss due to fluctuation of inflation rate 4. Loss due to fluctuation of interest rate 5. Lost due to fluctuation of RMB exchange rate 6. Low credibility of shareholders and lenders Legal risk 7. Breach of contracts by other participants 8. Breach of contracts by project partner 9. Lack of enforcement of legal judgment 10. Loss due to insufficient law for joint ventures 11. Uncertainty and unfairness of court justice Management risk 12. Change of organisation within local partner 13. Improper project feasibility study 14. Improper project planning and budgeting 15. Improper selection of project location 16. Improper selection of project type 17. Inadequate choice of project partner 18. Inadequate project organisation structure 19. Incompetence of project management team 20. Incomplete contract terms with partner 21. Increase in project management overheads 22. Poor relation and disputes with partner 23. Poor relation with government departments 24. Problems associated with culture difference 25. Project delay Market risk 26. Competition from other similar projects 27. Fall short of expected income from project use 28. Increase of accessory facilities price 29. Increase of labour costs 30. Increase of materials price 31. Increase of resettlement costs 32. Inadequate forecast about market demand 33. Local protectionism 34. Unfairness in tendering Policy and political risk 35. Cost increase due to changes of policies 36. Loss incurred due to corruption and bribery 37. Loss incurred due to political changes 38. Loss due bureaucracy for late approvals Technical risk

			39. Accidents on site 40. Design changes 41. Equipment failure 42. Errors in design drawings 43. Hazards of environmental regulations 44. Incompetence of transportation facilities 45. Increase in site overheads 46. Industrial disputes 47. Local firm's incompetence and low credibility 48. Materials shortage 49. Obsoleteness of building equipment 50. Poor quality of procured accessory facilities 51. Poor quality of procured materials 52. Problems due to partners' different practice 53. Shortage in accessory facilities 54. Shortage in skilful workers 55. Shortage in supply of water, gas, and electricity 56. Subcontractor's low credibility 57. Unknown site physical conditions 58. Unusual weather and force majeure
5	Baloi, D. & Price, A. D. F. (2003)	40	I. Organisation specific; II. Acts of God; III. Global risk; a) Estimator related 1. Cognitive biases 2. Availability 3. Representative 4. Adjustment and anchoring 5. Motivational bias b) Design related 6. Scope vagueness 7. Project complexity 8. Project size and type c) Level of competition related 9. Policies of the contractor 10. Need for job 11. Market conditions 12. Number of bidders d) Fraudulent practices related 13. Corrupt practices 14. Fraudulent practices 15. Theft e) Construction related 16. Geological conditions 17. Unexpected site conditions 18. Weather conditions 19. Accessibility 20. Client generated 21. Sub-contractor generated f) Economic related 22. Market conditions 23. Price fluctuations 24. Inflation 25. Exchange rate 26. Interest rates g) Political related 27. Political system 28. Nature of the firm's operation 29. Strikes 30. Regional and external factors 31. Influence of power groups 32. Project desirability 33. Labour restrictions

			34. Change in labour costs 35. Civil disorder losses 36. Taxation on imported materials 37. Supply of local materials 38. Taxation changes 39. Foreign exchange rate 40. Government relations
6	Fang et al. (2004)	45	1. Capital return difficulty 2. Owners' delayed payment 3. Unfairness in tendering 4. Local protectionism 5. Owners' unreasonable upfront capital demand 6. Owners' unreasonably tight project duration 7. Difficulty in claiming indemnity 8. Owners' improper intervention in construction phase 9. Subcontractors' poor management 10. Low efficiency of construction administration departments, and late approvals by relevant departments 11. Government's improper intervention during construction 12. Subcontractors' poor technology 13. Absence of sound, effective, and fair arbitration means 14. Difficulty in relevant insurance compensation 15. Quality problems of suppliers' goods 16. Inadequate and inaccurate information obtained by contractors prior to tendering 17. Unexpected change of design required by owners 18. Influence of noise, pollution, etc. measures on construction 19. Owners' breach of contracts and disputes with contractors 20. Accidents occurring during construction 21. Influence of unpredictably inclement weather on construction 22. Unexpected change of design required by design units 23. Personal corruption and bribes in construction management departments 24. Quotation errors in tendering or construction time prediction errors made by contractors 25. Sudden changes of government laws and regulations concerning construction 26. Lack or departure of competent and qualified technicians and operators 27. Subcontractors' breach of contracts, and disputes with main contractors 28. Unexpected delay of goods supply by suppliers 29. Supervising officers deliberately creating difficulties for contractors 30. Inflation and sudden changes of prices 31. Abrupt quality issues in construction 32. Import and export restrictions on imported goods needed in construction 33. Quality problem of construction machinery 34. Supervising officers taking bribes 35. Serious mistakes made by supervising officers in technical supervision 36. Errors in working drawings prepared by design units 37. Owners' sudden bankruptcy 38. Difficulty or failure in fundamental facilities such as water and power supply 39. Unpredicted technical problems in construction 40. Lack of raw materials and machinery for construction 41. Internal conflicts between employers and employees 42. Conflicts resulting from cultural differences (behaviour patterns) between cooperating enterprises

			43. Machinery and materials stolen from construction sites 44. Difficulties in equipment transportation or in getting in and out of construction sites 45. Social disorder (demonstration, strike, turmoil, etc.)
7	Wang et al. (2004)	28	1. Approval and permit 2. Change in law 3. Justice reinforcement 4. Local partner's creditworthiness 5. Political instability 6. Cost overrun 7. Corruption 8. Inflation and interest rates 9. Government policies 10. Government influence on disputes 11. Termination of JV 12. Corporate fraud 13. Competition 14. Foreign exchange and convertibility 15. Market demand 16. Improper design 17. Improper project management 18. Improper quality control 19. Expropriation 20. Human resource 21. Low construction productivity 22. Quota allocation 23. Force majeure 24. Site safety 25. Cultural differences 26. Public image 27. Intellectual property protection 28. Environment protection
8	Ghosh, S. and Jintanapakanont, J. (2004)	35	Financial and economic risk 1. Unavailability of funds 2. Economic disaster 3. Tendered price 4. Exchange rate fluctuation 5. Inflation 6. Financial failure of contractor Contractual and legal risk 7. Delay in solving contractual issues 8. Delay in solving disputes 9. Change order negotiation 10. Delay payment on contract and extras Subcontractors related risk 11. Subcontractor failure 12. Co-ordination of subcontractor 13. Subcontractor lack of adequate number of staff 14. Financial failure of subcontractor Operational risk 15. Equipment productivity 16. Labour productivity 17. System outage 18. Treatment of material removed from site Safety and social risk 19. Pollution and safety rules 20. Accidents 21. Damage to persons or property 22. Ecological constrains

			23. Public consultancy Design risk 24. Inadequate specification 25. Conflict of document 26. Scope of work definition 27. Design change Force majeure risk 28. Act of God 29. War 30. Fire and theft Physical risk 31. Subsurface condition of geology 32. Subsurface condition of ground water 33. Unforeseen site condition Delay risk 34. Construction delay 35. Third party delays
9	Andi (2006)	27	1. Changes in work 2. Defective design 3. Delayed payment on contract 4. Financial failure of owner 5. Delays in resolving contractual disputes 6. Labour disputes 7. Labour, equipment and material availability 8. Productivity of labour 9. Contractor competence 10. Defective materials 11. Poor performance of suppliers/subcontractors 12. Productivity of equipment 13. Third party delays 14. Safety 15. Poor quality of work 16. Unforeseen site conditions 17. Financial failure of contractor 18. Political uncertainty 19. Changes in government regulation 20. Environmental hazards of the project 21. Acts of God 22. Permits and ordinances 23. Delays in resolving litigation/arbitration disputes 24. Site access/right of way 25. Deficiencies in specifications and drawings 26. Inflation 27. Cost of legal process
10	Wiguna and Scott (2006)	16	External and site condition risks 1. Unforeseen site ground condition 2. Weather condition 3. Difficult in obtaining permits and ordinances 4. Changes in government actions Economic and financial risks 5. High inflation/ increased price 6. Delayed payments on contract 7. High interest rate 8. Poor cost control Technical and contractual risks 9. Defective design 10. Design change by owner 11. Inadequately compensated variation order

			12. Delay in providing detail drawing Managerial risks 13. Defective construction work 14. Low labour and equipment productivity 15. Inadequate project program 16. Problems with availability of labour, material and equipment
11	Dikmen, I., Birgonul, M.T. and Han, S. (2007)	12	1. Vagueness of construction techniques/methods 2. Complexity (technical and managerial) 3. Unavailability of resources 4. Poor Planning 5. Vagueness of Scope 6. Design errors 7. Unavailability of funds 8. Delay in payments 9. Attitude of client 10. Inexperience of client 11. Unavailability of subcontractors 12. Poor performance of subcontractors
12	Tang, W., Qiang, M., Duffield, C. F., Young, D. M., & Lu, Y. (2007)	31	1. Quality of work 2. Premature failure of facility 3. Safety Inadequate or incorrect design 4. Financial 5. Failure to identify defects 6. Material or equipment quality *7. Force majeure* 8. Inadequate management method 9. Inadequate planning 10. Claims and disputes 11. Incompetence of subcontractor 12. Unforeseen site condition 13. Feasibility of const'n method 14. Shortage of skills/techniques 15. Delay of drawing supply 16. Insufficient technology 17. Poor coordination 18. Change in codes and regulations 19. Inappropriate risk allocation 20. Exchange rate fluctuation and inflation 21. Third party delay 22. Quantity variations 23. Adequacy of insurance 24. Poor definition of scope 25. Shortage of labour, materials and equipment 26. Conflicts in documents 27. Poor relationship between parties 28. Organisational interface 29. Environmental 30. Site access 31. Logistics
13	Zhang, G.M. and Zou, P.X.W. (2007)	39	Internal risks 1. Partner's financial ability 2. Distrust among partners 3. Local partners' incompetence 4. Interference by parent companies 5. Disagreement on staff allocation 6. Disagreement on work allocation 7. Dispute on technology transfer 8. Internal conflicts between parties 9. Inadequate project organisation structure 10. Bankruptcy of project partner 11. Poor relations within project partners 12. Change of organisation within local partner

			Project specific risks 13. Cash flow problems of client 14. Project delay 15. Subcontractor/supplier's incompetence 16. Excessive design variations by client 17. Incomplete contract terms 18. Disagreement on some conditions of contract 19. Improper project planning and budgeting 20. Client's improper intervention in construction phase 21. Unpredicted technical problems in construction 22. Incompetence of project management team External risks 23. Cost rise due to changes of policies 24. Bureaucracy for late approvals 25. Economy fluctuation 26. Exchange rate and convertibility 27. Force majeure and social disorder 28. Inflation 29. Import restriction/local protectionism 30. Security problems 31. Safety issues during construction 32. Language barrier 33. Capital return difficulty 34. Different social, cultural, and religious background 35. Pollution 36. Loss incurred due to corruption 37. Expropriation 38. Poor relations with government bodies 39. Shortage in supply of water, gas, and electricity
14	El-Sayegh, S.M. (2008)	10	1. Inflation and sudden changes in prices 2. Owners' unreasonably imposed tight schedule 3. Subcontractors' poor performance and management 4. Delay of material supply by suppliers 5. Change of design required by owners 6. Owners' improper intervention during construction 7. Shortage in manpower supply and availability 8. Delays in approvals 8 9. Lack or departure of qualified staff 10. Shortage in material supply and availability
15	Jha, K.N. and Devaya, M. (2008)	14	1. Poor government responsiveness 2. Weak legal system 3. Political instability 4. Cultural differences 5. Force majeure 6. Poor financial capability of local partner 7. Foreign exchange risk (forex) 8. Inaccurate assessment of market demand 9. Low project team cohesion 10. Ambiguous project scope definition 11. Poor cost management and control 12. Poor project management 13. Poor productivity and quality 14. Weak safety ethos
16	Skorupka, D (2008)	9	1. Operational risk 2. Economic risk 3. Political risk 4. Financial risk 5. Legal risk 6. Currency and inflation risk 7. Corruption risk 8. Risk of change in prices of raw materials and construction

			9. Tendering procedures as well as planning permissions
17	Zayed, T., Amer, M. and Pan, J. (2008)	27	Company level 1. Financing difficulties because of tax or capital movement restrictions 2. Financial difficulties because of currency exchange rate 3. Difficulty in converting local to foreign currency 4. Dependence on or importance of major power 5. Hostilities with neighboring country or region 6. Interaction of foreign management with local contractors 7. Current market volume in competency 8. Future market volume in competency Project level 1. Problems in technology transfer and implementation 2. Retention of technology advantage 3. Possibility if contractual disputes 4. Problems in dispute settlement due to country's laws 5. Shortage of skilled workers 6. Availability of special equipment 7. Delays in material supply 8. Delay in design and regulatory approval 9. Defective design, error, and rework 10. Work change order 11. Difficulties to meet construction programs supply 12. Unforeseen adverse ground conditions 13. Bad quality of materials 14. Bad quality of workmanship 15. Construction manager 16. Third party delays 17. Safety 18. Weather and natural causes of delay 19. Physical damage
18	Luu, V. T., Kim, S. Y., Tuan, N. V. & Ogunlana, S. O. (2009)	16	1. Owners' financial difficulties 2. Inadequate contractors' experience 3. Shortage of materials 4. Contractors' financial 5. Slow site handover 6. Delays in progress payments by owners 7. Low awarded bid prices 8. Inappropriate construction methods 9. Defective works and reworks 10. Material price fluctuations 11. Lack of capable and responsible site supervisors 12. Inclement weather 13. Owners' site clearance difficulties 14. Lack of capable owners/project managers 15. Designers' inadequate experience and capability 16. Shortage of equipment
19	Mahamid (2011)	43	Logic and Environment group 1. Insufficient labours 2. Rework from poor material quality 3. Rework from poor workmanship 4. Disturbance to public activities 5. Unavailable construction material 6. High competition in bids 7. Limited construction area 8. Poor terrain condition 9. Poor ground condition 10. Poor soil suitability Managerial group 11. Delays in decision making 12. Postponement of project

			13. Late land hand-over 14. Late submission of nominated materials 15. Poor communication between construction parties 16. Unreasonable project time frame 17. Poor resource management 18. Changes in management ways 19. Design changes 20. Internal administrative problems 21. Undefined scope of working 22. Late documentation 23. Delay in commencement 24. Improper construction method 25. Late issuing of approval documents Consultant group 26. Late design works 27. Mistake in design 28. Inappropriate design 29. Late inspection 30. Late approval 31. Insufficient inspectors 32. Incapable inspectors Financial group 33. Payments delay 34. Exchange rate fluctuation 35. Monopoly 36. Financial status of owner 37. Financial status of contractor 38. Changing of bankers policy for loans External group 39. Segmentation of the West Bank 40. Closure 41. Political situation 42. Weather condition 43. Natural disaster
20	Nieto-Morote and Ruz-Vila (2011)	13	Project management risks 1. Lack of adequate process 2. Lack of resources 3. Inexperienced team members 4. Lack of motivating attitudes Engineering risks 5. Design errors 6. Design changes Execution risks 7. Mistakes construction 8. Low productivity 9. Lack of previous experience 10. Accidents Suppliers risks 11. Technical problems 12. Delays in supply 13. Lack of quality
21	Alarcón, L. F., Ashley, D. B., de Hanily, A. S., Molenaar, K.	14	1. Changes in design and quantities 2. Extreme bad weather 3. General inflation 4. Inadequate claims administration 5. Inefficient contracting process 6. Inefficient planning

	R., & Ungo, R. (2011)		7. Insufficient revenues 8. Lack of controls 9. Lack of skilled and local labour 10. Local labour strikes 11. Material, equipment, and labour cost 12. Organisation risks 13. Owner driven changes 14. Referendum delays
22	Subramanyan et al., (2012)	93	Project-Specific Risk 1. Size of the project 2. Location uniqueness 3. Regulatory approvals 4. Type of project 5. Intense competition at tender stage 6. Tender selection methodology 7. Deviation of scope 8. Original contract duration is rigid and has no scope to accommodate any changes 9. No clear definition of completion of work 10. Delay penalties 11. Legal disputes and lawsuits 12. Flow of finance 13. Insurance strategy 14. Exposure to accidents 15. Information management 16. Unanticipated impacts Owner-Specific Risk 17. Inadequate definition of project scope in the beginning 18. Delay in handing over the site to contractor 19. Chances of facing financial crisis 20. Delay in revising and approving design document by owner, i.e., inefficient in decision making 21. Delay in payments by owner; not offering incentives for early completion of activities 22. Sudden termination of work by owner 23. Unreasonably high expectation of owner 24. Lack of vision/inability in identifying critical activities 25. Holding key decisions in abeyance 26. Changes made by owner during construction 27. Owner's lack of exposure to changing trends in industry Contractor-Specific Risk 28. Delay in mobilization 29. Poor site management and supervision by contractor 30. Improper construction methods/quality variations 31. Delays in subcontractor's work 32. Frequent change of subcontractors 33. Poor qualification/experience of the contractor 34. Holding key decisions in abeyance 35. Ignorance of impact of contract clause 36. Chances of facing financial crisis Architect/Consultant-Specific Risk 37. Insufficient data collection and survey before design 38. Inadequate experience of consultant with regard to type of project 39. Delay in performing inspection and testing by consultant 40. Inflexibility of consultant 41. Complex/non-executable design 42. Unclear and inadequate details in drawings 43. Chances of consultant leaving the project midway 44. Non use of advanced engineering design software

			Project-Manager-Specific Risk 45. Project manager's technical capability 46. Use of appropriate planning tools and techniques by project manager 47. Holding key decisions in abeyance 48. Lack of induction and training of human resources 49. Negative attitude of project manager 50. Lack of coordinating ability and rapport of project manager with other contractors at site 51. Reluctance in maintaining target schedule by top management 52. Lack of leadership quality of project manager 53. Lack of effective monitoring and feedback by project manager 54. Chances of project manager leaving the project 55. Tools and techniques Resource-Specific Risk 56. Selection of material and equipment 57. Delay in materials delivery 58. Changes in material types and specifications during construction 59. Unrealistic price variation in material 60. Improper selection of equipment 61. Equipment breakdowns 62. Shortage of equipment 63. Quality variations 64. Shortage of labours 65. Unqualified workforce 66. Poor inventory management External-Environment Specific risk 67. Unfavorable social environment 68. Unfavorable economic/market fluctuations 69. Unfavorable political environment 70. Changing government policies 71. Labour strikes 72. Natural calamities 73. Sudden unforeseen events Finance-Specific Risk Factors 74. Financial policies 75. Liquidity 76. Cost of capital 77. Market risk 78. Credit risk 79. Operational risk 80. Profitability risk 81. Contingency risk 82. Time risk Contract-Clause-Specific Risk 83. Differing site conditions clause 84. Delay damages clause 85. Extension of time clause 86. Forfeiture of security deposit clause 87. Termination of contract clause 88. Responsibility of design clause 89. Defect liability period clause 90. Dispute resolution clause 91. Price escalation clause 92. Use of barchart/CPM clause 93. Ambiguities in defining certain clauses

23	Lu, S. and Yan, H. (2013)	15	1. Lack of insurance 2. Lack of professionals 3. Defective materials 4. Poorly trained labourers 5. Inflation 6. Amphibolous contract 7. Design variations 8. Government bureaucracy 9. Inaccurate cost estimate 10. Poor communication 11. Unavailability of funds 12. Long term of investment 13. Deregulation of safety 14. Theft 15. Pollution
24	Goh et al., (2013)	21	Planning stage 1. Frequent design changes 2. Discrepancy in design 3. Unclear roles and responsibilities of project stakeholders 4. Inadequate soil investigation data 5. Inaccessible supply of temporary utilities to the construction site Design stage 6. Inadequate time allocated 7. Delay in material approval 8. Human resources shortage in design team Procurement stage 9. Delay in appointing the erosion control contractor 10. Delay in appointing subcontractor 11. Delay in issuing construction drawing Construction stage 12. Poor relationship between primary contractor and consultants 13. Poor coordination among the consultants 14. Poor quality product 15. Delay in material approval 16. Delay in consultant inspection 17. Discrepancy in applied and approved payment 18. Shortage of construction labour and management staff 19. Discrepancies in technical drawing Handing over stage 20. Late handing due to incomplete documents 21. Late handling due to the inspection of numerous parties
25	Gündüz, M., Nielsen, Y. and Özdemir, M. (2013)	15	1. Inadequate contractor experience 2. Ineffective project planning and scheduling 3. Poor site management and supervision 4. Design changes by owner or agent during construction 5. Late delivery of materials 6. Unreliable subcontractors 7. Delay in performing inspection and testing 8. Unqualified/inexperienced workers 9. Change orders 10. Delay in site delivery 11. Delay in approving design documents 12. Delay in progress payments 13. Slowness in decision making 14. Poor communication and coordination with other parties 15. Unexpected surface and subsurface conditions (soil, hw t.)
26	Kuo and Lu (2013)	19	1. Design drawing errors 2. Conflicting interfaces of work items 3. Poor construction site surveys

			4. Inappropriate design and poor engineering 5. Insufficient experience and skill in construction works 6. Poor construction plan 7. Delay in relocating existing pipelines 8. and facilities 9. Unstable supply of critical construction 10. materials 11. Ground water seepage 12. Typhoon 13. Heavy rainfall 14. Heavy 15. Earthquake 16. Increases in prices of construction materials 17. Protest and interference of nearby residents 18. Political interference 19. Increases in labours and employee salaries
27	Al-Sabah et al. (2014)	74	**External risks** *Political risks:* 1. War threat; 2. Political instability; 3. Government act; 4. Insecurity and crime; 5. Bribery and corruption; 6. Disputes and strikes. *Economic risks:* 7. Tax rate; 8. Currency exchange rate; 9. Fund transfer fees; 10. Price inflation; 11. Resources availability and quality. *Legal risks:* 12. Nationalism and local protectionism; 13. Legal entity establishment; 14. Import and export restrictions; 15. Authorities and regulations requirements; 16. Intellectual property protection; 17. Permits and licences; 18. Altered contract forms; 19. Law and arbitration system. *Social risks:* 20. Language barrier; 21. Religious differences; 22. Holidays and religion observances; 23. Cross-cultural differences. *Natural risks:* 24. Pestilence; 25. Inclement climate; 26. Natural catastrophic events; 27. Different time zones. **Internal risks** *Design risks:*

			1. Defective/late design documents; 2. Excessive design review; 3. Inaccurate supplemental design information; 4. Latent design defect; 5. Differences in design practices and standards; 6. Contractors'/Subcontractors' design insurance. *Construction risks:* 7. Project location and accessibility; 8. Hazardous material; 9. New technology usage; 10. Long lead material/equipment; 11. Material, equipment or work furnished by owner; 12. Material, equipment or work furnished by other contractor; 13. Testing laboratories; 14. Equipment and labour productivity; 15. Subcontractors' performance; 16. Nominated subcontractors' performance; 17. Differing and unforeseen site conditions; 18. Inadequate schedule; 19. Progress acceleration; 20. Accident/Safety. *Financial risks:* 21. Error in bids/quotation; 22. Subcontractor payments; 23. Monthly payment; 24. Constructive changes; 25. Cardinal changes; 26. Retention; 27. Assessment of liquidated damages; 28. Indirect, consequential and punitive damages. *Management risks:* 29. Insufficient scope definition; 30. Insufficient compensation and project delivery strategies; 31. Coordination between design firms; 32. Packages consideration; 33. Projects supervision and administration; 34. Coordination between subcontractors/suppliers; 35. Power of engineer to fix rates; 36. No damages for delay; 37. Submittals and approvals; 38. Request for information; 39. Insurance, bonds and guarantees; 40. Contractual relationship intervention. *Maintenance risks:* 41. Testing and acceptance; 42. Warranty and decennial liability; 43. As-built drawing preparation; 44. Site clearance; 45. Substantial completion acceptance and payment release; 46. Maintenance period; 47. Final payment.

Appendix 4 Initial Survey

Dear Respondent,

In partial fulfillment of the requirements for obtaining the PhD Degree in Civil Engineering from Engineering and Design School of Brunel University – United Kingdom, the researcher is conducting a survey on **Identification and Assessment of Risk Factors Contributing to Time Delay and Cost Overrun in Construction Projects in Kuwait** as essential part of the PhD thesis requirement. The aim is to identify the risk factors effecting cost overrun and time delay in construction projects in Kuwait. The objectives of this survey are:

1. Identify and priorities the critical risk factors contributing to cost and time overrun in Kuwait's construction projects;
2. Assess the most critical risk factors affecting the delivery of construction projects in Kuwait;
3. Present response strategies to reduce the negative impact of time delay and cost overrun on the project;

It is targeted at practitioners, engineers and contractors in construction industry in order to investigate their practices in risk management. The researcher would like to draw your attention to the following:

- The information given by you is for the purpose of academic research, with an absolute commitment to maintaining the confidentiality of your information and only the researcher and his supervisory team will have access to it.
- The researcher hopes that the information is accurate and correct to reach the desired results of this survey.
- This survey is designed to take no more than 15 minutes of your valuable time. Your input is crucial for the researcher project and it will be highly regarded.

Best Regards,

Eng. Ghadeer Alfandi
PhD Candidate
Engineering and Design College
Civil Engineering Department
Brunel University – United Kingdom

Respondent profile (Optional):

1. Name: ……………………………………………………………………………………
2. Address: …………………………………………………………………………………
3. Tel.: ……………………………………………………………………………………
4. Fax: ……………………………………………………………………………………
5. E-mail address: ………………………………………………………………………

FIRST SECTION: GENERAL INTRODUCTION

- Risk can be defined as an event or action which tends to cause a negative impact on project performance, which includes (Scope, Time, Cost, and Quality).
- PMBOK included risk management as one of the nine focuses in project management.
- Risk management is a systematic process of identifying, analyzing, and responding to project risk (PMI, 2000).

SECOND SECTION: BACKGROUND *(Please Tick × in one answer from the following options):*

1. **Organisation \ Company name:** ……………………………………………

2. **Please indicate your working place:**

☐ Government sector	☐ Private sector	☐ Academic sector	☐ Others

3. **Please indicate your current job position in your organisation:**

☐ Chairman	☐ Director	☐ Executive Manager	☐ Deputy Director
☐ Head of technical department	☐ Site Engineer	☐ Architectural Engineer	☐ Design Engineer
☐ Project Manager	☐ Risk Manager	☐ Quantity Surveyor	☐ General Supervisor
☐ Planning Engineer	☐ Office Engineer	☐ Contract Engineer	☐ Others, please specify

4. **Age:**

☐ Under 25	☐ 25 – 30	☐ 31 – 35	☐ 36 - 40
☐ 41 - 45	☐ 46 – 50	☐ 51 – 55	☐ Above 60

5. **Nationality:**

☐ Kuwaiti ☐ Non-Kuwaiti, specify …………………

6. **Level of education:**

☐ Graduate	☐ High Diploma	☐ Master Degree	☐ MBA
☐ Doctoral	☐ Others		

7. **How many years do you have practical experience working in construction projects?**

☐ Under 5 years	☐ 5 - 10 years	☐ 11 - 15 years	☐ 16 - 20 years
☐ 21 – 25 years	☐ above 25 years		

8. **Working sector:**

☐ Government sector	☐ Private sector	☐ Corporate bodies	☐ Private Developers

9. **What types of construction projects you are experienced in?**

☐ Building	☐ Residential	☐ Highway	☐ Roads
☐ Sewerage and water supply	☐ Bridges	☐ Tunneling	☐ Industrial projects

☐ Infrastructure ☐ Airports ☐ Commercial ☐ Others, please specify

10. Do you work on a current project?
☐ Yes ☐ No

If yes, specify the name of the project ………………………………………………

11. Did you study risk management or/and project management courses?
☐ Yes ☐ No

If yes, what courses? …………………………………………………………………

12. How do you evaluate your knowledge of risk management?
☐ Advanced ☐ Fair ☐ Low ☐ None

13. Is there a designated department or staff for risk management in your organisation?
☐ Yes ☐ No

14. If No, according to your perception, do you think it is essential to have a risk management department in your organisation?
☐ Yes ☐ No

Why? ……………………………………………………………………………………

15. Does your organisation use any procedures to identify and manage project risks?
☐ Yes ☐ No

If yes, what project(s) is it? ………………………………………………

16. How often has <u>time overrun</u> problems occurred in the housing projects you have undertaken in Kuwait?
Please indicate the number of these projects…………………………………………………

Indicate by percentage (approx.), how much these projects represent with respect to the total projects handled by you:
☐ In < 20 % ☐ In 20 – 50 % ☐ In 50 – 80 % ☐ In 80 – 100 %

17. How often has <u>cost overrun</u> problems occurred in the housing projects you have undertaken in Kuwait?
Please indicate the number of these projects ……………………………………………

Indicate by percentage (approx.), how much these projects represent with respect to the total projects handled by you:
☐ In < 20 % ☐ In 20 – 50 % ☐ In 50 – 80 % ☐ In 80 – 100 %

18. Have you directly or indirectly been involved in managing risks?
☐ Yes ☐ No

19. If yes, indicate your role in which phase of risk management?
☐ Risk identification phase
☐ Risk assessment phase

- ☐ Risk response phase
- ☐ All of the above

20. Please indicate what types of risks did you face in the project? (Specify 3 risks)

THIRD SECTION: THE ASSESSMENT OF RISK FACTORS CONTRIBUTING TO COST OVERRUN AND TIME OVERRUN WITHIN THE LIFE CYCLE OF PROJECT IN CONSTRUCTION PROJECTS IN KUWAIT

The following tables illustrate risk factors in projects, please specify the **probability of occurrence** of these risks, and specify **the impact** of these risk factors on the contractual time and cost budget. *(Please tick × in the appropriate box for indicating your response rating, where 5 = very high and 1 = very low)*

ID	Risk Factors	What is the **probability of occurrence** of risk factor in projects?					What is the **impact** of the risk factor on **Time** of projects?					What is the **impact** of risk factor on **Cost** of projects?				
		5	4	3	2	1	5	4	3	2	1	5	4	3	2	1
	Group 1: Country and Surroundings Region															
1	Monopoly materials because of closures or unexpected political factors															
2	Restricted access/ external or internal military action															
3	Unstable political situation and change of government															
4	Workers strike															
5	Civil wars and revolutions															
6	Delay and difficulty in approval of permits to work															
7	Unanticipated inflation and interest rates															
8	Language barriers and cultural differences															
9	The lack of security and stability															
10	Theft															
11	Delay in land acquisition															
12	Differing site conditions from what was expected															
13	Force majeure by natural disasters															
14	Adverse weather conditions and environmental change															
15	Unforeseen ground conditions															

16	Poor accessibility to the construction site and vulnerable construction conditions															
	Group 2: Industry and market															
17	Shortage of skilled labour															
18	Low performance level of labour															
19	Low capability of subcontractor															
20	Low availability of experienced and qualified subcontractors															
21	Unavailability of required materials in markets															
22	Shortage in equipment / and required spare parts															
23	Lack of presence of engineering specialists in resolution of conflicts															
24	Third party delays															
25	Change in standards and specifications															
26	Delay in the settlement of contractor claims															
27	Lack of presence of arbitrators															
28	Delay of materials procurement															
	Group 3: Capability of construction firms															
29	Absence of advance information (host country and firms)															
30	Lack of technical skills and construction experience															
31	Lack of capability to provide sufficient cash flow															
32	Lack of capability in cost estimation and price															
33	Lack of capability in materials estimation															
34	Inadequate cost forecasting															
35	Insufficient use of management techniques															
36	Lack of capability of contract management and administration															
37	Inadequate of method of statements															

	Group 4: Project management and implementation															
38	Worsening in relations between constituent members and organisations															
39	Conflicts between local firms and subcontractors															
40	Conflicts among project parties															
41	Unreasonable requests for changes in design from employer															
42	Delay in progress payments															
43	Changes in material types and specifications during construction															
44	Gaps between implementation and specifications															
45	Reconstruction on account of design errors and defects															
46	Occurrence of accidents															
47	Client induced additional work beyond															
48	Project complexity															
49	Lack of design capabilities and experience															
50	Creep in scope of project															
51	Unexpected breakdown for equipment															
52	Failure in equipment															
53	Equipment maintenance difficulties															
54	Lack of capability of financial planning for the project															
55	Lack of capability in supervising engineers/supervisors and dealing with business															
56	Effects of subsurface conditions (type of soil, water table)															
57	Shortage of construction materials on site															
58	Delay in the approval of the materials used															
59	Actual quantities differ from the contract quantities															
60	Unclear contract terms, conditions, and provisions															

61	Delay in preparation of shop drawings																
62	Delay in approval of shop drawings																
63	Lack/inaccuracy of BOQ in contracting total amount																
64	Inaccurate time estimate																

I would thank you for your time and support. Should you have any questions about completing the questionnaire, please do not hesitate to contact me at the contact details shown below.

Appendix 5 Main questionnaire survey

Dear participant

The researcher at the Brunel University London conducts the research project 'An investigation into the risk management process (RM) implementation in the Gulf Co-operation Council' (GCC). The aim of the project is to systematically investigate the overall aspects of risk management. The overall aspects involved investigating the status of the risk management system, the barriers to risk management implementation, and the current risk management practices which were perceived by the main project participants in the Arabic Gulf Region.
This questionnaire is an important part of data collection in the project. The questionnaire consists of a total of 31 questions. It takes approximately 16 minutes to answer the questionnaire.

This information given by you will be treated confidentially and is going to be used for educational purposes only. It worth mentioning, that the questions should be answered from the project perspective, not from the general perspective.

Thank you in advance.

Ghadeer Alfandi, PhD Student, Brunel University London
Phone: +44 (0)7425838092, E-mail: Ghadeer.alfandi@brunel.ac.uk

General questions				
1. Name (optional)	………………………………………………………………………………			
2. Company name (optional)	……………………………………………………………			
3. Describe your position within organisation	……………………………………………			
4. Educational background	☐Graduate ☐Diploma	☐ Masters ☐PMP	☐PhD	
5. Service provided in the GCC	☐Architectural consultancy ☐Engineering consultancy	☐Construction ☐Project Management Office (PMO)		
6. Number of years of work experience	☐ 5 -10 ☐11 -15	☐16-20 ☐21 - 25	☐ over 25	
7. Number of years of work experience (in Gulf Region)	☐ 5 -10 ☐11 -15	☐16-20 ☐21 - 25	☐ over 25	
8. Type of construction projects involved (check all that applies)	☐ Building ☐Commercial ☐Educational ☐Residential ☐Industrial	☐Recreational ☐Health ☐Heritage ☐Energy ☐Off – shore	☐Infrastructure ☐Transportation ☐Geotechnical ☐Property development ☐ Government facility	☐Fit out projects ☐Others …………………
9. Location of projects (check all applies)	☐ State of Kuwait ☐ Kingdom of Saudi Arabia ☐ Kingdom of Bahrain	☐United Arab Emirates ☐ Oman ☐ Qatar		
10. Is there a designated department or staff in charge of RM in your organisation?	Yes ☐	No ☐		

11. Are risk management activities undertaken as an individual exercise or as a group exercise?

Individual exercise	Group exercise
☐	☐

12. Please evaluate the average success of your completed projects

	Strongly disagree	Disagre e	Neutral	Agree	Strongly agree
a. Your projects are completed with a high degree of schedule adherence	☐	☐	☐	☐	☐
b. Your projects are completed with a high degree of budget adherence	☐	☐	☐	☐	☐
c. Your projects are completed and fulfil all quality requirements	☐	☐	☐	☐	☐

13. Is there a difference between risk and uncertainty?

Yes	No
☐	☐

14. To what extent the following objectives below are affected by the risks you have defined?

	Very low	Low	Medium	High	Very high
Time	☐	☐	☐	☐	☐
Budget	☐	☐	☐	☐	☐
Quality	☐	☐	☐	☐	☐
Safety	☐	☐	☐	☐	☐
Sustainability	☐	☐	☐	☐	☐
Environment	☐	☐	☐	☐	☐
Performance	☐	☐	☐	☐	☐
Reputation	☐	☐	☐	☐	☐

15. Are there differences in managing risks at different stages of the project life cycle?

Yes	No
☐	☐

16.What kind of approach best describes your organisation's RM system?

Strongly Informal	Informal	Neutral	Formal	Strongly formal
☐	☐	☐	☐	☐

17.To what extend has this approach been standardised for use in your organisation?

Non- standardised	Low standardised	Neutral	Standardised	Highly standardised
☐	☐	☐	☐	☐

18.To what extent do you agree that your organisation's RM system is adequate?

Inadequate	Low adequate	Neutral	Adequate	Highly adequate

☐	☐	☐	☐	☐

19.To what extent is there the need to further develop your organisation's RM system?

Very low	Low	Medium	High	Very high
☐	☐	☐	☐	☐

20. Does your organisation have a plan in place for improving its RM system?

Yes	No
☐	☐

21.To what extent is risk management information distributed and communicated to all project participants within your organisation?

Very low	Low	Medium	High	Very high
☐	☐	☐	☐	☐

22. To what extent are risk management tools and techniques integrated and used in projects?

Very low	Low	Medium	High	Very high
☐	☐	☐	☐	☐

23. To what extent are resources dedicated to projects in accordance to the severity of risk events identified?

Very low	Low	Medium	High	Very high
☐	☐	☐	☐	☐

24. To what extent are team members taking risk ownerships during project implementation?

Very low	Low	Medium	High	Very high
☐	☐	☐	☐	☐

25. To what extent is the RM system embedded in the organisation's behaviour and practices?

Not embedded	Low embedded	Neutral	Embedded	Fully embedded
☐	☐	☐	☐	☐

26. For the RM processes listed below, please indicate the relative level of implementation difficulties

	Very low difficulty	Low difficulty	Neutral difficulty	High difficulty	Very high difficulty
a. Risk identification	☐	☐	☐	☐	☐
b. Risk analysis	☐	☐	☐	☐	☐
c. Risk response	☐	☐	☐	☐	☐
d. Risk monitoring	☐	☐	☐	☐	☐

27. Indicate your organisation's capability to effectively implement the RM processes listed below:

	Very low ability	Low ability	Neutral ability	High ability	Very high ability
a. Risk identification	☐	☐	☐	☐	☐
b. Risk analysis	☐	☐	☐	☐	☐
c. Risk response	☐	☐	☐	☐	☐

d. Risk monitoring	☐	☐	☐	☐	☐

28. What are the techniques currently you use in Risk Management Projects? (check all applies)

a. Risk identification	☐Brainstorming ☐Questionnaire ☐Review of historical data	☐Consulting experts ☐Industry information ☐ Ishikawa (fishbone)
b. Risk analysis	☐Board & review meetings ☐Scoring (PI Matrix) ☐Delphi technique	☐Risk analysis software ☐Decision making tools, decision trees ☐Experience from previous cases
c. Risk response strategies	☐ Avoid risk ☐ Transfer the risk through contract ☐ Risk reduction	☐ Risk sharing to other parties ☐Contingencies ☐ Insurance
d. Risk monitoring	☐Incident investigation ☐Risk audit/ inspection ☐ Ishikawa (fishbone)	☐Periodic documents reviews ☐Periodic risk status reporting ☐Periodic trend reporting

29. Please, evaluate the following statement with regards to your risk management practice in <u>your organisation:</u>

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1. Potential risks are identified each time for new projects	☐	☐	☐	☐	☐
2. You are aware of triggers in project causing risks to occur	☐	☐	☐	☐	☐
3. You can identify and recognise these triggers easily	☐	☐	☐	☐	☐
4. You conduct intensive analyses of causes in terms of the sources of risk	☐	☐	☐	☐	☐
5. A systematic identification method is used to ensure risks are identified	☐	☐	☐	☐	☐
6. Risks occurred are compared against to initially identified risks	☐	☐	☐	☐	☐
7. You take many actions at the sources of risk (e.g. by contractual obligation, …)	☐	☐	☐	☐	☐
8. All project participants are capable of basic risk analysis skills such as qualitative or quantitative analysis	☐	☐	☐	☐	☐
9. Qualitative and/or quantitative risk analysis tools and applications are used to assess identified risks	☐	☐	☐	☐	☐
10. The results of risk analysis is used as a basis for resource allocation and distribution to projects	☐	☐	☐	☐	☐
11. Risks are consistently identified, analysed, responded, and continuously monitored throughout the project life cycle	☐	☐	☐	☐	☐

12. You have enough freedom of action to react to risks adequately	☐	☐	☐	☐	☐
13. You can react to identified risks and carry out the necessary adaptive measures quickly	☐	☐	☐	☐	☐
14. There is formal report submitted to board level in your organisation at least annually on the current state of risk and effectiveness of RM	☐	☐	☐	☐	☐
15. The organisation board reviews the risk process on a regular basis	☐	☐	☐	☐	☐
16. The senior management fully engage with and commit to the Risk Management meetings	☐	☐	☐	☐	☐
17. The Department Managers fully engage with and commit to the Risk Management meetings	☐	☐	☐	☐	☐
18. The Risk Management team appropriately resourced	☐	☐	☐	☐	☐
19. The Risk Management plan & procedures are fully developed	☐	☐	☐	☐	☐
20. Risk management is widely implemented and practiced in all levels within the organisation	☐	☐	☐	☐	☐
21. Risk management process reviewed to ensure the process is effective	☐	☐	☐	☐	☐

30. Assess how the following factors could be barriers to risk management implementation in <u>your organisations</u>

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1. The political environment is one of our main concerns in managing risks in GCC	☐	☐	☐	☐	☐
2. Bureaucratic attitudes are an ever – present problem in GCC	☐	☐	☐	☐	☐
3. The language barriers is an obstacle for us	☐	☐	☐	☐	☐
4. Cultural differences have been a problem for us	☐	☐	☐	☐	☐
5. The hosting country (local laws, permits, etc.) is one of major reason for barriers/difficulties to Risk Management implementation	☐	☐	☐	☐	☐
6. Lack of required knowledge and skills in Risk Management	☐	☐	☐	☐	☐
7. Lack of RM awareness among top management staff	☐	☐	☐	☐	☐
8. Lack of interest or motivation	☐	☐	☐	☐	☐
9. Employees not empowered to implement RM process	☐	☐	☐	☐	☐
10. RM responsibilities not clearly defined	☐	☐	☐	☐	☐
11. Project participants do not regard RM as an integral part of the project management	☐	☐	☐	☐	☐
12. Lack of accepted industry model for analysis	☐	☐	☐	☐	☐
13. Lack of joint risk management mechanise by parties	☐	☐	☐	☐	☐
14. Lack of historical data for risk trend analysis	☐	☐	☐	☐	☐
15. Insufficient ongoing project information for decision making	☐	☐	☐	☐	☐

Thank You for Your Participation

Appendix 6 Interview questions for case studies

Case study

Interviewees	Firm	Country	Experience
Interviewee 1			
Interviewee 2			
Interviewee 3			

1. Basic information
1.1. Firm name:
1.2. Project:
1.3. Cost of project:
1.4. Contract:
1.5. The number of the board members:

2. Factors affecting risk management (RM) implementation
2.2 What are the drivers for RM implementation in your firm?
2.3 What are the barriers and challenges to RM implementation in your firm?
2.4 Do you consider RM system in your firm to be adequate, neutral or inadequate?
2.5 Do you consider your RM approach in your firm to be formal, neutral, or informal?
2.6 Does your RM approach have been standardised or non-standardised?

3. RM ownership
3.1 Who is ultimately responsible for risk management in your firm?
3.2 Is there any designated RM department or staff in your firm?
3.3 Do they work as an individual exercise or group exercise?
3.4 Who actually is in charge of the RM department?

4. Risk communication
4.1 How do you communicate and distribute risk information in your firm?
4.2 Do you use emails, meetings, phone calls, etc. to communicate?
4.3 How do you report the RM implementation status to the board/project director in your firm?

5. Risk-aware culture
5.1 Is RM embedded in your organisation's behaviour and practices?
5.2 Does your firm take any actions to raise the culture and awareness about RM?
5.3 Do you conduct any training courses, workshops, or conferences?

6. RM framework or process
6.1 What RM framework do you use (for example, ISO 31000)?
6.2 How do you identify risks? What are the tools?
6.3 How do you collect risks? What are the resources (for example, past projects, plans)?
6.4 What is the total number identified of risks in the project? Does the risk materialise? Any issues?
6.5 What are the critical risks?
6.6 Do you have a risk checklist or risk indicators in place to help identify risks?
6.7 Could you give any example about a risk in the project and how did you manage it?
6.8 Do you review and update the risk register weekly, monthly, or periodically?
6.9 How do you analyse risks? Do you use experience, techniques or software?

6.10 How are the risk response measures decided in your firm? Who decides it?
6.11 How does RM contribute to the decision making in your firm?
6.12 How do you review and monitor risks? Tools?
6.13 Do you use a set of key triggers for the critical risks to monitor risks?

Appendix 7 Interview questions for validation of the framework

Cover Letter

Dear participant,

This questionnaire represents the end of the research project into investigating risk management capability of construction firms in the Gulf Cooperation Council region. The aim of the framework is to enhance risk management implementation in construction projects. The purpose of writing to you is to give feedback on the information that you provided and ask your assistance in the validation of the framework. Please, evaluate the framework including the schematic diagram before completing the questionnaire. Please, provide more details on answering "yes" or "no" questions. Should any question arise do not hesitate to contact-me at any time.

Yours faithfully,
Ghadeer Alfandi

Section I: Trigger, Risk, and Issue Triangle

According to the Triangle shown below, answer the following questions, on a scale from 1→5, where 1 = very low and 5= very high.

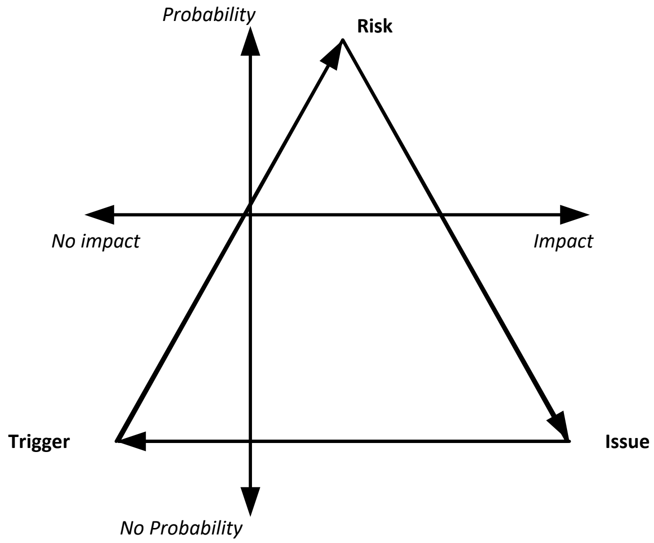

Figure 51 Triangle shows the relationship between *triggers* – *risks* and *issues*

Table 52 Differentiating criteria between the three events

Event(s)	Probability	Impact
Trigger	×	×
Risk	√	√
Issue	×	√

Table 2 validation questions

Validation criteria		Very low	Low	Medium	High	Very high
1	To what extent does using the Triangle improve your understanding about triggers, risks, and issues in construction projects?	1	2	3	4	5
2	To what extent the Triangle helped you to differentiate between the events (trigger, risk, and issue)?	1	2	3	4	5
3	To what extent the Triangle could help you to more understand the risk identification process in construction projects?	1	2	3	4	5
4	To what extent the Triangle easy to follow and implement?	1	2	3	4	5
5	To what extent the Triangle could improve the risk identification process?	1	2	3	4	5
6	How generally are you satisfied with the proposed approach the (Triangle)?	1	2	3	4	5

7	Do you think the proposed Triangle useful for risk management in construction projects?	1	2	3	4	5
8	Is there any tool or approach similar to this triangle in your company used to differentiate between triggers, risks, and issues? If yes, describe please.	☐ Yes			☐ No	

Section II: Probability-Impact Matrix

Probability (P) – Impact (I) Matrix is used to assess the relative importance of risks, and determine which risks need detailed risk response plans. In the proposed matrix below, the risk rating can be determined through the following equation:

(Probability x Impact) + (velocity of risk) = Risk rating

Value > 0.5 is considered risk;

Value < 0.5 is considered uncertainty

Probability										
		0.9		0.9		0.9		0.9		0.9
		0.7		0.7		0.7		0.7		0.7
5	5	0.5	10	0.5	15	0.5	20	0.5	25	0.5
		0.3		0.3		0.3		0.3		0.3
		0.1		0.1		0.1		0.1		0.1
		0.9		0.9		0.9		0.9		0.9
		0.7		0.7		0.7		0.7		0.7
4	4	0.5	8	0.5	12	0.5	16	0.5	20	0.5
		0.3		0.3		0.3		0.3		0.3
		0.1		0.1		0.1		0.1		0.1
		0.9		0.9		0.9		0.9		0.9
		0.7		0.7		0.7		0.7		0.7
3	3	0.5	6	0.5	9	0.5	12	0.5	15	0.5
		0.3		0.3		0.3		0.3		0.3
		0.1		0.1		0.1		0.1		0.1
		0.9		0.9		0.9		0.9		0.9
		0.7		0.7		0.7		0.7		0.7
2	2	0.5	4	0.5	6	0.5	8	0.5	10	0.5
		0.3		0.3		0.3		0.3		0.3
		0.1		0.1		0.1		0.1		0.1
		0.9		0.9		0.9		0.9		0.9
		0.7		0.7		0.7		0.7		0.7
1	1	0.5	2	0.5	3	0.5	4	0.5	5	0.5
		0.3		0.3		0.3		0.3		0.3
		0.1		0.1		0.1		0.1		0.1
	1		**2**		**3**		**4**		**5**	

Impact

Figure 52 The proposed (Probability-Impact-Velocity) matrix

Table 53 Scale of the velocity of risk

Scale of the velocity of risk		
Rating	*Description*	*Definition*
0.9	Very High	Very rapid onset, little or no warning, instantaneous, days
0.7	High	Onset occurs in a matter of days to a few weeks
0.5	Medium	Onset occurs in a matter of several months
0.3	Low	Onset occurs in a matter of one year
0.1	Very Low	Very slow onset, occurs over 3 years or more

According to the matrix shown above, answer the following:

1	Is there any tool or approach to assess the uncertainties in construction projects in your company? If yes, explain please.	☐ Yes		☐ No		
2	What is the current method used in your company to priorities the risks and uncertainties?	☐ Yes		☐ No		
		Very low	**Low**	**Medium**	**High**	**Very high**
3	Do you have similar of the proposed Matrix in your company?	1	2	3	4	5
4	Do you think the proposed Matrix could help you to more understand the risk assessment process in construction projects?	1	2	3	4	5
5	Do you think the proposed Matrix easy to follow and implement?	1	2	3	4	5
6	Do you think the Matrix could improve the risk assessment process?	1	2	3	4	5
7	How generally are you satisfied with the proposed Matrix?	1	2	3	4	5
8	Do you think the proposed Matrix useful for risk management in construction projects?	1	2	3	4	5

Section III: Risk management framework (According to the risk management framework shown below, answer the following, on a scale from 1→5, where 1 = very low and 5= very high**).**

	Validation criteria	**Very low**	**Low**	**Medium**	**High**	**Very high**
1	To what extent the model addresses the activities necessary for managing risks in construction projects in practice?	1	2	3	4	5
2	To what extent do you agree that the steps identified in the model can help in the management of risks in construction projects?	1	2	3	4	5
3	To what extent the steps and procedures comprising the present framework easy to follow and implement?	1	2	3	4	5
4	How generally satisfied are you with the proposed RM framework?	1	2	3	4	5
5	To what extent the proposed framework useful for RM?	1	2	3	4	5
6	To what extent do the inputs and outputs easy to understand?	1	2	3	4	5
7	To what extent are you willing to implement the proposed RM framework in your company?	1	2	3	4	5
8	To what extent are you capable to implement the proposed RM framework in your company?	1	2	3	4	5
9	To what extent do you think the present framework could enhance project performance in your company?	1	2	3	4	5
10	To what extent the risk identification process in the proposed framework differ from the one you use in your company?	1	2	3	4	5
11	To what extent the risk assessment process in the proposed framework differ from the one you use in your company?	1	2	3	4	5
12	To what extent the risk response process in the proposed framework differ from the one you use in your company?	1	2	3	4	5

13	To what extent does using the proposed framework improve your understanding of RM process in construction?	1	2	3	4	5
14	To what extent do you think the framework can improve the RM for construction project in the Gulf Cooperation Council countries?	1	2	3	4	5
15	To what extent do you think the proposed framework could improve the maturity of RM in your company?	1	2	3	4	5
16	Have your organisation been using a RM framework similar to the one presented to you?	☐ Yes			☐ No	

17 Do you have any suggestion, improvements, comment or recommendation?

Explain……………………………………………………………………………………………………
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Thank you very much for your co-operation. Your contribution will be added significantly to this research.

Appendix 8 Further studies on RM techniques and tools usage

Author (Year)	Study	Main techniques/tools identified
Hull (1990)	Benefits of risk analysis techniques	• Probability trees • Activity networks • Monte Carlo simulation
Simister (1994)	Usage of risk analysis techniques in the UK	• Catastrophe theory • Checklists • Controlled Interval and Memory (CIM) Modelling • Decision trees • Fuzzy set theory • Game theory • Influence diagrams • Monte Carlo simulation • Multiple criteria decision making models • Project Evaluation and Review Techniques (PERT) • Sensitivity analysis • Utility theory
Akintoye and MacLeod (1997)	Usage and Barriers for using the techniques of risk analysis and management in the UK	*Techniques* • Risk premium • Risk adjusted discount rate • Subjective probability • Decision analysis: • Algorithms • Mean end analysis • Bayesian theory • Decision trees • Sensitivity analysis • Monte Carlo simulation • Stochastic dominance • Caspar • Intuition/judgment/experience *Strategies for risk response* • Retention • Reduction • Transfer • Avoidance

Appendix 8 Usage and barriers for using RM techniques and tools – continuation

Author (Year)	Study	Main techniques/tools identified
Bajaj et al. (1997)	Usage and benefits of risk identification techniques in Australia	• Bottom-up approach • Financial statement method • Flow chart approach • Questionnaire • Check-list approach • Scenario building • Influence diagram • Top-down approach • Case based approach • Aggregate or bottom line approach
Tummala et al. (1997)	Use of risk assessment techniques	• No explicit allowance • Subjective or intuitive assessment • Sensitivity analysis • Risk discounted -cash flows • Hertz type simulation
Mok et al. (1997)	Techniques sued	• Monte Carlo simulation • Subjective/intuitive assessment • No explicit assessment • Sensitivity analysis
Shen (1997)	Project RM in Hong Kong	• Insufficient understanding and experience in RM techniques • Practitioners' experience and subjective judgement are the most used RM action
Chapman (1998)	Risk identification and assessment techniques	Risk identification • Brainstorming • Delphi technique • Nominal group technique

Appendix 8 Further studies on RM techniques and tools usage – continuation

Author (Year)	Study	Main techniques/tools identified
Baldry (1998)	The evaluation RM in public sector capital projects	• Risk register • Risk retention • Risk reduction • Risk transfer • Risk avoidance
Baker et al. (1999)	Risk response techniques in the UK	Risk response methods • Risk elimination • Risk transfer • Risk retention • Risk reduction
Raz and Michael (2001)	RM tools and techniques	• Periodic document reviews • Periodic trend reporting • Analysis of trends, deviations and exceptions • Risk probability assessment • Simulation • Checklists • Cost-benefit analysis • Cause and effect analysis • Periodic reporting of risk mitigation plans • Critical risk reporting to senior management • Contingency plans for risk mitigation failure
Wood and Ellis (2003)	RM services, tools, and techniques currently used by consultants in the UK	• Intuition/judgment/experience • Prompt lists • Checklists • Risk register • Monte Carlo simulation • Workshop
Lyons and Skitmore (2004)	the usage of RM techniques in Queensland/ Australia	Risk identification • Brainstorming • Case based approach • Checklists • Flow charts • HAZOP • Influence diagram • Questionnaires • Scenario building

Appendix 8 Further studies on RM techniques and tools usage – continuation

Author (Year)	Study	Main techniques/tools identified
continue Lyons and Skitmore (2004)		Risk analysis • Algorithms • Decision analysis • Decision trees • Expected monetary value • Intuition/judgment/experience • Monte Carlo simulation • Risk adjusted discount rate • Risk impact assessment • Risk premium • Sensitivity analysis • Subjective probability Risk response method • Risk elimination risk reduction • Risk retention • Risk transfer Risk response technique • Contingencies • Contractual transfer • insurance
Tang et al. (2007)	Application of RM techniques in Chinese construction industry	Risk identification • Checklists • Brainstorming • Consulting experts Risk analysis • Qualitative analysis • Semi-quantitative analysis • Quantitative analysis • Consulting experts • Joint evaluation by key participants • Use of computers and other modelling Risk response • Avoid the risk • Reduce the likelihood of occurrence • Reduce the consequences • Transfer the risk • Retain the risk Risk monitoring • Periodic document reviews • Periodic risk status reporting • Periodic trend reporting

Appendix 8 Further studies on RM techniques and tools usage – continuation

Author (Year)	Study	Main techniques/tools identified
Choudhry and Iqbal (2013)	Identification of current RM techniques in Pakistan	Risk identification • Consulting experts • Industry information • Checklists • Risk review meetings • Brainstorming Risk analysis • Qualitative • Semi-quantitative • Quantitative Risk response strategies • Avoid the risk • Transfer the risk completely • Reduce the likelihood of occurrence • Reduce the consequence • Risk sharing • Retain the risk completely Risk monitoring • Incident investigation • Risk audit/inspection
Goh et al., (2013)	To explore how a RM workshop can be effectively used in managing project risks;	• Workshop
Patterson and Neailey (2002)		• Risk register
Williams (1994)		• Risk register