ASSESSING RISK MANAGEMENT MATURITY: A FRAMEWORK FOR THE CONSTRUCTION COMPANIES

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ABSTRACT

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Due to its complex nature, risk and uncertainty are more widespread in construction industry than many other industries. Aiming to ensure that all project objectives are met, risk management is considered as a critical success factor for construction projects. The core elements of risk management are now known and used by many organizations. On the other hand, as declared by Project Management Institute (PMI), the ability to measure the effectiveness in managing risk is one of the most important areas that risk management needs to be developed in.

Designed to assess the capability of a project or an organization in a particular area, a maturity model aids in determining strengths and weaknesses, and to target improvement strategies accordingly. Several maturity models have been developed for the area of risk management and furthermore, an attempt to adapt a generic risk management maturity model to the construction industry was specified from the literature. All in all, when examined, it was seen that most of these models outline the topics to be investigated in a maturity assessment and provide guidance in terms of content. It was believed that a practical approach was needed and the diagnostic

characteristics of these models should be enhanced. Therefore, the aim of this study was to propose a construction risk management maturity framework, together with an easily applicable and effective questionnaire. To achieve this aim, six outstanding risk management maturity models were examined, and the proposed model was further supported with construction-specific attributes such as construction supply chain issues. The applicability of the model was tested through case studies conducted with five large scale Turkish construction companies. The results were evaluated and interpreted for each company and the gathered data were further investigated through statistical tests for certain comparisons. Finally, the questionnaire was revised with respect to the feedback received from the case studies.

Keywords: Construction Risk Management, Risk Management Maturity, Capability Maturity Model.

ÖZ

RİSK YÖNETİMİ OLGUNLUĞUNUN DEĞERLENDİRİLMESİ: İNŞAAT ŞİRKETLERİ İÇİN BİR MODEL ÖNERİSİ

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Barındırdığı kompleks süreçler ve ilişki ağından dolayı risk ve belirsizlik inşaat sektöründe diğer sektörlere göre daha yaygın olarak bulunmaktadır. Tüm proje hedeflerinin düzgün bir şekilde yerine getirilmesini hedefleyen risk yönetimi, inşaat projeleri için kritik başarı faktörleri arasında kabul edilmektedir. Günümüzde risk yönetiminin temel esasları inşaat firmaları tarafından bilinmekte ve kullanılmaktadır. Diğer taraftan, Project Management Institute (PMI) tarafından bildirildiği üzere, risk yönetimi verimliliğinin ölçülmesi kabiliyeti, risk yönetiminin geliştirilmesi gereken alanlarından birisidir.

Olgunluk modeli, bir projenin veya organizasyonun belirli bir alandaki kapasitesini değerlendirmek için tasarlanmıştır. Model, güçlü ve zayıf noktaların ortaya konulmasıyla gelişim için stratejilerin belirlenmesine yardımcı olur. Risk yönetimi alanında çok sayıda olgunluk modeli geliştirilmiştir. Literatür incelendiğinde, genel bir olgunluk modelinden inşaat sektörüne uyarlanan bir risk yönetimi olgunluk modeline de rastlanmaktadır. Fakat ele alındığında, bu modellerin birçoğunun olgunluk değerlendirmesi yapılırken üzerinde durulması gereken konuları özetlediği ve bu şekilde içerik açısından yol gösterdiği görülmüştür. Daha pratik bir yaklaşımla

bu modellerin ölçme kabiliyetinin artırılması gerektiğine inanılmaktadır. Bu çalışmada bir inşaat risk yönetimi olgunluk çerçevesi ve beraberinde, kullanım kolaylığı ve etkililik sağlayacak bir anket formu geliştirilmesi amaçlanmıştır. Bu amaç doğrultusunda, öne çıkan altı risk yönetimi olgunluk modeli incelenmiş, ve tasarlanan yeni model, tedarik zinciri gibi yapım sürecine özgü özellikler ile desteklenmiştir. Geliştirilen modelin kullanılabilirliği, beş büyük ölçekli Türk inşaat firmasıyla yürütülen örnek çalışmalar aracılığıyla test edilmiş ve sonuçlar herbir şirket için değerlendirilmiş ve yorumlanmıştır. Ayrıca toplanan veriler üzerinden belirli kıyaslamalar yapmak amacıyla istatistiksel metodlar kullanılmıştır. Son aşama olarak model, örnek çalışmalardan elde edilen geri bildirimler doğrultusunda revize edilmiştir.

Anahtar Kelimeler: İnşaat Risk Yönetimi, Risk Yönetimi Olgunluğu, Yetenek Olgunluk Modeli.

To my beloved family...

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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
CMM	Capability Maturity Model
CMMI	Capability Maturity Model Integration
CSCM	Construction Supply Chain Management
HSE	Health, Safety and Environment
ISO	International Organization for Standardization
LSD	Least Significant Difference
MSE	Mean Square Error
PMBoK	Project Management Body of Knowledge
PMI	Project Management Institute
RM	Risk Management
RMM	Risk Maturity Model by Hillson (1997)
RMMM	Risk Management Maturity Model by PMI (2002)
SEI	Software Engineering Institute
SPICE	Standardized Process Improvement for Construction Enterprises
SPSS	Statistical Package for the Social Sciences
SWOT	Strengths, Weaknesses, Opportunities and Threats

CHAPTER 1

INTRODUCTION

In this chapter are initially presented the argument for and objectives of the study. It continues with the procedure of the study, outlining the principal stages of the investigation. The chapter is concluded with a preview of the content embodied in the following chapters.

1.1 Argument

Currently, the construction sector is giving a high importance to the management activities of the construction projects throughout the world. When compared with other manufacturing industries, high fragmentation, low productivity, cost and time overruns, conflicts and disputes characterize the construction industry (Vrijhoef and Koskela, 2000; Love, Irani and Edwards, 2004). Risk and uncertainty are more widespread in the construction industry than many other industries. This is due to the nature of construction business activities, processes, environment and organization (Akintoye and MacLeod, 1997). From the beginning to the end, the construction process is complex and characterized by many uncertainties (Al-Bahar and Crandall, 1990). Therefore, as pointed out by several authors (Hayes, Perry, Thompson and Willmer, 1986; Flanagan and Norman, 1993; Raftery, 1994; Chapman and Ward, 1997), a risk-driven approach is a critical success factor for construction projects. Effective risk management brings about tighter margins and less contingency, making use of opportunities rather than rejecting works as too risky, as well as avoiding unforeseen disasters (Chapman and Ward, 1997).

Being one of the nine knowledge areas of project management, risk management is now an accepted discipline within organizations and individual projects, with its own language, techniques, procedures and tools (PMI, 2002). Risk management aims to

ensure that all activities are fulfilled in order to achieve the project objectives (Flanagan and Norman, 1993). The value of risk management is increasingly being recognized by companies as they are searching for improvement steps to become more competitive in the industry.

As claimed by PMI (2002), although the core elements of project risk management are known and used by many organizations, risk management needs to be developed in a number of areas to build on the foundation that currently exists. PMI (2002) declares the ability to measure the effectiveness in managing risk as one of the most important of these. According to Hillson (1997), an organization's current approach to risk, as well as a definition of the intended destination should be identified to define its goals, specify the process and manage progress. Therefore, as Hillson (1997) continues, an accepted framework is needed to assess the current level of maturity and capability objectively, and assist in defining progress towards increased capability. From this point, "maturity" concept is introduced to the organizations, which is a term started to be used to describe the state of an organization's effectiveness at performing certain tasks (Crawford, 2002). The maturity concept is utilized for benchmarking the current capability against best practices or against competitors, and by determining the strengths and weaknesses in a particular area, to devise improvement strategies.

To quote Ren and Yeo (2009), "Risk management capability maturity is vital to project and business performance." As Ren and Yeo (2009) continue, such efforts should be thoroughly undertaken by organizations for all projects and throughout the whole project lifecycle. Several risk management maturity models have been developed to serve for the assessment of organizational risk management capability, for various industries. An attempt was also distinguished from the literature to adapt a generic risk management maturity model to the construction industry. All in all, when the existing risk management maturity models were examined, it was observed that most of these models are in the form of a framework, indicating the topics to be investigated for a maturity assessment. It was believed that there was a need for a practical approach, in order to enhance the diagnostic characteristics of these models

by forming a questionnaire to serve for easy and effective usage. Furthermore, when the Turkish construction industry was considered, the applicability and comprehensibility of these models for the Turkish construction organizations were in question. Based on the previous work done in this area, it was to develop a construction risk management maturity framework together with its questionnaire, which is also applicable to the Turkish construction organizations that the investigation being reported on here was undertaken. To be noted here is that, this study does not aim to provide a generalized picture of the current risk management maturity of the Turkish construction industry. This can be undertaken as a further effort based on the work reported herein.

1.2 Aim and Objectives

The aim of this study was to propose a construction risk management maturity model, which is easily applicable and effective for the construction organizations, based on the previously developed risk management maturity models and related information. In order to achieve this aim, the following objectives were attempted to be accomplished:

- to provide a picture of the previously developed maturity models in the area of risk management and to determine their advantageous and disadvantageous aspects by comparing and evaluating them in terms of their usability and effectiveness,
- to investigate the components of a construction-specific risk management maturity model through literature review,
- to investigate the applicability of the proposed model via case studies from the Turkish construction industry and search for improvement steps.

1.3 Procedure

A literature review survey was carried out on maturity and risk management maturity models, and six risk management maturity models were identified as outstanding and devoted for further research. The reviewed models were compared and evaluated

with the main concerns of usability and effectiveness. As the next step, a construction risk management maturity model framework and questionnaire were proposed. In the development process, all of the six reviewed models were utilized, together with inferences drawn from their evaluation. In addition to that, construction-specific attributes, especially construction supply chain, were investigated from the literature in order not to overlook the unique characteristics of the industry and utilized in model development. Subsequently, the proposed questionnaire was administered to five construction companies as case studies via face-to-face interviews. The companies were selected among the 125 member companies of Turkish Contractors Association (TCA). The respondents belonged to top management or related management positions. Other than filling out the questionnaire, the commentaries of the respondents were also taken related with the model and related with the subject domain. This method of administration was also useful in terms of identifying unclear questions.

In the following step, the results of the questionnaire survey were evaluated and interpreted for each company. To facilitate certain comparisons of the gathered data and also to evaluate the capability of the questionnaire in identifying different maturity levels, two statistical analysis methods were utilized. The first method, namely Randomized Complete Block Design was applied to search the differences between the attribute scores and between the overall maturity scores of the companies. After this, a second test, namely Pearson correlation test was applied to check the relationship between the attributes. Results of the statistical tests were given together with inferences related with the companies and the model. Finally, the model was revised in light of the feedback received from the case study applications.

1.4 Disposition

This report is composed of five chapters, of which this Introduction is the first.

The second chapter covers the literature review on risk management, risk management processes, maturity, risk management maturity models and construction

supply chain, looking from the view of risk and risk management, and is finalized with a discussion on the inferences drawn from the literature review.

The third chapter is dedicated to the material and method of the study. As the material, first of all, the proposed construction risk management maturity model is presented. Afterwards, the case study organizations are introduced, with reasons to their selection process. In pursuit of defining the material of the study, the method of the study is given in the second section.

In the fourth chapter, is first given the results of the study, together with interpretations. Subsequently, statistical tests conducted on the gathered data are presented and discussed with respect to the companies and the model. Finally, revisions made on the model are explained along with the reasons prompted them.

In the final chapter are presented a brief outline of the study and the findings, bottlenecks of the study, and a discussion of how this study can be utilized for future research.

CHAPTER 2

LITERATURE REVIEW

This chapter is comprised of the issues searched from the literature, which are presented under four main sections. First section covers the definition of risk, risk management and related topics, and also explores risk management within the construction industry, its benefits and integration. In the second section are explained the processes of risk management, while the third section is dedicated to the maturity concept with an insight to maturity models and risk management maturity. Previously developed risk management maturity models are introduced. In pursuit of that, construction supply chain issues and supply chain maturity models are presented. The chapter is concluded with inferences drawn from the literature review, focusing on the comparison and evaluation of the reviewed risk management maturity models, to shed light on the research proposal.

2.1 Exploring the Concept of Risk and Risk Management

In this section, first of all, the issues of risk and uncertainty, risk sources and risk management are explained with various definitions. Following that, in pursuit of a succinct look to the history and research of risk management in construction, benefits of risk management are explored. Finally, the integration of risk management with other management functions is briefly described.

2.1.1 Risk and Uncertainty

Risk and uncertainty exist in all construction projects, regardless of its size (Hayes, *et al.*, 1986). In a similar vein, Chapman and Ward (1997) state that a non-risky project is not worth pursuing, to mention that all projects involve some degree of risk. The high degree of risk in construction is attributed to the nature of construction business

activities, processes, environment and organization (Akintoye and MacLeod, 1997). To quote Latham (1994), “Risks can be transferred, managed, minimized or shared, but cannot be ignored.”

According to Al-Bahar and Crandall (1990), no uniform or consistent usage of the word “risk” exists in the literature. As Al-Bahar and Crandall (1990) continue in their claim, most definitions are concerned with the downside of risk, indicating losses and damages, but the upside and opportunities such as profits or gains are often disregarded. Accordingly, risk definitions in literature show variety in a way that consequences of it are always negative, can be positive or negative, or neither is mentioned and the emphasis is on the project objectives being affected. Royal Society (1991) gives the definition of risk as “probability that an adverse event occurs during a stated period of time”. Al-Bahar and Crandall (1990) made the definition as “the exposure to the chance of occurrences of events adversely or favorably affecting project objectives as a consequence of uncertainty”. Another common definition of risk is given by Burtonshaw-Gunn (2009) as “the threat or possibility that an action or event will adversely or beneficially affect an organization’s ability to achieve its objectives”. Wharton (1992) claims that the word “risk” is simply describing any unintended or unexpected outcome, good or bad, of a decision or course of action. According to Loosemore, Raftery, Reilly and Higgon (2006), risk is a complex phenomenon that has physical, monetary, cultural and social dimensions and is defined as being concerned with the unpredictable events that might occur in the future whose exact likelihood and outcome is uncertain but could potentially affect the interests and objectives of an organization in some way.

To continue from here, project risks have an impact on one or more of the project objectives. While several authors (Akintoye and McLeod, 1997; Smith, Merna and Jobling, 2006; Burtonshaw-Gunn, 2009) give cost, time and quality for the affected project objectives, Mills (2001) adds productivity and performance as subject to risk and uncertainty in construction projects.

While the terms risk and uncertainty can be used interchangeably, as Merna and Al-Thani (2005) make it clear, their meanings differ in a way that risk refers to statistically predictable occurrences whereas uncertainty refers to an unknown of generally unpredictable variability. If a decision-maker can assess, either intuitively or rationally, the probability of a particular event occurring, then that decision is made under risk (Flanagan and Norman, 1993). To outline the relationship between risk and uncertainty, Raftery (1994) developed a "risk-uncertainty continuum" as in Table 2.1.

Table 2.1. Risk-uncertainty continuum (Source: Merna and Al-Thani, 2005)

RISK		UNCERTAINTY
Quantifiable	→	Non-quantifiable
Statistical Assessment	→	Subjective Probability
Hard Data	→	Informed Opinion

As Flanagan and Norman (1993) claim, if there is no historic data or previous history related to the situation being considered by the decision-maker, then there is uncertainty. As Flanagan and Norman (1993) continue in their claim, the term risk is more relevant for the construction industry than the term uncertainty, as there is always some information to be based on, and by using that information, a company has to convert the uncertainty to risk.

According to Allen (1995), risk is composed of four essential parameters. These are probability of occurrence, severity of impact, susceptibility to change and degree of interdependency with other factors of risks. According to Loosemore, *et al*. (2006), there are risk events and their potential impacts and consequences. Similarly, Kerzner (2005) states that a risk is noted by having a cause and if it occurs, it has a consequence. According to Loosemore, *et al*. (2006), the probability and consequence terms are used to express and assess risks, and this can be given as:
Risk = Probability of event x Magnitude of loss/gain.

2.1.2 Sources of Risk

An organization must examine many sources of risk before a decision is made. The sources of risk occur at different times over an investment (Merna and Al-Thani, 2005). An extensive list of risk sources produced by Merna and Smith (1996) and reproduced by Merna and Al-Thani (2005) is given in Table 2.2, as being a comprehensive outline.

Table 2.2 Typical sources of risk to business from projects (Source: Merna and Al-Thani, 2005)

Heading	Change and uncertainty in or due to:
Political	Government policy, public opinion, change in ideology, dogma, legislation, disorder (war, terrorism, riots)
Environmental	Contaminated land or pollution liability, nuisance (*e.g.* noise), permissions, public opinion, internal/corporate policy, environmental law or regulations or practice or 'impact' requirements
Planning	Permission requirements, policy and practice, land use, socio-economic impacts, public opinion
Market	Demand (forecasts), competition, obsolescence, customer satisfaction, fashion
Economic	Treasury policy, taxation, cost inflation, interest rates, exchange rates
Financial	Bankruptcy, margins, insurance, risk share
Natural	Unforeseen ground conditions, weather, earthquake, fire or explosion, archaeological discovery
Project	Definition, procurement strategy, performance requirements, standards, leadership, organization (maturity, commitment, competence and experience), planning and quality control, program, labor and resources, communications and culture
Technical	Design adequacy, operational efficiency, reliability
Regulatory	Changes by regulator
Human	Error, incompetence, ignorance, tiredness, communication ability, culture, work in the dark or at night
Criminal	Lack of security, vandalism, theft, fraud, corruption
Safety	Regulations (*e.g.* CDM, Health and Safety at Work), hazardous substances (COSSH), collisions, collapse, flooding, fire and explosion
Legal	Those associated with changes in legislation, both in the UK and from EU directives

The relationship between the source of risk, risk event and its effect is shown by Flanagan and Norman (1993) as in Figure 2.1.

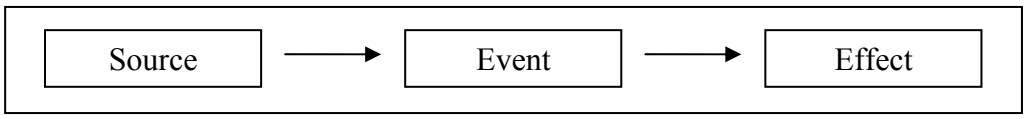

Figure 2.1. Source-event-effect relationship for risk **(**Flanagan and Norman, 1993)

Typical **risk sources on a construction project** are quoted from Flanagan and Norman (1993) as follows:

- Failure to complete within the stipulated design and construction time
- Failure to obtain the expected outline planning, detailed planning or building code/regulation approvals within the time allowed in the design program
- Unforeseen adverse ground conditions delaying the project
- Exceptionally inclement weather delaying the project
- Strike by the labor force
- Unexpected price rises for labor and materials
- Failure to let to a tenant upon completion
- An accident to an operative on site causing physical injury
- Latent defects occurring in the structure through poor workmanship
- Force majeure (flood, earthquake, *etc.*)
- A claim from the contractor for loss and expense caused by the late production of design details by the design team
- Failure to complete the project within the client's budget allowance.

The effects of risks are quoted from Flanagan and Norman (1993) as:

- Failure to keep within the cost budget/forecast/estimate/tender
- Failure to keep within the time stipulated for the approvals, design, construction and occupancy
- Failure to meet the required technical standards for quality, function, fitness for purpose, safety and environment preservation.

2.1.3 Risk Management

Risk management is designated as one of the nine knowledge areas of Project Management Body of Knowledge (PMBoK) by PMI. As claimed by several authors (Akintoye and McLeod, 1997; Raz and Michael, 2001; Burtonshaw-Gunn, 2009), risk management is a continuous activity and covers the whole project life cycle, from inception through its planning, execution, control, up to its closure. Systematic risk management aims the project to be completed on time, within budget, to the required quality and with proper provision for safety and environmental issues (Mills, 2001). As Merna and Al-Thani (2005) claim, throughout the life of a project, risk management aims to obtain the optimum or acceptable degree of risk elimination or control.

According to Merna and Smith (1996), risk management can be defined as any set of actions taken by individuals or corporations in an effort to alter the risk arising from their business. PMI (1996) defines project risk management as the systematic process of identifying, analyzing and responding to project risk. Similarly, Crawford (2002) claims that risk management aims to identify, analyze, respond and control risk factors throughout the life of a project. Dikmen, Birgönül, Anaç, Tah and Aouad (2008) define risk management as a four-step procedure composed of: risk identification; in which the sources of uncertainty are defined, risk analysis; in which the consequences of uncertain events/conditions are evaluated, risk response; in which appropriate strategies according to the expected outcomes are set forth, and finally, repeating the steps continuously throughout the life cycle of a project in consideration of the feedback received on actual outcomes and risks emerged, to achieve the project objectives.

According to Flanagan and Norman (1993), risk management should involve common sense, analysis, judgment, intuition, experience, gut feel and willingness to operate a disciplined approach. As claimed by Merna and Al-Thani (2005), overcoming risks often have a positive impact if managed in the correct way;

therefore risk management should consider the opportunities (possible gains) as well as the threats (possible losses).

2.1.4 Risk Management in Construction

Risk has become an issue of business literature during the last two decades of the twentieth century (Loosemore, *et al*., 2006). As Flanagan and Norman (1993) argue, risk management in construction has perhaps a greater significance at 1990s than any other time since the 1970s. As Flanagan and Norman (1993) continue, this is because of the increased integration between financial and real sectors of the economy and major capital commitments in the building industry. According to Merna and Al-Thani (2005), for forward-thinking companies, risk management has become an important issue by the increasing pace of change, customer demands and market globalization. As Merna and Al-Thani (2005) further state, the failure of projects to meet their budgets, completion dates, quality and performance or generate sufficient revenues to service the principal and interest payments generated the need for risk management. The activities of many industries like construction have come into question, putting forward new challenges for managers (Loosemore, *et al*., 2006). As further claimed by Loosemore, *et al*. (2006), while traditionally companies were relying on insurance as a mechanism for managing their risks, recently, more and more firms are realizing that risk management cannot be done solely by passing it on to insurance and finance companies. Risk management is now a basic necessity for every organization.

To quote Flanagan and Norman (1993), "Construction projects have a large number of risks, contractors cope with it and owners pay for it." To continue with Flanagan and Norman (1993), the complex nature of construction industry comes from the time-consuming design and production processes that a construction project possesses. The process of taking a project from the initial investment appraisal to completion requires a wide range of people with different skills and interests, and quite different but interrelated activities. The external, uncontrollable factors are into

the bargain. In spite of all these, managerial techniques used to identify, analyze and respond to risk have been applied in the industry only during the last decade.

In a similar vein, Mills (2001) points out the very poor reputation for managing risk in the construction industry, although it is one of the most dynamic, risky and challenging businesses. As claimed by several authors (Tah, 2005; Kumar and Viswanadham, 2007), a high level of coordination is needed among various stakeholders who have conflicting interests. As claimed by O'Brien (1999), construction process has a fragmented nature, often associated with poor productivity. Deadlines and cost targets are failed to be met by many major projects (Mills, 2001). Smith, *et al.*, (2006) extends this argument with quality, as another frequently missed target in construction projects. According to Al-Bahar and Crandall (1990), the contractors develop rules of thumb based on experience and judgment to deal with risk. Ignorance of risks or simply adding a 10 percent contingency onto the estimated project cost is common (Mills, 2001).

In terms of risk management research, four main areas can be identified from the literature that risk management studies are concentrated on (Dikmen, Birgönül and Arıkan, 2004).

(1) Development of conceptual frameworks and process model for systematic risk management,

(2) Investigation of risks, risk management trends and perceptions,

(3) Application of risk identification and analysis techniques in specific projects, and

(4) Development of risk management support tools.

The studies related with development of risk management maturity models can be categorized in the first group, on which detailed review is given in Section 2.3.

2.1.5 Why Risk Management is Important?

To quote Ren and Yeo (2004), "There is clearly an intimate link between effective risk management and the success of projects, since risks are measured by their potential impact on achievement of project objectives." In a similar vein, according to Loosemore, *et al*. (2006), rather than avoiding risks, it is important to take calculated risks by recognizing and managing them effectively. As Loosemore, *et al*. (2006) further continue, the more confident a company is in its risk management systems, the more likely it is able to turn these risks into opportunities to make profit.

According to several authors (Kerzner, 2000; Chapman and Ward, 2003), in ensuring successful project management, the single most important factor or function is managing risk. As claimed by Ren and Yeo (2009), the chances of meeting or even surpassing the predefined project objectives are increased by means of a comprehensive approach to dealing with risk. Chapman and Ward (2003) argue that organizations which have an established risk management capability as a process, obtain an important advantage over competitors.

There are several sources in the literature that iterate benefits of risk management. A major one is presented in Table 2.3, which is adapted from Newland (1992) and Simister (1994) by Merna and Al-Thani (2005), categorizing the potential benefits of risk management in two types: hard benefits and soft benefits. Loosemore, *et al*. (2006) list important benefits provided by effective risk management as: a better basis for decision-making at strategic, tactical and operational levels, better corporate reporting, better use of human resource expertise, increased engagement with stakeholders, less adverse publicity, a better basis for negotiations, reduced finance costs, increased reliability and quality of services and products, lessons and feedback to improve future business activities, reduced claims and legal costs, better change management, enhanced morale, reduced levels of conflict and stress, and enhanced competitive advantage. Another important benefit of risk management is given by Merna and Al-Thani (2005), as it helps to make the stakeholders aware of the risks, both negative and positive, and to manage them effectively. Burtonshaw-Gunn

(2009) looks through the consequences of ignoring risks and risk management tools, and claims that it will cause adverse effects on projects, such as cost overruns, schedule delays and inability to achieve desired project technical objectives. Other important consequences are iterated as: project de-scoping, loss of credibility, project cancellation and unhappy clients, personal or organizational liability and fines.

Table 2.3. The hard and soft benefits of risk management
(Source: Merna and Al-Thani, 2005)

Hard benefits	**Soft benefits**
- Enables better informed and more believable plans, schedules and budgets - Increases the likelihood of a project adhering to its plans - Leads to use of the most suitable type of contract - Allows a more meaningful assessment of contingencies - Discourages the acceptance of financially unsound projects - Contributes to the build up of statistical information to assist in better management of future projects - Enables a more objective comparison of alternatives - Identifies, and allocates responsibility to, the best risk owner	- Improves corporate experience and general communication - Leads to a common understanding and improved team spirit - Assists in the distinction between good luck/good management and bad luck/bad management - Helps develop the ability to staff to assess risks - Focuses project management attention on the real and most important issues - Facilitates greater risk taking thus increasing the benefits gained - Demonstrates a responsible approach to customers - Provides a fresh view of the personnel issues in a project

2.1.6 Risk Management Integration

Risk management processes interact with each other and also with the processes in the other project management knowledge areas as well (PMI, 2004). As PMI (2004) continues, poor project management activities and lack of integrated management systems contribute to project risk. As also claimed by Heldman (2005), there is a high integration between risk management and other project management processes. In a similar vein, Ren and Yeo (2009) claim that all other project management knowledge areas such as cost, time, quality, scope, resources (human and procurement), communication and integration are covered by risk management. As

Ren and Yeo (2009) further insist in their claim, business objectives of value creation and profitability are also among the objectives of risk management, as well as project or system level objectives, and issues of safety, health and environment. Integration of risk management with other project management functions is demonstrated by Burtonshaw-Gunn as in Figure 2.2, which was reproduced from PMI (1992).

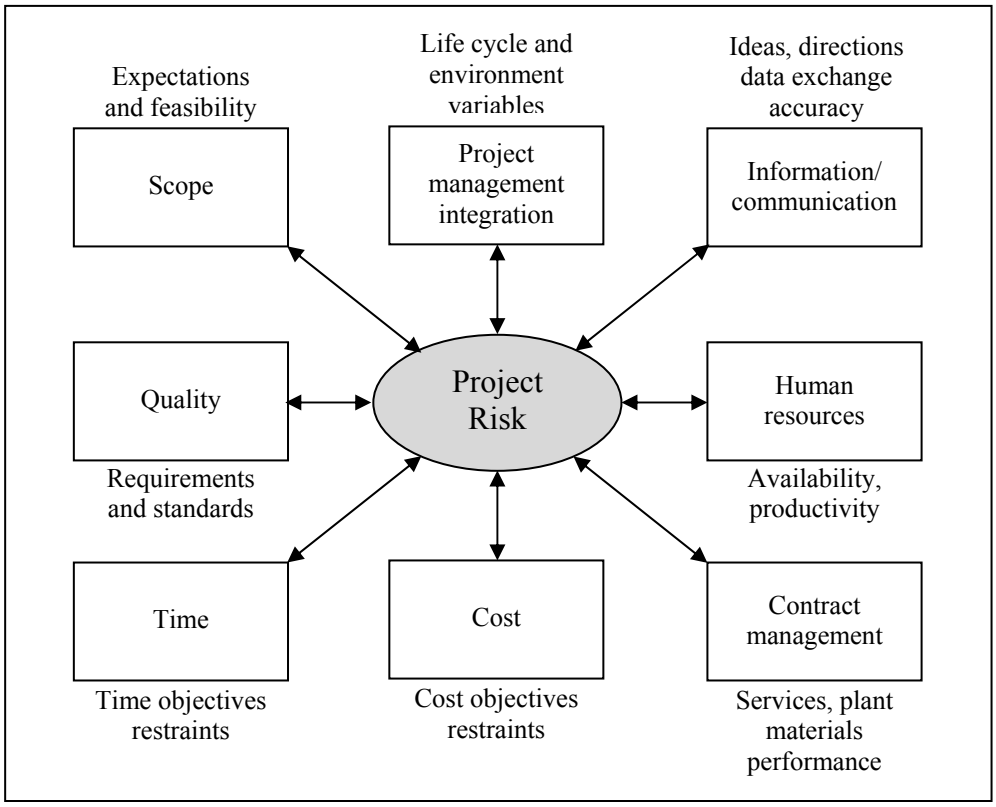

Figure 2.2. Integrating risk management with other project management functions (Source: Burtonshaw-Gunn, 2009)

As claimed by Burtonshaw-Gunn (2009), risk management has an impact on many facets of the project. According to the traditional view, risk management is a part of project management and realized by the project manager and delegated team member. An alternative view is risk-driven project management, since there is no need for project management if there are no risks in a project. Accordingly, all aspects of the project should be considered in risk management and whole project life cycle should be covered.

2.2 Risk Management Processes

Various classifications of risk management processes exist in the literature. According to Raz and Michael (2001), these variations depend on the level of detail and assignment of activities to steps and phases, but the content of the whole cycle does not change. A diagram outlining the continuous steps of risk management is given in Figure 2.3.

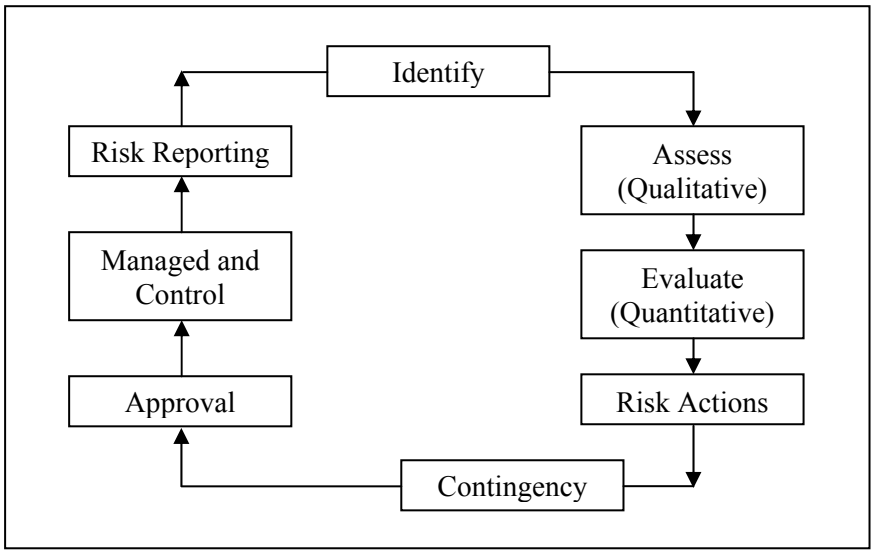

Figure 2.3. Risk management steps (Source: Burtonshaw-Gunn, 2009)

With a similar approach, Smith (1995) defines three processes for risk management as risk identification, analysis and response. According to Merna and Al-Thani (2005), risk management has a continuous cycle of identification, analysis, control and reporting of risks. Chapman and Ward (1997) have another point of view and claim that there are eight phases in the risk management process; namely define, focus, identify, structure, ownership, estimate, evaluate and plan. While the first edition of PMBoK (PMI, 1996) defines four main processes for risk management as risk identification, risk quantification, risk response development and risk response control, the third edition (PMI, 2004) has extended the groupings as risk management planning, risk identification, qualitative risk analysis, quantitative risk analysis, risk

response planning, and risk monitoring and control. Burtonshaw-Gunn (2009) claims that all descriptions follow a similar basic approach of risk identification, risk quantification, risk response and risk control. Crawford (2002)'s classification is utilized for this study, which defines a fifth component in addition to this classification, as risk documentation.

2.2.1 Risk Identification

Risk identification includes determining the risks that might affect the project and documenting their characteristics (PMI, 2004). Al-Bahar and Crandall (1990) attach this process considerable importance since processes of risk analysis and response management are conducted on identified potential risks. As Flanagan and Norman (1993) claim, after being identified and defined, a risk becomes a management problem. As Flanagan and Norman (1993) continue in their claim, risk identification involves the determination of the source and type of risks.

Tools and techniques used in risk identification process were gathered from PMI (2004), Al-Bahar and Crandall (1990), Smith, *et al*. (2006) and Burtonshaw-Gunn (2009) as: Documentation reviews, information gathering techniques (*e.g.* brainstorming sessions, Delphi technique, interviewing, SWOT analysis), analysis of historical data for similar projects, use of checklists, diagramming techniques (*e.g.* influence diagrams), risk mapping and probability-impact matrices. As claimed by PMI (2004), the output of risk identification is a risk register. As defined by Smith, *et al*. (2006), a risk register is composed of documents, spreadsheets or database systems that list the risks in a defined project and their associated attributes, and also contains assessments of the potential impacts of risks on the project. List of potential responses may also be defined in the risk register (PMI, 2004). According to Crawford (2002), the main products of risk identification are potential risk events and risk triggers.

2.2.2 Risk Quantification

Risk quantification process is defined by PMI (1996) as evaluating risks and risk interactions to assess the range of possible outcomes in order to determine which risk events warrant response. As claimed by Smith, *et al*. (2006), there are a number of techniques used for this process, and the appropriate technique should be chosen according to the type and size of project, the information available, the cost of analysis, time available and experience of the analysts. There are mainly two types of methods used for this process: qualitative and quantitative risk analysis.

In **qualitative risk analysis**, identified risks are prioritized in terms of their likelihood and impact on the project objectives (Burtonshaw-Gunn, 2009). It lays the foundation for quantitative risk analysis and risk response planning (PMI, 2004). With these characteristics, it is featured as the most useful part of the risk management process by Smith, *et al*. (2006). Tools and techniques for qualitative risk analysis include probability and impact matrices (Dallas, 2006). Inputs for this phase are a risk register, data about risks on past projects and the lessons learned, whereas the output is an updated risk register (PMI, 2004).

On the other hand, by the use of analytical techniques, **quantitative risk analysis** involves evaluation of the consequences associated with the type of risk, or combination of risks and assessing the impact of them by using various risk measurement techniques (Flanagan and Norman, 1993). Risk analysis is conducted by the use of computer models employing statistical data (Merna and Al-Thani, 2005). Tools and techniques utilized for quantitative risk analysis are sensitivity analysis, expected monetary value analysis, decision trees and, modeling and simulation such as Monte Carlo (PMI, 2004).

2.2.3 Risk Response Development

According to Merna and Al-Thani (2005), developing responses to threats and searching of enhancement steps for opportunities fall into the process of risk

response. As Flanagan and Norman (1993) claim, risk response development depends on how the risks should be managed, either by transferring it to another party or retaining it. Flanagan and Norman (1993) further continue that the risk attitude of the person or organization is effective in this phase. As claimed by several authors (Flanagan and Norman, 1993; Loosemore, *et al.*, 2006), responses may belong to categories of: risk avoidance, risk reduction, risk transfer and risk retention. Outputs of risk response development process are given by Merna and Al-Thani (2005) as: identified owners for each significant risk and suitable risk response options, the alternative strategies for dealing with the significant risks, the strategy/strategies chosen for implementation in each case and allocation of risk among project parties. PMI (2004) generalizes the outputs of this phase as an updated risk register, corrective actions and a risk management plan.

2.2.4 Risk Monitoring and Control

As claimed by several authors (PMI, 2004; Burtonshaw-Gunn, 2009), this process involves keeping track of the identified risks, monitoring the residual risks and identifying new risks, as well as reviewing the execution of risk responses and evaluating their effectiveness. According to Crawford (2002), taking corrective action also falls within the scope of risk control. As Crawford (2002) further argues, this process is carried out in accordance with the risk management plan and established procedures. Among the main products of this process are updates to risk register, corrective actions and updates to the risk management plan (PMI, 2004).

2.2.5 Risk Documentation

According to at least one author (Crawford, 2002), risk documentation aims to establish a project database to collect historical information on the risks encountered and related experiences. As well as the historical database, post project assessment is provided with this component. As Merna and Al-Thani (2005) claim, as the input, risk management makes use of the lessons learned from each failed project. Dikmen,

et al. (2008) pointed out the importance of a corporate risk memory for an effective risk management system, to provide experience-based solutions in managing risks.

2.3 Maturity Concept: Background, Maturity in Relation to Construction and Risk Management

In this section, "maturity" concept is introduced. Explanations are given for the use of a maturity model, together with an insight to Software Engineering Institute's Capability Maturity Model (CMM). Characteristics of immature and mature organizations are defined. Maturity research in construction industry and risk-maturity relationship are discussed. Finally, six identified risk management maturity models are presented in detail, which were used as a basis for this study.

2.3.1 Description of the Term "Maturity"

Maturity means fully developed or perfected, in general usage (Cooke-Davis, 2005). Andersen and Jessen (2003) claim that if the concept of maturity is adapted to an organization, then it might denote an organization being in a perfect state of condition to achieve its objectives. According to Crawford (2002), today this maturity concept is being utilized increasingly to map out logical ways to improve an organization's services. It is used in "Best Practice" benchmarks, indicating increasing levels of sophistication and other features (PMI, 2002). Maturity refers to the degree that an organization consistently carries out processes that are documented, managed, measured, controlled and continually improved (CMMI Product Team, 2002). As claimed by Andersen and Jessen (2003), maturity can best be described for the business community through a combination of three different dimensions: action (ability to act and decide), attitude (willingness to be involved) and knowledge (understanding of the impact of willingness and action).

2.3.2 The Need for Maturity Research

The purpose of benchmarking is to assess current capability, diagnosing strengths and weaknesses critical to process and performance improvement, and identifying gaps where improvement is required, within a particular domain (Hillson, 2003; Ren and Yeo, 2009). As claimed by several authors (Hillson, 2001; Foti, 2002), by means of the assessment framework, an organization becomes able to compare its project delivery with best practice or against its competitors. After an objective assessment, process improvement strategies can be defined (Hillson, 2001; Crawford, 2002; Foti, 2002; Ren and Yeo, 2009). To follow a logical and realistic route in order to reach higher standards, an organization should aim at achieving objectives at the next highest level (Hopkinson, 2000). By repeating the assessment over a period of time, comparisons can be made to prior assessments, impact of the changes made can be identified and future improvements can be guided (Ibbs and Kwak, 2000).

Being the most famous and most widely accepted maturity model, **Capability Maturity Model (CMM)** is explained herein to lay the foundation for the subsequently developed models. CMM was developed by the Software Engineering Institute (SEI) at Carnegie-Mellon University, with an extensive, government-funded research into how to evolve and measure an organization's effectiveness at developing software (SEI, 2009). As Kerzner (2005) claims, the tool aims to provide a structured and objective means for measuring a software organization's development processes and comparing these measures against optimum practices. Kerzner (2005) further continues that to become more competitive in the industry, CMM helped software developers identify specific improvements. To paraphrase Hillson (1997), the model defines five levels of increasing capability and maturity, termed Initial (Level 1), Repeatable (Level 2), Defined (Level 3), Managed (Level 4) and Optimizing (Level 5).

As Crawford (2002) argues, the CMM has gained widespread acceptance, and it has become a standard for process modeling and assessing an organization's maturity in several process areas. Similarly, Kerzner (2005) states that project management

measures and standards have been applied to CMM to utilize it in other industries. But as Hillson (1997) claims, CMM's application is limited to organizations involved in software development processes and attempts to broaden the scope of the model to other types of project have not gained widespread currency. According to Hillson (1997), as being the most common maturity model, there has been an attempt to modify the CMM to apply to risk, but it was for software development organizations and was not further developed. Hillson (1997) further argues that CMM is a general model of capability, maturity and business excellence, but it does not provide specific assistance for risk management. According to PMI (2002), although the superseded version of CMM, Capability Maturity Model Integration (CMMI), is becoming well established, its application is limited by its overall invasiveness. As PMI (2002) further argues, to fully apply the CMMI model (which contains a risk management maturity model) requires significant amounts of resources and integration within the overall Systems Engineering process.

According to Cooke-Davis (2005), capability maturity models are composed of process areas and capability levels, and by assessing the capability level of each process area separately, the overall maturity level of an organization is attained at the end. Andersen and Jessen (2003) define the maturity concept with the notion of a ladder of stages, and express that certain steps or stages assist maturity. As claimed by Hopkinson (2000), the levels of a maturity model are designed to aid assessment and set objectives. For a process to mature, it should develop from being unstable to stable and by that means, gain improved capability (Cooke-Davis, 2005).

Cooke-Davis (2004) mentions the growing number of maturity models that assist for the assessment of organizational maturity. Ren and Yeo (2004) argue that maturity models have been proposed for many activities like: quality management, software development, supplier relationships, research and development (R&D) effectiveness, product development, innovation, product design, product development collaboration and product reliability. Other application areas were specified through a literature review as: information technology and management, supply chain management, knowledge management, enterprise resource planning, people capability, earned

value management, e-government services, business continuity, e-learning and change management.

2.3.3 Characteristics of Immature and Mature Organizations

As claimed by various authors (Paulk, Weber, Curtis and Chrissis, 1995; Zahran, 1998), setting sensible goals for process improvement requires an understanding of the difference between immature and mature organizations. Such differentiation is necessary to identify reasonable targets for process improvement (Sarshar, Haigh, Finnemore, Aouad, Barrett, Baldry and Sexton, 2000).

In an immature construction organization, construction processes are not definite and are formed by practitioners and project managers during project execution (Sarshar, *et al.*, 2000). As Humphrey (1989) claims, even immature organizations may sometimes conduct projects with excellent results, but it is generally a result of the heroic efforts of a dedicated team rather than repeating systematic and proven methods of a mature organization. Sarshar, *et al.* (2000) state that there is no objective basis for judging product quality or for solving product and process problems in immature construction organizations. As Sarshar, *et al.* (2000) continue in their claim, the organization is reactionary, dealing with the problems as they emerge.

On the other hand, as Sarshar, *et al.* (2000) argue, mature organizations have planned processes which are accurately communicated to the employees, and design, construction and maintenance activities are managed by means of an organization-wide ability along with a supportive organizational culture. As Sarshar, *et al.* (2000) continue in their argument, roles and responsibilities are defined and clear for projects and organization, and product quality and client satisfaction are monitored.

2.3.4 Maturity Research in Construction Industry

The lack of project predictability and under achievement of the UK construction industry were the major concerns of various studies and reports (Latham, 1994; Love and Li, 1998; Egan, 1998; Santos and Powell, 2001; Koskela, Ballard and Howell, 2003). In the mid 1990s, there was a call for more systematic and industry-wide efforts to increase productivity and improve quality in the UK construction industry, with the reports by Latham (1994) and Egan (1998). It was suggested that to overcome the performance related problems, lessons should be learned from other industries and capabilities should be developed to successfully execute business processes. With these reports, the industry was urged to focus in particular on construction processes (Sarshar, *et al.*, 2000). As mentioned by several authors (Hobday, 1998; Brady, Davies and Hobday, 2003), developing organizational capabilities is a vital issue for achieving competitive advantage of construction industry or organizations.

In response to such calls from the industry's critics, there was an attempt to apply the maturity concept to construction organizations through a research project titled SPICE (Standardized Process Improvement for Construction Enterprises), conducted at Salford University, beginning in 1998. The argument is given by Sarshar, *et al.* (2000) as that the construction organizations has no methodological mechanism to systematically assess the construction process, prioritize process improvements, direct resources accordingly, and benchmark their performance relative to other organizations. The objective of SPICE was to investigate how CMM's basic concepts and framework can be applied to the construction industry and by that means, tailor the successful CMM from software industry to a construction-specific model to create an evolutionary framework for process improvement and also an assessment tool for organizational maturity (Sarshar, Finnemore, Haigh and Goulding, 1999). As Sarshar, *et al.* (1999) continue, research findings reveal that the basic process concepts of CMM are generic and applicable to the construction industry, but the major concern was related with complex supply chain arrangements in construction projects. It was concluded that the framework must address the project supply chain

for adaption to the construction industry. The model utilizes five maturity levels and a number of processes associated with each level. Also, process enablers (*i.e.* commitment, ability, verification, evaluation and activities) are developed to aid for the assessment procedure and ensure that the processes are properly performed.

Fengyong and Renhui (2007) applied the generic principles of the Project Management Maturity Model (PM3) developed by Remy (1997) to the construction industry and developed a Construction Project Management Maturity Model (CPM3), which aims to assess construction project management maturity and aid improvement. In a similar vein, Guangshe, Li, Jianguo, Shuisen and Jin (2008) investigated the applicability of Organizational Project Management Maturity Model (OPM3), developed by PMI (2003), to construction industry in China. The findings of the study reveal that it is not appropriate to directly apply the OPM3 to the construction projects and barriers were identified against the application. In the area of risk management, an attempt to adapt a generic risk management maturity framework to construction was taken by Loosemore, *et al.* (2006), which is explained in detail in Section 2.3.6, as Model 6.

2.3.5 Risk-Maturity Relationship

According to Loosemore, *et al.* (2006), the sophistication of an organization's understanding of its risk portfolio, its knowledge of how to mitigate those risks and the extent of its internal business continuity systems needed to cope with and recover from risk events reflect the risk management maturity of an organization. Loosemore, *et al.* (2006) examined risk-immature organizations and argue that risk-immature organizations tend to have task-oriented cultures; their focus is on profits over people and other corporate goals. They are reluctant to re-examine their existing organizational practices and to learn lessons for the future. They rely on their company size and past successes to provide protection from future risks and insulate themselves from the uncertainty of the environment.

On the other hand, as claimed by several authors (Ginn, 1989; Lerbinger, 1997; Pearson, Misra, Clair and Mitroff, 1997), typically risk-mature organizations have a culture of openness, awareness and sensitivity to organizational risks and of their social and financial responsibilities to stakeholders, to the general public and wider environment. In a similar vein, Loosemore, *et al*. (2006) claim that risk-mature organizations attach importance to effective communication systems and encourage collective responsibility for the management of the interdependent risks between everyone involved in their supply chains. According to More (1995), such organizations incorporate proactive risk management into strategic planning processes and it is an integral and instinctive aspect of organizational life at all levels. Loosemore, *et al*. (2006) state that large organizations tend to have a permanent risk management team responsible of creating a comprehensive risk management plan and to continuously communicate, coordinate and review risk management efforts.

2.3.6 Risk Management Maturity Models

According to Hopkinson (2000), by using a risk-based approach, value can be added to a company's operations by improving its performance and enhancing its own future. To quote Hillson (1997), "In order to define the goals, specify the process and manage progress, it is necessary to have a clear view of the enterprise's current approach to risk, as well as a definition of the intended destination." Hillson (1997) further insists that a generally accepted framework is needed for an organization in order to benchmark its current maturity and capability in managing risk, and this framework should also assist in defining progress towards increased maturity. Being an assessment tool, a risk maturity model is designed to measure risk management capability and to provide objectives for improvement (Hopkinson, 2000).

Several tools have been designed for diagnosing risk management maturity of a project or an organization. To be further examined in this study, six outstanding risk management maturity models were identified. These models are described in detail in the following sub-sections.

a. Model 1: Risk Maturity Model

Hillson (1997)'s Risk Maturity Model (RMM) is the first notable attempt to develop a framework for a risk maturity model. It serves as a foundation for many of the subsequent maturity models such as RMMM, RMMM Adapted to the Construction Industry, IACCM Business Risk Management Maturity Model and Risk Management Capability Maturity Model for Complex Product Systems Projects.

According to Hillson (1997), RMM serves for the organizations wishing to implement a formal approach to risk management or to improve their existing approach. The main aim of the model is to provide a framework against which current risk management practice can be benchmarked. The benchmarking is done in terms of maturity. The model assists organizations to assess their current level of risk management capability maturity, identify targets for improvement, and to devise strategies for developing or enhancing their risk management capability maturity level. It also suggests strategies to move to the next level of maturity. The RMM has four levels of capability maturity, each linked to specific attributes. These are: **Level 1**: Naive, **Level 2**: Novice, **Level 3**: Normalised and **Level 4**: Natural. Each RMM level is briefly described in Table 2.4. As claimed by Hillson (1997), to achieve a more detailed diagnostic tool required for objective and consistent assessment of risk management process maturity, four attribute headings are integrated to the system: **Culture**, **Process**, **Experience** and **Application**. With this breakout, clear criteria that had been accepted by numerous risk management organizations were attempted to be utilized in the assessment. The barriers faced by organizations when attempting to progress to the next level of maturity were also given by the author and some strategies were suggested for overcoming them.

Table 2.4. Risk Maturity Model (RMM) framework (Source: Hillson, 1997)

DEFINITION	**Naive**	Unaware of the need for management of risk. No structured approach to dealing with uncertainty. Repetitive and reactive management processes. Little or no attempt to learn from past or to prepare for future.
	Novice	Experimenting with risk management (RM) through a small number of individuals. No generic structured approach in place. Aware of potential benefits of managing risk, but ineffective implementation, not gaining full benefits.
	Normalised	Management of risk built into routine business processes. RM implemented on most or all projects. Formalized generic risk process. Benefits understood at all levels of the organization, although not always consistently achieved.
	Natural	Risk-aware culture, with proactive approach to RM in all aspects of the business. Active use of risk information to improve business processes and gain competitive advantage. Emphasis on opportunity management ("positive risk").
CULTURE	**Naive**	No risk awareness. Resistant/reluctant to change. Tendency to continue with existing processes.
	Novice	Risk process may be viewed as additional overhead with variable benefits. RM used only on selected projects.
	Normalised	Accepted policy for RM. Benefits recognized and expected. Prepared to commit resources in order to reap gains.
	Natural	Top-down commitment to RM, with leadership by example. Proactive RM encouraged and rewarded.
PROCESS	**Naive**	No formal processes.
	Novice	No generic formal processes, although some specific formal methods may be in use. Process effectiveness depends heavily on the skills of the in-house risk team and availability of external support.
	Normalised	Generic processes applied to most projects. Formal processes, incorporated into quality system. Active allocation and management of risk budgets at all levels. Limited need for external support.
	Natural	Risk-based business processes. "Total Risk Management" permeating entire business. Regular refreshing and updating of processes. Routine risk metrics with constant feedback for improvement.
EXPERIENCE	**Naive**	No understanding of risk principles or language.
	Novice	Limited to individuals who may have had little or no formal training.
	Normalised	In-house core of expertise, formally trained in basic skills. Development of specific processes and tools.
	Natural	All staff risk-aware and using basic skills. Learning from experience as part of the process. Regular external training to enhance skills.
APPLICATION	**Naive**	No structured application, no dedicated resources and risk tools.
	Novice	Inconsistent application. Variable availability of staff. Ad-hoc collection of tools and methods.
	Normalised	Routine and consistent application to all projects. Committed resources and integrated set of tools and methods.
	Natural	Second-nature, applied to all activities. Risk-based reporting and decision-making. State-of-the-art tools and methods.

b. Model 2: Project Management Maturity Model by Project Management Solutions

Project Management Maturity Model (PMMM) by Project Management Solutions is intended for diagnosing the maturity of the project management processes of an organization. Its focused view on the processes constitutes the main difference of the model from the other investigated models.

According to Crawford (2002), this model was developed to assist organizations in improving their project management processes by providing a conceptual framework. As Crawford (2002) continues, it has become the industry standard in measuring project management maturity. Furthermore, it serves for improvement by mapping out a logical path and to track progress. The PMBoK Guide's nine knowledge areas and the Software Engineering Institute's five levels of maturity were utilized in this model. The knowledge areas are: Project Integration Management, Scope Management, Time Management, Cost Management, Quality Management, Project Human Resource Management, Communications Management, Risk Management and Procurement/Vendor Management. Five levels of maturity are; **Level 1:** Initial Process, **Level 2:** Structured Process and Standards, **Level 3:** Organizational Standards and Institutionalized Process, **Level 4:** Managed Process and **Level 5:** Optimizing Process.

Each knowledge area is defined at each level of maturity. These knowledge areas are broken down into their specific components to provide the most complete definition. The model defines five components for risk management: **Risk Identification**, **Risk Quantification**, **Risk Response Development**, **Risk Control** and **Risk Documentation.** For each maturity level, along with a brief general description of the characteristics, more detailed descriptions are provided for each component at each maturity level. By the use of the descriptions in risk management knowledge area, a matrix of maturity levels and components was produced accordingly (Table 2.5).

Table 2.5. Component-maturity level matrix outlined from Crawford (2002)

PROJECT RISK MANAGEMENT		
RISK IDENTIFICATION	**Level 1**	- Risks are not identified as a standard activity - There is reaction to risks when the risk is already a current problem versus a future possibility
	Level 2	-Organization has a documented process for identifying project risks, but it is used only for large, highly visible projects - A conscious effort to identify total project risks - Input from key stakeholders is also considered in discussions - To help identify the risks; scope statement, WBS, a more detailed project schedule and cost estimate are used - Procurement and staff management plans are also examined - Top-level risks are included in project plan - Expert judgment and known industry lessons are used
	Level 3	- A documented, repeatable process exists - Documentation exists on all processes and standards - Expanded with checklists, automated forms, *etc.* - Risk triggers are also identified - Interrelationships among related projects are also considered - Input from past, similar projects, lessons learned, key stakeholders are all consolidated and integrated
	Level 4	- Integrated with the cost management and time management processes and the project office - Made within individual project, within programs and between projects and programs
	Level 5	- An improvement process is in place - Lessons learned are being captured - Includes a method to identify an organizational priority for the project
RISK QUANTIFICATION	**Level 1**	- The impact of the somehow identified risks on the project is speculated without any analysis, forethought, standard approach/process
	Level 2	- A more structured approach to quantifying risks - A standard methodology to consistently assess the risk items -May include; low-medium-high ratings or expected monetary value of risks using simple probability and value calculations - Employ more objective approaches to quantify the probability and impact of the risks - Evaluation still on a project-by-project basis - Risks are prioritized based on a single factor
	Level 3	- More advanced procedures to quantify risks - Multiple criteria to prioritize risk items - The entire process is fully documented and repeatable - Range predictions, optimal calculations using simulation tools and decision trees, weighted average calculations - Risks are prioritized based on multiple factors like EMV, criticality, timing, risk type
	Level 4	- Integrated with cost management, time management, finance/accounting, strategic planning processes and project office - The risks on other projects and other parts of the organization are also considered - Risks are evaluated on an organizational basis - Performance indices can be used (to calculate the impact of risk on a project)
	Level 5	- An improvement process is in place - Cost and schedule impacts are adequately captured - Lessons learned are being captured - Management uses the quantified risks to make decisions regarding the project
RISK RESPONSE DEVELOPMENT	**Level 1**	- Risks are considered as they arise - Determination of mitigation strategies or contingency plans for future is seldom
	Level 2	- Informal gatherings on the strategies to deal with the risk events - A risk management (RM) plan that documents the procedures to manage risk - Contingency plans for near-term risks and mitigation strategies for large projects
	Level 3	- Templates are used - Contingency plans and mitigation strategies are identified for each risk item
	Level 4	- Integrated with cost management, time management, finance/accounting, strategic planning processes and project office
	Level 5	- Lessons learned are being captured - A process for tracking the use of project reserves is in place

Table 2.5, continued.

RISK CONTROL	**Level 1**	- Day-to-day problem solving if a new risk event arises - No RM plan or additional risk response strategies
	Level 2	- Apply their own approach to manage and control risks - Assign responsibility for each risk item as it occurs - Discussion of the risks in staff meetings - Risk status of large projects is tracked - There is a process to report risk status to key stakeholders - A risk log, periodic meetings - Tracking changes and incorporating into the project schedule
	Level 3	- Fully developed process, project risks are actively, routinely tracked - Corrective actions are taken, RM plan is updated and metrics are used
	Level 4	- Integrated with organization's control systems, monitoring programs, cost and time management
	Level 5	- Risk assessments and the current risk status are utilized for management decisions
RISK DOCUMENTATION	**Level 1**	- No historical database on typical risks encountered and related experiences - Individuals rely upon their own past experiences and discussions with other team members
	Level 2	- Some historical information about general tendencies in risk may have been collected - No typical and centralized method to collect historical information
	Level 3	- A historical database of information such as common risk items and risk triggers
	Level 4	- Historical database is expanded to include inter-dependency risks between projects
	Level 5	- An improvement process is in place - Post-project assessments - Lessons learned are being captured

c. Model 3: Risk Management Maturity Model

According to PMI (2002), this model is an elaboration of the initial work accomplished by Hillson (1997), which is presented as Model 1, to enhance its diagnostic elements and to further aid in identification of the current level at which an organization is operating. As claimed by PMI (2002), this is a simplified maturity model designed to quickly target weaknesses and is applicable to all types of projects and all types of organizations in any industry, government or commercial sector.

The naming of the levels has been changed but the basic structure remained the same with the Hillson (1997)'s model. The maturity levels of Risk Management Maturity Model (RMMM) are: **Level 1**: Ad-Hoc, **Level 2**: Initial, **Level 3**: Repeatable and **Level 4**: Managed. Also the four attribute headings were taken from the Hillson (1997)'s model, therefore the headings remained the same as; **Culture**, **Process**, **Experience** and **Application**. Framework of RMMM is constructed as in Table 2.6. There are some elaborations made upon RMM, on the descriptions of the maturity levels and on the suggested strategies for moving to the next level.

Table 2.6. RMMM Risk Management Maturity Model (Source: PMI, 2002)

DEFINITION	**Level 1- Ad Hoc**	Unaware of the need for management of uncertainties (risk). No structured approach to dealing with uncertainty. Repetitive and reactive management processes. Little or no attempt to learn from past projects or prepare for future projects.
	Level 2 – Initial	Experimenting with risk management (RM) through a small number of individuals. No structured approach in place. Aware of potential benefits of managing risk, but ineffective implementation.
	Level 3 – Repeatable	Management of uncertainty built into all organizational processes. RM implemented on most or all projects. Formalized generic risk process. Benefits understood at all organizational levels, although not always consistently achieved.
	Level 4 - Managed	Risk-aware culture with proactive approach to RM in all aspects of the organization. Active use of risk information to improve organizational processes and gain competitive advantage.
CULTURE	**Level 1- Ad Hoc**	No risk awareness. No upper management involvement. Resistant/reluctance to change. Tendency to continue with existing processes even in the face of project failures. Shoot the messenger.
	Level 2 – Initial	Risk process may be viewed as additional overhead with variable benefits. Upper management encourages, but does not require, use of RM. RM used only on selected projects.
	Level 3 – Repeatable	Accepted policy for RM. Benefits recognized and expected. Upper management requires risk reporting. Dedicated resources for RM. “Bad news” risk information is accepted.
	Level 4 - Managed	Top-down commitment to RM, with leadership by example. Upper management uses risk information in decision-making. Proactive RM encouraged and rewarded. Organizational philosophy accepts idea that people make mistakes.
PROCESS	**Level 1- Ad Hoc**	No formal process. No RM plan or documented process exists. None or sporadic attempts to apply RM principles. Attempts to apply RM process only when required by customer.
	Level 2 – Initial	No generic formal processes, although some specific formal methods may be in use. Process effectiveness depends heavily on the skills of the project risk team and the availability of external support. All risk personnel located under project.
	Level 3 – Repeatable	Generic processes applied to most projects. Formal processes incorporated into quality system. Active allocation and management of risk budgets at all levels. Limited need for external support. Risk metrics collected. Key suppliers participate in RM process. Informal communication channel to organization management.
	Level 4 - Managed	Risk-based organizational processes and RM culture permeating the entire organization. Regular evaluation and refining of process. Routine risk metrics used with consistent feedback for improvement. Key suppliers and customers participate in RM process. Direct formal communication channel to organization management.
EXPERIENCE	**Level 1- Ad Hoc**	No understanding of risk principles or language. No understanding or experience in accomplishing risk procedures.
	Level 2 – Initial	Limited to individuals who may have had little or no formal training.
	Level 3 – Repeatable	In-house core of expertise, formally trained in basic RM skills. Development and use of specific processes and tools.
	Level 4 - Managed	All staff risk aware and capable of using basic risk skills. Learning from experience as part of the process. Regular training for personnel to enhance skills.

Table 2.6, continued.

APPLICATION	**Level 1- Ad Hoc**	No structured application. No dedicated resources. No RM tools in use. No risk analysis performed.
	Level 2 – Initial	Inconsistent application of resources. Qualitative risk analysis methodology used exclusively.
	Level 3 – Repeatable	Routine and consistent application to all projects. Dedicated project resources. Integrated set of tools and methods. Both qualitative and quantitative risk analysis methodologies used.
	Level 4 - Managed	Risk ideas applied to all activities. Risk-based reporting and decision-making. State-of-the-art tools and methods. Both qualitative and quantitative risk analysis methodologies used with great stress on having valid and reliable historical data sources. Dedicated organizational resources.

d. Model 4: IACCM Business Risk Management Maturity Model

The IACCM Business Risk Management Working Group (2003) designed a tool for the organizations to evaluate their level of maturity in the area of business risk management. IACCM Business Risk Management Maturity Model (BRM3) aims to assist an organization to assess whether its approach to risk management is adequate or not, to compare its approach with best practice or against its competitors and create an accepted benchmark for organizational risk management. The developer of RMM (Model 1) took part in this project and provided a framework to be utilized in this model. Accordingly, the basic structure of the framework is not so different from RMM and RMMM. Four levels of organizational business risk management maturity were utilized (*i.e.* Level 1: **Novice,** Level 2: **Competent,** Level 3: **Proficient,** Level 4: **Expert**) against four key attributes (*i.e.* **Culture, Process, Experience, Application**).

The model provides the maturity characteristics by a maturity level – attribute matrix which is presented in Table 2.7. However, instead of this general framework, a detailed questionnaire is provided as a set of tables, each row containing one characteristic within an attribute (refer to IACCM Business Risk Management Working Group, 2003 for the questionnaire). For the culture section there are ten

rows of characteristics. Similarly, it is eight for the process, six for the experience and seven for the application sections. Each characteristic is scored according to the maturity levels (1, 2, 3 or 4) and at the end, total attribute scores and maturity score of the organization are achieved. The variation in the characteristic and attribute scores reflects the strengths and weaknesses of the organization. Thus, along with serving for the assessment of the maturity level of the organization, the questionnaire can also be used to set realistic targets for improvement, on the basis of the identified strengths and weaknesses.

Table 2.7. Maturity level – attribute matrix of Model 4 (Source: IACCM Business Risk Management Working Group, 2003)

	LEVEL OF MATURITY				
ATTRIBUTE		**Novice**	**Competent**	**Proficient**	**Expert**
	Culture	- Risk averse - Lacking awareness/ understanding - Lacking strategy - Lacking commitment	- Patchy, inconsistent - Some understanding/ awareness - Cautious approach, reactive	- Prepared to take appropriate risks - Good understanding of benefits across most of organization - Strategy mapped into process implementation	- Proactive - Intuitive understanding - Belief, full commitment to be the best
	Process	- Where present tend to be inefficient, informal, ad-hoc	- Inconsistent - No learning from experience - Standard approach/ generic	- Consistent approach but scalable - Tailored to specific needs	- Adaptive - Proactively developed - Fit for purpose - Best of breed
	Experience	- None; nothing relevant	- Basic competence	- Proficient - Formal qualifications	- Extensive experience - Leading qualifications - Externally recognized high competence
	Application	- Not used	- Inconsistent- major projects only - Process driven - Inadequately resourced	- Consistently applied - Adequately resourced	- Proactively resourced - Across entire business - Flexible - Measured for improvement

e. Model 5: Risk Management Capability Maturity Model for Complex Product Systems Projects

According to Ren and Yeo (2004), this model was built upon RMM, HVR Risk maturity model by Hopkinson and Lovelock (2004), RMMM and CMM. It offers a

framework for complex product systems projects to benchmark the current approach in risk management against five standard levels of maturity. The tool allows for the assessment of the current level of the organization, identify realistic targets for improvement and develop action plans for enhancing its risk management maturity. The model utilizes the maturity levels of CMM, which are; **Level 1:** Initial, **Level 2:** Repeatable, **Level 3:** Defined, **Level 4:** Managed and **Level 5:** Optimizing. As claimed by Ren and Yeo (2004), for the improvement of risk management maturity, the organization must develop its capabilities in organizational culture (context), risk management process (process) and risk management knowledge/techniques (content) simultaneously. Accordingly, the tool defines three key capability areas; **Organization Culture**, **Risk Management Process** and **Risk Management Knowledge/Technology**. For each maturity level, the model defines major organization culture characteristics, risk management process characteristics and knowledge characteristics, and a theoretical framework is obtained as in Table 2.8.

The model also includes a questionnaire based on this framework, made up of 75 statements in total, which are assumed to have the same weight (refer to Ren and Yeo, 2004 for the questionnaire). The questionnaire defines key attributes for each of the three key capability areas, which are iterated as follows:

For the organization culture;

- Attitude towards risk and uncertainty,
- Stakeholders and
- Leadership and commitment to risk management.

For the risk management process;

- Risk identification,
- Risk analysis,
- Risk mitigation and
- Integration with other processes.

And for the risk management knowledge/technology;

- Management of risk knowledge and
- Experience and competence.

Table 2.8. Framework of Model 5 (Source: Ren and Yeo, 2004)

	Major Organization Characteristics	Major RM Process Characteristics	Major Knowledge Characteristics
Level 5	- Strong risk-awareness culture with proactive approach to risk management (RM) in the CoPS network - Active use of risk information to gain competitive advantage - Risk-based organization that is dynamic and energetic, and flexible - Develop and sustain goodwill and long term relations with lead customers and clients	- RM processes are continuously improved - Develop a system of coalition and partnering with vendors and contractors - Project risk management process integrated into other project management processes	- Excellence in RM knowledge management - Continuous RM learning - Center of excellence in RM - RM knowledge shared and transferred
Level 4	- Strong teamwork, even with external partners - Continuous formal RM training for project teams - Strong risk-based organization process - Strong senior support to RM	- Consistent and systematic RM for project portfolios - RM processes are integrated internally and with external partners - RM processes data are quantitatively analyzed, measured, and stored continuously	- Strong RM learning capability - RM information management system - Integrated sets of tools and methods - All staff risk aware and capable of using basic risk skills
Level 3	- Dedicated resources to RM - Formal training of RM skills and practices - Risk awareness at the organizational level - Recognition of risk ownership and allocation of risk and responsibility	- Formal project planning and control systems are established and applied - RM system and procedures are used to identify, confront and mitigate risks continuously - Ensure real time monitoring of budgets and schedules	- Full understanding of RM principles - Mastering basic RM tools and techniques - The personnel in charge of RM has high level of RM competence - Formal RM databases are maintained
Level 2	- Partial acceptance of RM - Initial assignment of responsibility and accountability for risks - Informal training of RM skills and practices	- Informal RM processes are defined - RM problems are seldom systematically identified and analyzed - Fragmented RM data are collected	- Partial knowledge on RM principle and language - Historical risk data are used in assessing future projects - RM tools are used in some activities
Level 1	- No senior management support and involvement - Shoot the messenger, risk-fear culture - Unaware of the need for RM	- No formed RM processes or practices are available - No RM data are consistently collected or analyzed	- No understanding of RM principles or language - No RM tools in use - No historical risk data collected and maintained

Tentative items of measuring each attribute are listed in the questionnaire. A scale of five choices, ranging from “strongly disagree” to “strongly agree”, was introduced for the measurement of responses, by Ren and Yeo (2004).

f. Model 6: PMI's Risk Management Maturity Model Adapted to the Construction Industry

Loosemore, *et al.* (2006) built their work upon the Risk Management Maturity Model (RMMM) designed by the PMI (2002), which is presented as Model 3. While valuable, the RMMM was evaluated by the authors as being quite narrow in its description of what characterizes each level of maturity. According to Loosemore, *et al*. (2006), it needs refining to suit the peculiarities of different industries such as construction. Utilizing the integration of work by Mitroff and Pearson (1993) and Loosemore (2000), PMI's work was adapted and expanded for the construction industry by Loosemore, *et al*. (2006), and a more robust model was obtained.

This new model lists the typical attributes of an organization at each level of maturity under the headings of: **Awareness**, **Culture**, **Processes**, **Skills/Experience**, **Image**, **Application**, **Confidence** and **Resources**. Other than the attributes maintained from RMMM, awareness, image, confidence and resources are the extra attribute headings integrated to the structure. The final model utilizes the mentioned headings against four levels of maturity; which are; **Level 1:** Ad-Hoc, **Level 2:** Established, **Level 3:** Managed and **Level 4:** Integrated, as depicted in Table 2.9. As claimed by Loosemore, *et al*. (2006), an organization may belong to different levels of maturity for different attributes and may be operating at different levels of maturity for different types of risk. As Loosemore, *et al*. (2006) further continue in their claim, to achieve a consistent level of maturity across all risk categories and across all attributes is the challenge for any organization.

Table 2.9. Framework of Model 6 (Source: Loosemore, *et al*., 2006)

Culture	**Level 1- Ad Hoc**	No risk awareness, RM seen as a nuisance and peripheral activity with no relevance or value to core business objectives. No upper management involvement or support. Resistance and reluctance to adopt risk management (RM). Tendency to continue with existing processes even in the face of project failure. Managers do not want to hear about problems. Many undiscussable problems. People are punished for communicating bad news. Secretive inward looking – no stakeholder communication.
	Level 2 – Established	Risk processes are viewed as a compliance requirement and an additional overhead with variable practical benefits. Scepticism of ability of RM to add value to organization. Focus on downside of risk. RM system is primarily for public relations purposes but not implemented. Upper management encourages but does not require RM. Little communication with stakeholders.
	Level 3 – Managed	Benefits of RM recognized, accepted and proven. Focus on upside and downside of risk. Upper management requires risk reporting. Bad news risk information is accepted. Informal communication channels to top management. Effective communication with stakeholders.
	Level 4 - Integrated	RM widely seen as a core business function. Risk is an instinctive and automatic way of thinking for all employees at all levels of organization. Open flows of information and trusting relationships with business partners along entire supply chain. Collective responsibility for risks and opportunities along supply chain. No blame culture – acceptance of mistakes. Formal communication channels to top management. External stakeholders actively encouraged through formal mechanisms to participate in business decisions.
Processes	**Level 1- Ad Hoc**	No structured and documented approach to deal with risk. No formal processes. No RM plan. Reactive management of risks. Over reliance on insurance as a substitute for effective RM. A policy of risk transfer to weaker parties through contractual mechanisms. Internal business processes actively create risks.
	Level 2 – Established	Project-based RM systems with little inter-relationships. No generic risk processes and no RM planning across projects. RM processes inconsistent across different management systems. No attention to reducing risk exposure created by internal business processes.
	Level 3 – Managed	Generic RM processes widely communicated and implemented on most projects and common across different management systems. Risks metrics collected to support basic quantitative analysis. A policy of risk fairness in contracts rather than risk transfer. Steps activity taken to reduce risk in products, services, business and production processes. Use of external experts and services in RM.
	Level 4 - Integrated	Risk-based organizational processes at all levels and functions of organization. Well-developed, tested and refines RM procedures. Regular monitoring, evaluation, auditing and improvement of processes. Management of risk built into all organizational processes and consistent across all management systems. Wide range of reliable risk metrics covering whole risk portfolio collected and analysed systematically. Processes reflect good principles of RM/transfer – re; pricing, capability, resources must be appropriate to risk. Diversification and portfolio strategies in place. Computerized inventories of plant, employees, products and capabilities. Business continuity planning, crisis management and emergency systems in place and regularly tested – backed up by technical redundancy. Regular legal and financial audits of threats and opportunities undertaken. Dedicated research on hidden opportunities and threats. Critical follow up and learning from incidents.

Table 2.9, continued.

Awareness	**Level 1- Ad Hoc**	Unaware of the need for RM. Little or no attempt to learn from past projects.
	Level 2 – Established	Experimenting with RM through a small number of enthusiastic individuals. Aware of potential benefits of managing risk but no effective implementation. Staff tends to react to risks as and when they arise.
	Level 3 – Managed	Benefits of RM understood at all organizational levels and along supply chain, although not consistently. Key internal stakeholders and suppliers can participate in RM process. Proactive approach to risk when making decisions.
	Level 4 - Integrated	Risk awareness applied proactively in making all decisions. Risk awareness instilled throughout all organizational levels and along entire supply chain. Active use of risk feedback to improve organizational processes and gain competitive advantage. Collective responsibility for risk along entire supply chain. Key suppliers, external and internal stakeholders and customers participate in RM process.
Skills/Experience	**Level 1- Ad Hoc**	No understanding of RM language or principles.
	Level 2 – Established	Basic understanding of RM language or principles in organizational pockets. Limited to individuals who have had little or no formal training. No analysis capability apart from some basic qualitative analysis by individual managers.
	Level 3 – Managed	Widespread understanding of RM language or principles. Qualitative analysis is widely practiced and some basic quantitative analysis.
	Level 4 - Integrated	Intimate and developing understanding of RM language or principles and how it applies to organization's business. Where appropriate, complex quantitative analysis is possible using sophisticated probabilistic and simulation techniques. State of the art tools and methods in use. Evolving corporate memory of and learning about past risks and opportunities.
Image	**Level 1- Ad Hoc**	Reputation for poor RM associated with cost overruns, delays, poor safety, poor quality on projects.
	Level 2 – Established	Perception of competence but unreliability associated with variable performance and well publicised problems on contracts spreading between clients.
	Level 3 – Managed	Reputation for effective RM consistency of service, and product quality based on well publicised and widely implemented RM system.
	Level 4 - Integrated	Reputation for excellent RM acquired from successful completion of high-risk projects. Company attracts educated clients which are sophisticated in RM and expect same standards. Customers have confidence that organization can take on higher risks than competitors. Added value to customers often added by emphasis on upside as well as down side of risk. Major efforts in public relations and stakeholder management.
Application	**Level 1- Ad Hoc**	No or very few managers practice RM.
	Level 2 – Established	RM applied inconsistently in response to customer demands and practiced on selected projects depending on knowledge of managers on those projects.
	Level 3 – Managed	RM applied consistently across systems and levels but needs continuous support and leadership to maintain. RM focused on operational risks. RM training.
	Level 4 - Integrated	RM consistently and systematically implemented on all projects and across all management systems. Enthusiasm for value of system develops its own momentum for continuous improvement. RM applied to broad range of risks – political, reputational, strategic, commercial and operational. Regular RM training to all staff.

Table 2.9, continued.

Confidence	**Level 1- Ad Hoc**	Fear of RM. No experience in implementing risk procedures. No confidence in identifying, analysing and controlling risks.
	Level 2 – Established	Fear of RM remains in pockets. Risk analysis beyond most people – better risk identification processes are a major step forward.
	Level 3 – Managed	Perceptions of fear have been broken. People work confidently at own ability level and actively seek further information to help manage risks. Support system in place to help people with RM activities.
	Level 4 - Integrated	Overt confidence in managing risks communicated to customers and clients. Enthusiasm to learn about RM and develop skills. Staff see RM as their core skill. Interactive and intelligent support system available to staff which enables learning across different functions. RM system develops a life of its own – driven forward and developed by staff. Risk leadership provided by staff. Staff externally communicate RM capabilities as a competitive advantage.
Resources	**Level 1- Ad Hoc**	No dedicated resources for RM.
	Level 2 – Established	All risk personnel located under project. No central support. Risk financed under project cost centres.
	Level 3 – Managed	Top management commitment to RM. Active allocation and management of risk budgets. In-house core of expertise, formally trained in basic RM skills. Development and use of specific dedicated processes and tools for business. Training of key people in organization who administer and involved in RM system.
	Level 4 - Integrated	Dedicated budget/resources for RM. Top-down implementation of system led by strong management leadership. Dedicated RM unit or team. Centralised RM expertise and resources and support for everyone in the organization. Human resources management support RM activities through incentives, training, rewards, *etc*. Resources to support, train supply chain in RM. Psychological support for employees, stress management.

2.4 Supply Chain as a Construction-Specific Entity

In construction, there is collaboration between multiple firms (Vaidyanathan and Howell, 2007). Accordingly, in their claim, Vaidyanathan and Howell (2007) further argue that the maturity models developed on a single enterprise basis (*e.g.* CMM) cannot be directly applied to the construction industry, as they do not take the multi-enterprise supply chain aspects into account. Similarly, as mentioned before, Sarshar, *et al.* (1999) investigated the applicability of CMM to the construction industry and found out that the major barrier against the application is the supply chain configuration in construction. In this respect, construction supply chain issues are explored from the literature, especially in terms of maturity and in terms of risk management.

Mentzer, DeWitt, Keebler, Min, Nix, Smith and Zacharia (2001) conducted a literature review and stated a consensus that a supply chain in its simplest form comprises three entities: a company, a supplier and a customer directly involved in the upstream and downstream flows of products, services, finances and information. As Mentzer, *et al.* (2001) continue, supply chain management is about the coordination of activities between these interdependent organizations. To quote Christopher (1992), "Supply chain management is the management of upstream and downstream relationships with suppliers and customers in order to create enhanced value in the final marketplace at less cost to the supply chain as a whole."

2.4.1 Construction Supply Chain and Its Management

As claimed by several authors (Vrijhoef and Koskela, 2000; Tah, 2005), in construction, each project is a one-off and a construction supply network tend to be temporary, which is reconfigured for each incoming project. As Vrijhoef and Koskela (2000) further argue, construction supply chain is characterized by instability and fragmentation.

According to Tah (2005), long supply chains that extend across different product/service types and commercial interests characterize construction projects, and many contemporary problems as poor delivery to time, cost, quality, the fragmentation of design and construction responsibility, and poor trading relations between parties stem from this fact. As several authors (Taylor and Bjornsson, 1999; O'Brien, 2001; Tah, 2005) claim, a construction supply chain may include contractors, subcontractors, material and equipment suppliers, engineering and design firms, consulting firms, *etc*. There is the flow of information, the flow of materials, services and products, and the flow of funds among these agents (Shaoyan, 2008). As quoted in Shaoyan (2008), Vrijhoef and Koskela (2001) consider supply chain problems as a major problematic issue in construction, which originates at the interfaces of different organizations or stages involved in the construction supply chain. According to Hendrickson and Au (1989), in a construction project, there are many sources creating the uncertainty and many participants in the project.

Therefore, as Hendrickson and Au (1989) continue in their claim, conflicts between these participants can affect the project in a negative way, as each participant tries to minimize its own risk. As claimed by several authors (Wong and Fung, 1999; Akintoye, McIntosh and Fitzgerald, 2000), the core issue to improve construction performance is effective coordination among project participants with different objectives. Similarly, Love, Irani and Edwards (2004) state that improved collaboration, integration, communication and coordination are needed between customers and suppliers throughout the project supply chain.

According to Shaoyan (2008), construction supply chain management (CSCM) is the integration of key construction business processes, focusing on how firms utilize their suppliers' technologies and capabilities to enhance competitive advantage. O'Brien (1999) argues that CSCM aims at reduced costs, and increased reliability and speed for the facility construction. Akintoye, *et al.* (2000) regarded CSCM as the process of strategic management of information flow, activities, tasks and processes, involving various networks of organizations and linkages (upstream and downstream) involved in the delivery of quality construction products and services through the firms, and to the customer, in an efficient manner.

2.4.2 Construction Supply Chain Maturity Models

To quote Kumar and Viswanadham (2007), "For complete operational efficiency of the construction supply chain, process maturity has to be gained along three dimensions- functional, project and firm, and not necessarily in that order." Maturity concept has been also applied to supply chain, although not extensive. Two supply chain maturity model frameworks were identified from the literature. McCormack and Lockamy (2004) developed a **Supply Chain Management (SCM) Process Maturity Model** for enhanced supply chain performance. The model has five stages of maturity showing the progression of activities toward effective supply chain management and process maturity. Characteristics associated with process maturity such as predictability, capability, control, effectiveness and efficiency are contained in each level, which are: Level 1: Ad Hoc, Level 2: Defined, Level 3: Linked, Level

4: Integrated and Level 5: Extended. Vaidyanathan and Howell (2007) developed a **Construction Supply Chain Maturity Model**, which addresses the construction industry. It is a four staged maturity model, with the maturity levels named as: Level 1: Ad-Hoc, Level 2: Defined, Level 3: Managed and Level 4: Controlled. This model is construction-specific by covering the issues and problems of the construction industry. All in all, these models are looking from the supply chain management perspective and no specific maturity model was found directly addressing the construction supply chain risk management.

2.4.3 Risks in Construction Supply Chain

London and Kenley (2001) consider the uncertainty that exist in the supply of projects and the inherent risk for firms involved as very important factors in supply chain management. According to Kumar and Viswanadham (2007), since a construction supply chain involves hundreds of channels for various materials and services, risks exist at various nodes. As Jüttner (2005) claims, the disruptions of "flows" between organizations constitute the focal points for risk in the supply chain. As Jüttner (2005) further argues, these flows are related with information, materials, products and money, and supply chain risk extends beyond the boundaries of the single firm.

As Giunipero and Eltantawy (2004) claim, there are several conditions that create risks in a supply chain: world political events, product availability (Singh, 1998), distance from source (MacKinnon, 2002), industry capacity (Lee, Padmanabhan and Wang, 1997), demand fluctuations (Singh, 1998), changes in technology (Iyer, 1996), and labor markets (Wiseman and Gomez-Mejia, 1998), financial instability (Larson and Kulchitsky, 1998) and management turnover (Wiseman and Gomez-Mejia, 1998).

Mason-Jones and Towill (1998) suggest five overlapping categories of supply chain risk sources: environmental risk sources, demand and supply risk sources, process risk sources and control risk sources. These are grouped in two as environmental,

supply and demand risk sources on one hand and processes and control mechanisms as a risk amplifier or absorber on the other. Accordingly, environmental risk sources are any external uncertainties arising from the supply chain such as disruption caused by political, natural or social uncertainties. Supply risk is the uncertainty associated with supplier activities and in general supplier relationships. Demand risk is any risk associated with the outbound logistics flows (Svensson, 2002) and product demand. Processes refer to the design and implementation of processes within and between the entities in the supply chain. Supply chain control mechanisms are as decision rules and policies regarding order quantities, batch sizes and safety stocks.

2.4.4 Supply Chain Risk Management

According to Kumar and Viswanadham (2007), for preventive risk management, the contractor has to find out various mechanisms to make the supply chain robust and risk resilient. As claimed by Jüttner (2005), instead of a single organization focus, managing risks from a supply chain perspective must have a broader scope and define the way of performing the key processes across at least three organizations. To continue with Kumar and Viswanadham (2007), supply chain risk management involves identification of risk events with their sources, prioritizing risks, and devising ways in which probability of occurrence of such events can be minimized.

Jüttner (2005) defines supply chain risk management as "the identification and management of risks for the supply chain, through a coordinated approach amongst supply chain members, to reduce supply chain vulnerability as a whole". As Jüttner (2005) further argues, to see the differences between a single company perspective and a supply chain perspective, the risk analysis process can be given as an example. Companies must identify not only direct risks to their operations but also the risks to all other entities as well as those risks caused by the linkages between the organizations in order to assess vulnerabilities in a supply chain context. According to Giunipero and Eltantawy (2004), there are relationships between risk, strong pursuit of objectives, early supplier involvement, and careful development, evaluation and management of suppliers.

From Jüttner (2005), some critical points for supply chain risk management were extracted. Communication lines between all organizations should be ensured in crisis situations. There should be openness to share risk-related information and acceptance of supply chain risks as joint risks (trust and open communication). Organizations need to develop a common understanding of the risks surrounding their supply chain. Supply chain risk management processes within and across companies are of critical importance. In a supply chain context, joint continuity planning processes need to be undertaken to meet the need to treat supply chain risks as shared risks.

2.5 Inferences Drawn from the Literature Review

Through the literature review it was observed that although construction process improvement and project management capabilities of construction organizations are addressed in several studies, there is a lack in maturity research specifically carried out in the area of construction risk management. The inferences drawn from the review of the risk management maturity models are further explained in detail.

After a thorough examination of the reviewed six maturity models dealing with risk management, several advantageous and disadvantageous points were identified, both in terms of effectiveness and in terms of usability. Table 2.10 was constructed based on the specific characteristics of the models, outlining the evaluation and comparison. The evaluation criteria were specified as attributes, number of maturity levels, content, specificity to the construction industry and assessment system. Accordingly, the evaluation of each criterion is expressed herein, in accordance with Table 2.10 facilitating easy follow up.

Attributes

Simple and reasonable attributes are provided by Model 1 as *culture*, *process*, *experience* and *application*. Under *culture* attribute the model examines risk awareness, top management commitment and approach towards risk management. *Process* attribute is concerned with the existence of formal processes, risk budget and

organizational learning from risks. Under *experience* attribute, staff dealing with risk management, training and use of tools are examined. And finally, *application* attribute deals with the existence of a structured application of risk management, dedicated tools and resources. Similarly, developed upon Model 1, Models 3 and 4 utilize the same attribute headings with Model 1. On the other hand, having a focused view on the processes, Model 2 takes risk management processes (in which it is called components) as attributes. In a different approach, Model 5 utilizes three key attributes as *culture*, *process* and *knowledge/techniques*. In Model 6, extra attribute headings are integrated to the RMM framework – *awareness*, *image*, *confidence* and *resources*. Taking cognizance of the descriptions of the term "organizational culture" in the literature, it was seen that the scope of *culture* attribute comprises awareness, so creating an extra heading may be unnecessary. Likewise, it was believed that *confidence* and *image* headings do not add any value to the model and the content of the confidence heading can be involved under the *experience* heading. To create a *resources* attribute heading was deemed reasonable in terms of comprehensiveness, since this subject is involved under the *application* heading of Model 1 and Model 3.

Maturity levels

As pointed out by Hillson (1997), having four standard levels of maturity provides clarity and simplicity, decreases fuzziness in determination of the maturity level of the organization. Similarly, PMI (2002) states that having more than four levels of maturity would increase ambiguity in the assessment without giving any additional refinement to the model. With five levels, the differences between the levels become minor and to distinguish the current level of the organization for each attribute turns into a tedious task. Therefore, having four levels of maturity was evaluated to be advantageous when compared with five levels.

Content

In terms of content, **company culture** is one dimension to assess, since it reflects the attitude of the organization towards risk management. As claimed by Hillson (2000),

the risk management efforts can be built up or blocked by the organization's attitude and culture. As Hillson (2000) continues, undertaking risk management successfully and effectiveness of a risk process are strongly connected with the belief and attitude of the team, since a strong belief in the process is a key component for a good implementation, as well as people and money resources and leadership. Therefore, this attribute was evaluated to be reasonable and to the point. In all of the reviewed models, organizational culture is assessed under its respective attribute, except Model 2, in which only risk management processes are examined rather than organizational aspects.

Assessment of **risk management processes** is essential, as it constitutes the backbone of risk management. As thoroughly depicted in Section 2.2, risk management is a stepwise procedure composed of several processes, and these processes should be continuously repeated throughout the project lifecycle. Though playing a vital role, it was seen that this section lacks elaboration in most of the reviewed models. Generalized entries do not give any clue about the risk management processes, thus inadequate to serve for an assessment. It was concluded that detailed diagnostic descriptions should be provided for each risk management process. In this respect, with its focused scope on the processes, Model 2 compensates this deficiency. Except Model 2, the only model with an elaborated process section is Model 5, utilizing the headings of risk identification, risk analysis and risk mitigation. This is a positive approach in terms of the effectiveness of the model.

Considered in Models 4, 5 and 6, **integration of risk management with other management tasks** is another critical dimension for effective application of risk management and should not be disregarded. In the literature, lack of integration of risk management system with the rest of the management activities, in other words, carrying out risk management occasionally as a separate activity independent from other project functions, is declared as one of the main factors that cause the risk management system to fail in some projects.

Another factor that contributes to the failure of the risk management system is given in the literature as the lack of a shared understanding of risks between the parties. Smith, *et al*. (2006) argue that the effectiveness of risk management is improved if all parties have the same appreciation of the identified risks. In a similar vein, Hendrickson and Au (1989) take "organizational relationships" in their risk classification as one of the major groups of risk, although they seem to be unnecessary. Under this heading, Hendrickson and Au (1989) iterate contractual relations, attitudes of participants and communication. Accordingly, effective **communication of risk information within the supply chain** is critical to consider, since there is multi-firm collaboration in construction, as explained in Section 2.4. Therefore, to provide a model specific to the construction industry requires the cognizance of supply chain issues. The only construction-specific model is Model 6, which includes issues related with supply chain and considers effective communication with stakeholders. Also, models except Model 1 consider the participation of key stakeholders in risk management process.

A relative issue is argued by Merna and Al-Thani (2005) that a clear and common understanding of the threats and opportunities associated with the project should be developed within the organization. Accordingly, effective **communication of risk information within the project team and within the company** should also be questioned. Model 4 and Model 5 take open communication to risk and uncertainty as one of the aspects to consider under *culture* attribute. Model 6 considers the existence of formal communication channels to top management, again under its culture attribute.

Pointing out to the criticality of **risk management resources**, Burtonshaw-Gunn (2009) states that for achieving effective risk management, an organization should have willingness to allocate budget or other resources to risk actions at each stage of the project. Correspondingly, all of the reviewed models except Model 2 examine the existence of organizational resources for risk management. Moreover, this aspect is dedicated a respective attribute in Model 6 and this approach was deemed as advantageous in terms of comprehensiveness.

Specificity to the construction industry

In models except Model 5 and Model 6, the definitions are generic, without specificity for a particular industry. On the other hand, Model 5 is specifically designed for complex product systems projects. As mentioned before, the only model that considers the construction-specific attributes is Model 6, as an adaptation of Model 3 to the construction industry with some elaborations on the content of it, mainly related with the issues on construction supply chain.

Assessment system

Most of the models investigated in this study (*i.e.* Models 1, 2, 3 and 6) are in the form of an attribute-maturity level matrix. These models provide general descriptions of the attributes at each maturity level, but do not provide a systematic assessment approach. Not each description entry has a correspondence in each of the maturity levels. As claimed by Hillson (1997) for Model 1, the diagnostic elements of the model should be enhanced. A self-assessment questionnaire is needed to better serve for the identification of the current risk management maturity level and provide sufficient usability as a diagnostic tool. As also pointed out by Loosemore, *et al.* (2006) for Model 6, these models are in the form of a guidance indicating the types of questions to ask for a maturity assessment. Models 4 and 5 are one step forward in this respect, by providing more detailed questionnaires with defined assessment systems. After all, the questionnaire of Model 5 consists of very brief statements, which are hard to comprehend and lead for an assessment at once. Moreover, to evaluate these statements on a 1 to 5 Likert scale also creates vagueness, in which further guidance is needed. The approach of Model 4 was evaluated to be more practical and elaborate in this respect when compared to Model 5, as each of the features in an attribute is defined at each maturity level.

Table 2.10. Evaluation and comparison of the existing risk management maturity models

	Attributes	Maturity Levels	Content	Construction-specificity	Assessment System	Additional Comments
Model 1	Simple and reasonable attributes	Four levels of capability maturity	The model is composed of brief descriptions of the levels according to the defined attributes.	×	No defined assessment system, as it only involves general descriptions.	Although constructing a strong basis, the practicality of the model is restricted. As also claimed by Hillson (1997), its diagnostic elements should be enhanced and a self-assessment questionnaire is needed.
Model 2	RM processes are taken as attributes	Five levels of capability maturity	• The model focuses on the RM processes of the project. Therefore, its effectiveness is restricted with the process attribute, when the aim is to measure the RM maturity of an organization. • Being effective only on a specific part, the model provides detailed characteristics of the processes at each maturity level.	×	No defined evaluation system. Assessments are carried out via benchmarking against brief descriptions of groupings.	Similar to Model 1, this model also does not provide a systematic assessment approach. In a similar vein, it is solely composed of descriptions for each attribute at each maturity level, which does not provide sufficient usability as a diagnostic tool.
Model 3	Reasonable attribute headings taken from Model 1	Four levels of capability maturity	When compared with Model 1, it is seen that some parts of the framework are expanded in terms of content. Some entries are added to the framework to provide a more detailed approach.	×	No defined assessment system. Listing of entries instead of a systematic approach.	The problematic point related with practicality in Model 1 remains the same. Enhancement of its diagnostic elements is still needed, as also pointed out by its developers (PMI, 2002).

Table 2.10, continued.

	Attributes	Maturity Levels	Content	Construction-specificity	Assessment System	Additional Comments
Model 4	Same attribute headings with Model 1 and Model 3	Four levels of capability maturity	• The content is parallel to Model 1 and Model 3. However, unlike the previous models, the model considers the integration of RM with other management processes, although in a very brief manner. • Diagnostic characteristics are given for each attribute and each characteristic is described for each level of maturity.	×	The assessment system is defined and clear which increases the usability of the model.	Provides not only a framework but also a detailed and systematic questionnaire. As mentioned, each attribute characteristic is given for each level of maturity so no gaps are left in the structure.
Model 5	Three key attributes as culture, process and knowledge/ techniques.	Five levels of capability maturity	The model elaborates its process section under the headings of risk identification, risk analysis and risk mitigation. This is a positive approach in terms of the effectiveness of the model. The model also includes the integration of RM with other processes in its process part as another improvement.	×	The evaluation system is based on a five-point Likert scale, by means of scoring each statement on a degree of agreement.	It has a different structuring than the mentioned models that are built upon Hillson (1997)'s model. Not only a framework, but also a more detailed outline composed of statements is developed by the authors. But the comprehensibility of the statements in terms of serving for a self-assessment is in question.
Model 6	Extra attribute headings are integrated to the Model 3 framework.	Four levels of capability maturity	• Considering the construction industry, Model 3 is expanded with some entries and the notable ones are regarding the supply chain in construction. • Integration of RM with other management processes is taken into consideration.	✓	No defined assessment system.	In terms of usability, same arguments are valid as for Model 3. As claimed by Loosemore, *et al.* (2006), the model guides for the assessment of RM maturity by denoting the types of questions to be asked, instead of constructing the actual questionnaire.

CHAPTER 3

MATERIAL AND METHOD

This chapter covers the research material and methodology that were used to conduct the study. In material section is first presented the proposed Construction Risk Management Maturity Model with insight to its structure and content. Subsequently, the questionnaire design is described. The material of the study is then outlined, which is composed of five large scale Turkish Construction Companies, together with the reasons for their selection. In the subsequent section is first presented the preferred method of administration. The assessment, interpretation and demonstration of the results are briefly explained afterwards, and finally, statistical methods that were used for analyzing of data are given at the end of the section.

3.1 Material

After a thorough examination of the reviewed six maturity models dealing with risk management, several advantageous and disadvantageous points were identified, both in terms of content and in terms of usability. Brief descriptions of the models are presented in Section 2.3.6 of Chapter 2. A discussion on the acquired inferences is given in Section 2.5 and Table 2.10 was constructed based on the specific characteristics of the models, outlining the evaluation and comparison. As a result of the aforementioned reasons, instead of taking and using one of them as the tool for this study; it was intended to construct a new framework by taking full advantage of these existing models. All of the six reviewed models were utilized in the development of the new framework, as well as the reviewed construction-specific attributes and construction supply chain issues. Since all of the existing frameworks consist of entries rather than open and elaborate questions, the major aim was to obtain an easily usable questionnaire. By using the risk management maturity

questionnaire, it was aimed for construction organizations to be able to assess their strengths and weaknesses in the area of risk management.

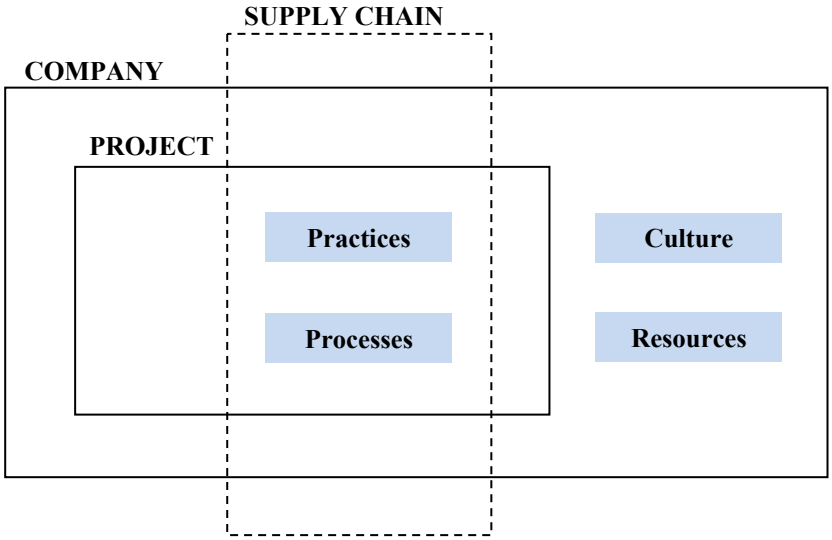

Figure 3.1. The framework of the proposed Construction Risk Management Maturity Model

The model framework integrates three sets for the area of construction risk management, which are: project level, company level and supply chain level, as depicted in Figure 3.1. For the project level, risk management practices and processes are considered, whereas for the company level, company culture and resources are also taken into account. As an important entity for the construction industry, supply chain level issues are integrated to the system, encompassing the practices and processes attributes. The attributes are composed of dimensions, which are the issues questioned under cover, as presented in Table 3.1. The content of each attribute is briefly described herein.

Table 3.1. Attributes and dimensions of the proposed model

ATTRIBUTES	DIMENSIONS
1. Culture	Belief Attitude Awareness Top management commitment Communication of risk information
2. Practices	Formalization Scope Integration with other management tasks
3. Resources	Budget People Training
4. Processes	Formalization Scope Tools Organizational learning Documentation

The "**Culture**" attribute aims to distinguish the attitude of the organization towards risk management, whether it is seen as a distraction or a critical success factor, and to what extent its value and benefits are recognized. The section also examines risk management awareness, by questioning the impact of risk management on project and company related success criteria. Top management's approach towards risk management is another dimension considered. Communication of risk related information is also assessed under this attribute, since it is important in terms of raising risk awareness within the project team, company and among the project parties.

The following section is "**Practices**", which examines the application of formal risk management practices within the organization; whether it is proactive, systematic, and standardized or not, and to what extend it is applied. The other issue covered is the scope of risk management practices, questioning if it is carried out on a project basis, organizational basis or supply chain basis. Integration of risk management with other management tasks is also included in this section. Project management tasks

and corporate management tasks are grouped and levels of integration that the company possesses between these and its risk management practices are questioned.

The third attribute is "**Resources**", dealing with organizational risk management resources in terms of budget, people and training. The allocation of a budget is the first dimension to examine, where the allocation can be with respect to tools, experts and training. Who deals with risk management within the organization is another question raised, dealing with knowledge, experience and teamwork on risk management. The existence of risk management training for the staff is another issue covered.

"**Processes**" section is composed of questions related with main processes of risk management; risk identification, risk analysis, risk response development and, risk monitoring and control. Formalization, scope, usage of tools, learning from experience, documentation and relations within the supply chain are the main concerns. In terms of risk identification, other than standardization and formalization, considered project objectives, scope of the risks identified and participation are all questioned. Risk analysis question explores the existence of a systematic analysis approach; qualitative and/or quantitative risk assessments. In terms of learning from experience, utilization of a historical database to collect information on typical risks encountered and related experiences is examined. To what extent formalized risk response strategies and risk monitoring and control processes are applied constitute the other concerns, together with preparation of reports documenting the risk management activities.

The original questionnaire of the framework is presented in Appendix A. Other than its main body consisted of four sections (*i.e.* the attributes), an initial section comprised of general questions is added to gather information about the company and the respondent. The main part includes twenty questions in total, some of them with sub-components. The answer choices are representatives of four levels of maturity, with most of them comprised of detailed descriptions and some of them having a four point Likert scale ranging from "not applicable" to "high".

The applicability of the proposed risk management maturity questionnaire was tested through case studies. As the material of the survey, 5 construction companies were selected among the 125 members of Turkish Contractors Association (TCA). Selection was done based on the reputation of the companies, considering their business volume, age, number of employees and international activity. Other criterion that formed the selection was the willingness of the companies for participation in this study. Each of the five selected companies has an annual turnover of more than 400 million USD, carries out a large workload abroad and has at least 30 years of experience in the construction sector. Three of them are ranked in "The Top 225 International Contractors" and two of them in "The Top 225 Global Contractors" lists of Mc Graw Hill's "Engineering News Record" in 2009 (ENR, 2009). The former is based on the construction revenues of companies in the international market, whereas the latter considers the revenues of the companies both in home country and international market. All of the respondents held important positions in their companies. The individual characteristics of each company are described in the following sub-sections.

3.1.1 Case Study A

For Company A, the interview and questionnaire were conducted with the general coordinator and a project manager from the firm, who responded in collaboration. Company A is the construction branch of a reputable international group of companies with its strong financial structure and specialist workforce in both domestic and international markets, founded in 1959. The group initiated works abroad in the early 1970s. The company group carries out projects over a vast geographical area; Middle East, Europe, CIS countries, South East Asia, North Africa and Ireland. The group undertakes works in the areas of industrial plants manufacturing and erection, power systems, energy, trade and tourism. In Turkey, the group has accomplished large scale projects in power generation, petroleum, petrochemical and gas plants, high rise buildings, water and sewage treatment plants, bridges and various other infrastructure facilities.

With 50 years of experience, the construction branch is specialized in manufacturing and erection of industrial plants, power plants, refineries, pipelines and water treatment systems. Other than industrial projects, the company also carries out civil construction projects, *i.e.* the construction of infrastructure facilities, dams, subway systems, factories, high rise buildings, housing complexes and commercial centers. The company has a 700 million USD approximate annual turnover and a workforce of 1022 employees in Turkey, with a total number of 24301 employees all over the world. Its international activities include numerous projects in Iran, Iraq, Jordan, the United Arab Emirates, Saudi Arabia, Malaysia, Russia, Turkmenistan, Uzbekistan, Azerbaijan, Kazakhstan, Libya, Qatar, Ireland, Bulgaria, Macedonia and Yemen.

3.1.2 Case Study B

The case study was conducted with the foreign relations and project development manager of Company B. The organization was founded in Ankara in 1966. It is the construction branch, the first and leading company of a group of companies, which serve in several different sectors, *i.e.* construction, trade, defense, machinery and manufacturing, tourism and finance. The group has over 20000 native and foreign employees. By the 1980s, the construction branch initiated activities outside Turkey. Its projects expand into Russian Federation, Turkic Republics, United Arab Emirates, Saudi Arabia, Libya, Algeria, Qatar, Georgia, Bulgaria, Poland and Afghanistan, with its 10000 employees. The company realizes infrastructure projects, industrial complexes, manufacturing facilities, industrial districts, business and commercial complex projects, luxury/mass housing complex projects, hotel, holiday village and tourism facility projects. The annual turnover of the company is around 400 million USD.

3.1.3 Case Study C

For Company C, the respondent was a senior project manager as representative for the organization. Other than construction and contracting, the group of companies that Company C belongs to is active in a broad range of sectors including energy, air

transportation, cargo transportation, tourism, finance, aircraft maintenance and media. Founded in 1976, the construction branch has a wide range of services for all types of building and infrastructure projects, including high-rise buildings, shopping and trade centers, hotels, holiday villages, housing complexes, office units and similar prestigious buildings, as well as industrial plants, dam and hydroelectric power plants, irrigation facilities, tunnels, motorways and highways, reinforced concrete silos, water treatment plants, ground stabilization and piling works. Other than the construction of prestigious large scale projects in Turkey, its significant projects are spread to Algeria, Libya, Saudi Arabia, United Arab Emirates, Bulgaria, Albania and Egypt. Being one of the largest contractors of Turkey, the approximate annual turnover of the company is 450 million USD and its number of employees is about 11000.

3.1.4 Case Study D

The questionnaire was administered to the tender department manager of Company D. Founded in 1977; the organization is now among Turkey's leading construction firms, with its head office in Ankara. The affiliate companies of Company D operate in the fields of tourism, marketing, energy transportation, automotive equipment, machine industries, natural gas distribution and port operating services. The construction company carries out projects extending on a wide area including transportation (highways, motorways, railways, bridges, tunnels, ports, airports, urban infrastructure), hydraulic projects (dams, irrigation systems, *etc.*), energy and communication projects, industrial complexes and pipelines, military and environment oriented projects, as well as mass housing projects, schools, hospitals, hotels and office buildings. The field of activities covers a large geographical area, including Russian Federation, Cyprus, Jordan, Libya, Azerbaijan and Afghanistan. The company has an approximate of 400 million USD annual turnover.

3.1.5 Case Study E

The case study was conducted with the assistant manager of Company E. Established in 1963 in Ankara; it is now one of the pioneer companies of the Turkish construction industry with its 46 years of experience. The firm has expanded its operation into international construction in 1983. Its subsidiaries provide services in a wide range of areas such as tourism, finance, information technology, manufacturing and investment. The company carries out major projects of various kinds, namely; dams and hydroelectric power plants, marine projects (ports, wharfs, quays), industrial projects (factories, treatment plants, transmission systems, natural gas plants), transportation projects (roads, railways, rail mass transit systems), infrastructure projects and building projects (hotels, business centers and others like airports, hospitals, offices, *etc.*). Other than the considerable projects in Turkey, the activities of the organization are dispersed into Saudi Arabia, United Arab Emirates, Afghanistan, Kazakhstan, Uzbekistan, Qatar, Libya, Jordan, Romania and Ukraine. With its approximate annual turnover of 500 million USD, together with its subcontractors the company has around 6000 employees.

3.2 Method

The questionnaires were administered via face-to-face interviews to prevent misunderstandings about the questions and gather more reliable data. Also this method allowed getting comments about the questions and distinguishing confusing statements. The interviews were conducted between 17 September-10 October, 2009. Initially, a presentation on risk management, covering issues such as its processes, tools and integration of it with other project management areas, was given to respondents who wished to have a clearer point of view on the topic. The opinion of respondents on the subject domain was also taken, together with the advantages and disadvantages of the systematic implementation of risk management.

The questionnaire findings are presented separately for each case, with the scores outlined by the use of tables and bar charts. Mean values were used in the calculation

of the attribute scores and overall maturity scores. Other than the mean scores, the mode depicting the most frequently repeated answer, and minimum and maximum levels of answers were also indicated in order to reflect the variance of the answers and thus, the degree of consistency. All in all, the mean values were utilized in determination of the maturity level. For the questions with sub-components (see questions 1.3 and 2.3 in Appendix A), the mean was calculated among the components and then rounded to the nearest integer to find the level for that question. Also, calculated attribute and overall maturity scores were generally not integers, indicating the organizations lying between the levels. Those scores were given in one decimal place, indicating progress towards the next maturity level in some areas. Supplementary to the scores and maturity levels, commentaries of the respondents were given in conjunction with discussion on the gathered data and identified maturity levels.

Moreover, statistical tests were conducted for certain comparisons and also to investigate the capability of the model to differentiate different levels of maturity. The data derived from this survey were qualitative and ordinal. The rankings were ordered from the least to the most, with respect to the maturity levels 1 to 4. Evaluations were carried out with Statistical Package for the Social Sciences software (SPSS 15.0). One dimension to assess was if there were any differences in terms of the attribute scores of the companies. The second dimension was to assess if there were any differences among the overall maturity scores of the companies. Both of these tests were carried out with Randomized Complete Block Design, at the 10% level of significance ($\alpha = 0.10$). The third dimension to assess was if there were any correlations between the attributes (*i.e. culture*, *practices*, *resources*, and *processes*). To test this, Pearson correlation was utilized.

As the last step, the questionnaire was revised in light of the feedback received from the case study applications. The final version of the questionnaire is presented in Appendix D.

CHAPTER 4

RESULTS AND DISCUSSION

This chapter is comprised of three sections. In the first section are given the results of the questionnaire survey. The subsequent section is composed of the statistical analysis tests conducted on the compiled data, the results given together with the inferences about the companies and commentaries related with the model. In the final section, revision of the model is explained, which was derived from the inspection of data.

4.1 Survey Results

In this section are presented the results of the questionnaire survey. Results are interpreted for each of the case studies and are given in the following sub-sections together with the commentaries made by the respondents. Complete response forms are given in Appendix B.

4.1.1 Results for Company A

Company A was rated at Level 3 maturity, with an average score of 3.2. The assessment results for Company A are given in Table 4.1 and maturity levels of each attribute are shown in Figure 4.1. The acquired high maturity level for this organization especially was in virtue of various applications related with risk management undertaken in the area of health, safety and environment (HSE). Conversely, when the other project performance criteria such as cost, time and quality were considered, the maturity level was relatively low, since no consistent practice existed with regard to. To be noted here is that, for questions that the respondent replied with respect to a specific area such as health and safety, the responds were used for data analysis as they were, in which maturity in other areas

were someway neglected. For example, Company A has a risk information database with respect to HSE, whereas such an application does not exist in terms of other areas such as cost and quality. The response that the respondents gave with respect to HSE was taken as indicating the level for this question. Therefore, it can be said that relatively higher scores were achieved. On the other hand, this distinction brought about a revision in the final model, which is expressed thoroughly in Section 4.3. To sum up, the company scored higher maturity levels in *culture* and *practices* attributes, but lower scores in the areas of *resources* and *processes*.

With regard to the face-to-face interview with the respondents, the approach of the company was evaluated to be open for innovation and change. The respondents stated that especially in the preceding years, the company had been undertaking a development process for the management activities. The company had initiated the application of SWOT analysis at the tendering stage. The respondents stated that they believe in the importance of risk management and consider it as one of the areas for their company which is open to improvement. They believed the systematic application of risk management to be an asset and advantage for their company. They also noted that requirements that come with specifications like ISO had already entailed the use of risk management. The individual interpretations of the attributes for Company A are given in the following sub-sections.

Table 4.1. Assessment results for Company A

	Mean Score	Mode	Range		Maturity Level
			Min	Max	
Culture	3.6	Level 4	Level 3	Level 4	Level 3
Practices	3.7	Level 4	Level 3	Level 4	Level 3
Resources	2.7	Level 3	Level 2	Level 3	Level 2
Processes	2.8	Level 2	Level 2	Level 4	Level 2
Overall	3.2				Level 3

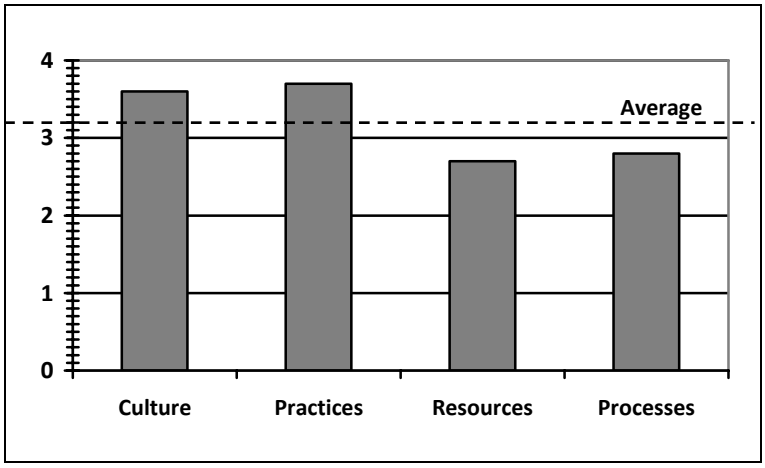

Figure 4.1. Maturity levels for Company A

A.1 Culture

Company A was rated at Level 3 maturity according to its company culture. It has a high awareness and belief in the value of risk management in average; risk management is considered as a critical success factor for the organization and thus, several benefits of it has been received with applications. The respondents had a high awareness of the impact of risk management on the various project and company related success criteria. Although not seen as a requirement and full commitment does not exist, top management supports risk management and is open for improvement. Risk related information is communicated not only within the project team but also within the company by the regular meetings held. On the other hand, communication of risk information within the supply chain does not exist.

A.2 Practices

Company A received its highest rating from the *practices* section, with a score of 3.7, owing to its risk management applications in the area of HSE. The respondents stated more systematic practices in terms of HSE, whereas other areas such as cost, time and quality are not systematically covered. On most projects, risk management is practiced and standardization efforts are undertaken. Although not applied

systematically on all projects, its ad-hoc implementation covers the project, organizational and supply chain risks. Integration of risk management with other management tasks were rated to be high in average, whereas the ones considered to be less integrated compared to others are scheduling, quality assurance and management, and value management.

A.3 Resources

The *resources* attribute was rated at Level 2 maturity, with a score of 2.7. There is no consistent budget allocation for risk management since budget allocation depends on project. Training exists only in terms of HSE, and utilized when required. There is no dedicated risk management team; project managers and tender managers deal with risk management.* External support is not used. Meetings are held to discuss the risks within a project.

A.4 Processes

Similar to the *resources* attribute, maturity of the *processes* could not reach Level 3, with a score of 2.8. As mentioned before, this score was also by means of the risk management applications in the area of HSE. For large projects, the organization makes use of some checklists for identifying project risks. Although there is no usage of advanced tools, the mentioned standard forms are utilized for the risk identification and analysis processes applied in the tendering stage. The probability and impact of the risks are evaluated thereby. Project related criteria are rated, and if the ratings are above the designated level, the project is determined as risky and the company does not take the project. In the risk identification process, long term objectives about the company are not among the ones that the company considers. Risk identification is performed by project managers and tender managers, and

* A problem was encountered for question 3.3, as in general, the respondents could not distinguish between choices Level 2 and Level 3. In the evaluation of the questionnaire, Level 2 was applied if it was top management dealing with risk management and Level 3 was applied if the project team was also involved in the process. Answers to question 3.3 were also considered during this determination. This point is further explained in Section 4.3.

covers a wide range of issues that are related with the project itself, macro environment, company and supply chain.

There is a risk information database that the risk items and risk triggers are collected, but only in terms of HSE. Same applies to risk monitoring and control, as a formalized generic process for actively and routinely tracking risks exists for HSE. For health and safety, reports are prepared, stored on the computer, shared and used for forthcoming projects. Accordingly, it can be inferred that the company has a more systematic approach for risk management in terms of HSE. In terms of risk response development, there is no consistent usage of risk management plans. Future risk events are dealt by informal gatherings.

4.1.2 Results for Company B

Company B was evaluated to have an overall maturity score of 2.5 and therefore Level 2 maturity. The assessment results for Company B are outlined in Table 4.2, whereas Figure 4.2 shows the maturity levels for each attribute. Although the company was assessed to have a Level 3 culture, its maturity level was found to be at Level 2 in terms of *practices* and *processes*, and Level 1 in terms of *resources*. The respondent of Company B stated that the risks within the project and whether to bid for the project or not are all discussed within the project team, but not as a systematic process. The interviewee considered the application of systematic risk management as a disadvantage at the tendering stage of the project. Because of the increased procedures, he believed that it would elongate the tendering process and cause to lose the project. According to the respondent, taking decisions in a short time and acting immediately is the way to leave their competitors behind. To quote the interviewee, "All the aspects of systematization, such as having the members rate the risks, presenting it to the board of directors and gather signatures require time and bring along delays." For Company B, each attribute is assessed in detail in the following sub-sections.

Table 4.2. Assessment results for Company B

	Mean Score	Mode	Range		Maturity Level
			Min	Max	
Culture	3.2	Level 3	Level 3	Level 4	Level 3
Practices	2.7	Level 2	Level 2	Level 4	Level 2
Resources	1.7	Level 2	Level 1	Level 2	Level 1
Processes	2.3	Level 2	Level 1	Level 4	Level 2
Overall	2.5				Level 2

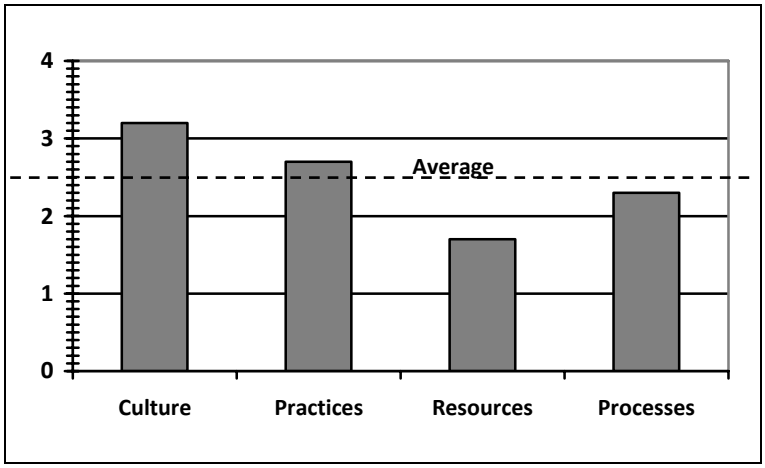

Figure 4.2. Maturity levels for Company B

B.1 Culture

With a score of 3.2 points, the company was rated at Level 3 maturity in terms of its organizational risk management culture. Value and benefits of risk management are recognized by the organization, although a consistent application does not exist. The respondent was evaluated to have medium-level awareness with respect to the impact of risk management on the mentioned success criteria. According to the respondent, the maximum impact of risk management is seen on time and cost; by increasing the profitability and reducing the time of projects, and minimum impact on organizational reputation and organizational learning. Top management supports risk management, but full commitment does not exist.

For the overseas projects, they work with a local subcontractor, joint venture or consultant. This is the main approach for the company to avoid risks. By this way, the company obtains information on the local circumstances of the country and the associated risks. Since the subcontractors are selected by this partner, risks are believed to be minimized. Risk related information is communicated within the project team and the company. When supply chain is considered, communication of risk information is among the company and the partners. There is no sharing of risk information with subcontractors, since it is not considered necessary with regard to the mentioned fact of working with a local agent.

B.2 Practices

Practices attribute of Company B was rated at Level 2 maturity, with a score of 2.7. There is no consistent application of risk management; it is practiced only on selected projects. Risks related to the project itself are considered for the risk management practices, but risks related to the organization and supply chain are out of scope. Integration of risk management with other project management tasks and corporate management tasks inside the organization is evaluated to be high by the respondent on average, where integration with resource management, quality assurance and management, supply chain management, procurement management and human resources management are evaluated to be relatively less integrated than the other tasks.

B.3 Resources

The *resources* attribute maturity of the organization was evaluated to be at Level 1, with a score of 1.7. First of all, there is no consistent budget allocation for risk management; it is project-dependent. Members of top management deal with risk management and the respondent believed that they have the related knowledge and experience. External support is not used. Formal training is not utilized for risk management.

B.4 Processes

Company B scored 2.3 for its *processes* attribute, indicating a Level 2 maturity. Risks are identified in large projects with formal gatherings, but there is no usage of formal tools such as checklists, automated forms, *etc*. The respondent considers such forms as of no use. When identifying project risks, the company considers tangible objectives such as quality, health and safety, and environment, as well as intangible objectives such as the reputation of the company. Project, country, company and supply chain risks are all covered under the scope of risk identification. Impacts of the identified risks are assessed, but only in terms of intuition and experience. Systematic risk analysis is not applied; there is no usage of qualitative and quantitative methods. The organization does not have an organizational learning mechanism, as they do not have a database to collect historical information about the risks encountered. In terms of risk response development, strategies to deal with risks are developed by informal gatherings rather than constituting formal risk management and risk allocation plans. There is no formal process for monitoring and controlling risks. Reports showing the progress of the project, incomes and expenses are prepared and presented to the board of directors once a month. As claimed by the interviewee, because of the critical economic conditions, the frequency of this application is increased than ever before. Other than this, the company does not have a documentation system intended for the risk management activities. The respondent stated that documentation can be done while the project progresses or as soon as it finishes, but considers its application as a distraction for the decision-making stage.

4.1.3 Results for Company C

Company C took an overall score of 3.1, indicating a Level 3 maturity. The company was assessed to be the most mature organization among the other four, with respect to its *resources* and *processes*. All of the attributes were assessed to be at Level 3 for the company, indicating consistency among company culture, practices, usage of resources and existence of formal processes for risk management. The assessment results can be seen in Table 4.3 and Figure 4.3. According to the respondent of

Company C, risk management is now well known among companies and applied extensively. For the overseas projects, especially if it is the first entrance to that country, systematic risk management applications are carried out by Company C. Qualitative and quantitative risk assessments are undertaken, with a budget allocated for the activities. The company works with subcontractors and suppliers that have been already known beforehand, so risks related with supply chain are minimized in this manner. Following sub-sections include further interpretations on each attribute for Company C.

Table 4.3. Assessment results for Company C

	Mean Score	Mode	Range		Maturity Level
			Min	Max	
Culture	3.2	Level 3	Level 3	Level 4	Level 3
Practices	3.0	Level 3	Level 3	Level 3	Level 3
Resources	3.0	Level 3	Level 3	Level 3	Level 3
Processes	3.1	Level 3	Level 2	Level 4	Level 3
Overall	3.1				Level 3

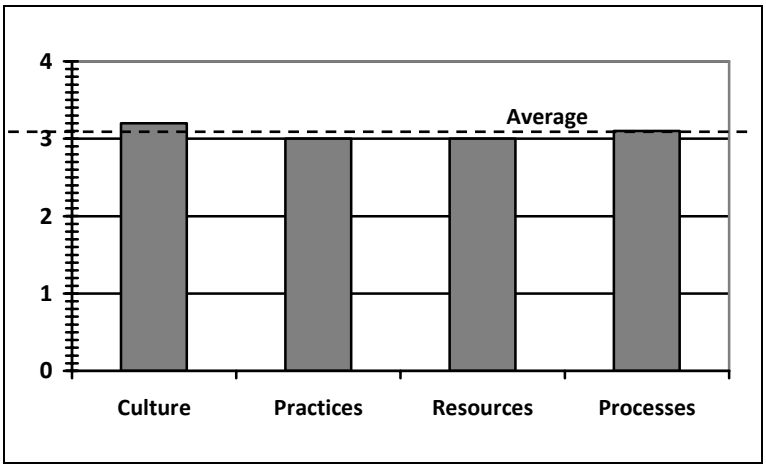

Figure 4.3. Maturity levels for Company C

C.1 Culture

Company C was assessed to have a Level 3 risk management maturity in terms of its organizational culture, with a score of 3.2. Belief and awareness in the value and benefits of risk management exist inside the organization. The respondent evaluated the impact of risk management on profitability and reducing time of projects as high, whereas on communication level, team spirit and relations with other parties as low. Accordingly, the awareness question dealing with the impact of risk management on project and company related success criteria returned an average score of 3. Top management supports risk management. Risk related information is communicated within the project team and the company.

C.2 Practices

Practices attribute was evaluated at Level 3, with a score of 3 for Company C. Especially in overseas projects, the company applies risk management systematically and they are trying to improve their practices. The respondent reported the scope of risk management practices as having an organizational basis. They are careful about their subcontractors and suppliers; they do not work with any firm that they do not rely on. As mentioned before, by working with parties that have been already known, the company believes to minimize the associated risks and does not feel the need for supply chain risk assessment. The respondent reported a high integration of risk management with scheduling, cost estimation, contract management, medium integration with resource, quality and value management, whereas a low integration with supply chain, health and safety, and environmental impact management in the company, therefore received a 3 points average score from the integration question. It can be inferred that integration of risk management with supply chain is low, since risk identification and analysis processes do not cover supply chain parties. It can also be said that the company is not sensitive as Companies A and E, for health and safety and environmental impact management. The respondent rated all of the corporate management tasks as having a high integration with risk management in the company, instead of human resources management.

C.3 Resources

Similar to the previous attribute, Company C was rated at Level 3 maturity from its *resources* attribute, with a score of 3. The company considers risk analysis as critical for overseas projects and therefore allocates a budget for that. The budget is used for staff to investigate the country conditions, for travel and extra expenses. Staff dealing with risk management depends on the project. If it is a risky project carried out abroad, a risk management team is assigned, whereas in ordinary projects, risks are dealt by project members who have basic risk management skills. Therefore, it can be said that risk management is not seen as a procedure under the sole responsibility of top management. Training on risk management is given to staff when required.

C.4 Processes

Consistent with its culture, practices and resources, Company C was rated at a Level 3 maturity in terms of its processes. For most projects, formalized risk identification procedures are applied by the organization. The company realizes the need for risk analysis in overseas projects and considers it in conjunction with risk identification. Critical factors such as the currency exchange rate, financial stability of the country, *etc.* are all investigated before project initiation. All tangible and intangible project objectives are considered during risk identification. In addition, the respondent noted relations with client as one of the considered factors. Technical project risks, country factors, risks related with company and supply chain are all assessed during risk identification.

According to the respondent, qualitative and quantitative risk assessments are complementary. If it is an overseas project, in addition to qualitative assessments, they gather statistical data related with the project and project environment, and make further analysis using a mathematical formula. This point is noteworthy, since Company C is unique among the others in terms of carrying out quantitative risk assessments. Obviously, this distinction carries the company one step forward on the maturity scale. Not to mention, the company has a historical database in which

historical information about the encountered risks are collected and organized. For overseas projects, contingency plans are prepared for each risk item and risks are routinely tracked with formalized procedures. Risk management activities are reported, and the reports are stored as hard-copy and used for forthcoming projects.

4.1.4 Results for Company D

Company D was evaluated to have Level 2 risk management maturity, with an average score of 2.6. The outlined assessment results are presented in Table 4.4 and maturity levels of the attributes are demonstrated in Figure 4.4. The results revealed a Level 3 culture, but Level 2 practices, resources and processes for Company D. According to the respondent of Company D, systematic implementation of risk management brings about extra costs, with extra paper work, extra personnel and extra time. The interviewee pointed out that US companies apply systematic risk management extensively, but they carry out projects for which risk management is certainly required or compete with other US companies. As the respondent continued, US firms give the construction work to subcontractors. By that means, they transfer the risky part of the project and deal with management and other risks. On the other hand, as claimed by the respondent, Turkish firms are generally responsible for complete works of the project. When competing with the US companies, the respondent stated that they give a lower bid amount and take the job, since the other company acts according to risk management. The respondent believed that risk management increases the costs and causes to lose the project. Accordingly, as the respondent further claimed, if Turkish firms spend time on systematization of their risk management processes, they would not be able to leave their competitors behind and undertake international projects as now. Therefore, the respondent mentioned the disadvantages of systematization as the slowing down of work, falling behind in competition with international companies and increase in costs. According to the respondent, there might be a few companies in Turkey that have a systematic application of risk management, which always take eligible international work. As expressed by the respondent, for their organization there may be some cases that the

project is considered as too risky and no bid is given; but in general, the priority is on taking the project and the organizational deficiencies are considered afterwards.

As the respondent claimed, systematic application of risk management has many advantages but is not suitable for the system in Turkey. Since most of the companies are family-based, managers carry out risk management according to their experience and consider it as an asset of them. Except the analysis part, they would not lean towards leaving the application of risk management to other personnel. But the respondent further added that the results may be very different if this study is repeated in ten years time. Each individual attribute is evaluated for Company D in the following sub-sections.

Table 4.4. Assessment results for Company D

	Mean Score	Mode	Range		Maturity Level
			Min	Max	
Culture	3.6	Level 4	Level 3	Level 4	Level 3
Practices	2.7	Level 3	Level 2	Level 3	Level 2
Resources	2.0	Level 2	Level 2	Level 2	Level 2
Processes	2.2	Level 2	Level 1	Level 4	Level 2
Overall	2.6				Level 2

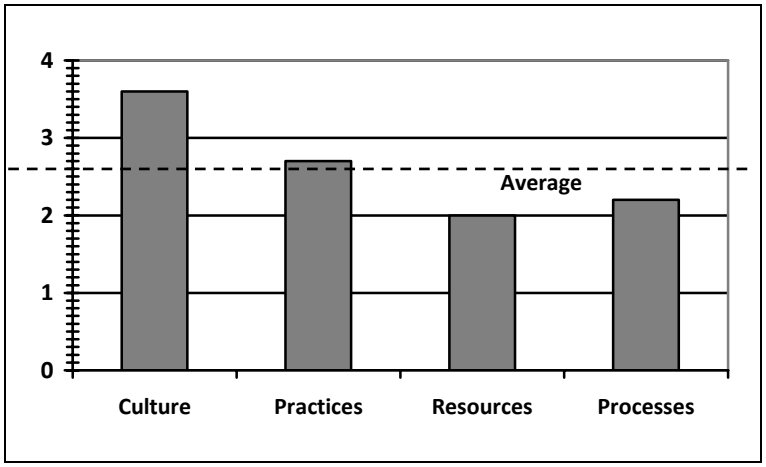

Figure 4.4. Maturity levels for Company D

D.1 Culture

Company D took 3.6 points for its organizational culture, indicating a Level 3 maturity. The respondent reported that the value and benefits of risk management are known and recognized by the company. Impact of risk management on the mentioned success criteria were evaluated as high in average, where impact on quality, organizational learning, communication level and team spirit were considered to have a lower impact when compared with the rest. Top management is informed about risk management and supports risk management. The respondent stated that communication of risk related information depends on the risk. Some risks are shared directly with the client at the very beginning of the project. On the other hand, in some situations, the respondent stated that they prefer not to share the risk with the client and communicate the risk information only within the project team.

D.2 Practices

The practices attribute was rated at Level 2, with a score of 2.7. As claimed by the respondent, the scope of risk management practices varies in domestic and overseas projects. For domestic projects, Company D practices risk management on a project basis. This is because in domestic projects, it is thought that deficiencies can be managed after the taking up of work. The focus is on taking the work rather than organizational deficiencies or the project parties. But for some overseas projects, in addition to the project risks, organizational and supply chain risks are all covered in terms of risk management. For the level of integration among risk management and other corporate and project management tasks, the company was evaluated at a medium level in average. The respondent reported the integration of risk management with human resources management as low. The reason was consideration of human resources subsequent to taking up of the work. The approach is that the personnel can anyway be found; the focus is again on taking the job. Similarly, the integration of risk management with resource management and supply chain management were evaluated as low. The respondent gave a medium rating to the risk management integration with scheduling, value management, strategic

planning and procurement management, whereas evaluating integration with other management tasks as high. The interviewee stated that integration of risk management with environmental impact management is very important, but it depends on the country. For example in Russia, he considered it as high, but for Libya, he stated that environmental impact management does not exist.

D.3 Resources

The use of risk management resources was rated at a Level 2 maturity for Company D. Budget allocation for risk management depends on project. Budget can be used for experts, but there is no budget allocation for tools and training. Risk management is carried out by top management. According to the respondent, they possess a risk management knowledge not based on formal training but based on experience. There is no regular risk management training taken by the organization.

D.4 Processes

Company D was assessed to have Level 2 *processes* with a score of 2.2. In this section, the respondent recommended the grouping of answers for domestic and overseas projects. They use a tender analysis form and risks are identified via that form in large projects. Although not a specific risk checklist, that form assists in tracking the risks also in the construction phase, identification of new risks and is helpful in following up of the project. The identified risks are reported and presented to the board of directors. All short-term and long-term project objectives are considered during risk identification. Identified risks cover project risks, country risks and organizational risks as well as risks related with supply chain. Although some degree of risk identification exists, there is no systematic risk analysis. Impacts of the identified risks are assessed by intuition and treated accordingly. Historical information about risks encountered is not collected. Mitigation strategies to deal with future risk events are always speculated instead of some risk free projects, but only in terms of informal gatherings. No formalized process exists for risk monitoring; the project team applies their own approach for controlling risks. Only

documentation for risk management activities is done by means of the mentioned tender analysis form.

4.1.5 Results for Company E

Company E was rated at an overall risk management maturity score of 2.6, indicating a Level 2 maturity. In spite of its Level 3 maturity in culture and practices, the maturity of its resources and processes attributes are relatively weaker with scores of 2 and 2.3.

According to the opinion of the respondent of Company E, risk management is valuable and beneficial, both in terms of cost and time. The interviewee considered the lack of a risk information database as a remarkable disadvantage for the company and believed that as a result of this, risks that have been encountered beforehand and are predictable become unpredictable. To be on the safe side, high contingencies are added to the bid amount. However, as the respondent continued, with systematic application of risk management and use of a database, risks on each type of project may become known. Accordingly, the use of checklists and other systematization efforts would give way to decisions that are taken more rapidly and correctly. By this way, lower and more competitive bid amounts can be given. Current application in the company is to determine a rough bid amount by gatherings, whereas the respondent noted that acting more consistently is possible with systematic risk management.

In the same manner, since there is no systematic application of risk management in the construction phase, that the respondent stated, “Rather than managing the risks, risks manage us.” The respondent was strongly opposed to the idea that risk management brings about the loss of time and resources. On the contrary, he believed that by planning the way to handle each risk proactively, no rooms are left for surprises in the construction phase and time is saved.

The respondent stated that the US companies apply systematic risk management extensively and expect the same from their collaborators. They finalize their projects as they figure out at project initiation. They are prepared for the surprises and confident during the construction phase. On the contrary, competing with them in specific locations, the respondent considered the case of Turkish companies as unstable, such that a project would be completed with loss subsequent to a satisfactory one.

Assessment results are outlined in Table 4.5 for Company E. Maturity levels for each attribute are shown in Figure 4.5 and each attribute is evaluated in detail in the following sub-sections.

Table 4.5. Assessment results for Company E

	Mean Score	Mode	Range		Maturity Level
			Min	Max	
Culture	3.2	Level 3	Level 3	Level 4	Level 3
Practices	3.0	-	Level 2	Level 4	Level 3
Resources	2.0	Level 2	Level 2	Level 2	Level 2
Processes	2.3	Level 2	Level 1	Level 4	Level 2
Overall	2.6				Level 2

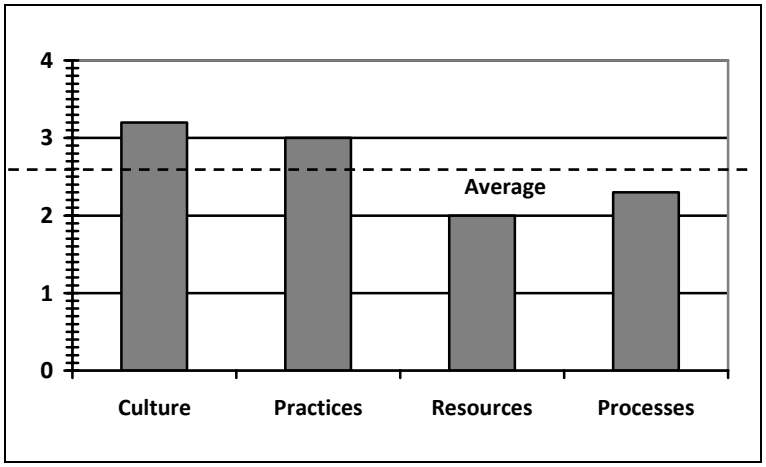

Figure 4.5. Maturity levels for Company E

E.1 Culture

Company E was assessed to have a Level 3 maturity in terms of its risk management culture, with a score of 3.2. The respondent of Company E had a high awareness of risk management and stated that it is also known and the benefits are recognized inside the organization. The interviewee reported a Level 3 awareness of impact of risk management on the project and company related criteria in average, specifying the highest impacted ones as safety and reliability, reputation, team spirit and client satisfaction. Although not fully committed, top management supports risk management. Company E communicates risk related information within the company through the regular meetings held by the board of directors each morning. Risks are among the topics that are discussed.

E.2 Practices

Company E scored 3 points with its risk management practices, indicating a Level 3 maturity for this attribute. For the formalization of practices, the respondent of Company E reported a Level 3 maturity, but pointed out that it is a partial application. In terms of health and safety, risk management is practiced on most projects and there are efforts for standardization. Statistics for health and safety are captured regularly. Risk management is practiced on a project basis. Integration of risk management with other management tasks is evaluated to be high on average, with cost estimation, resource management, contract management, health and safety management, business development, strategic planning and procurement management as the highest integrated ones. The reason for the respondent to evaluate the integration of risk management with cost estimation as high is the utilization of standard forms for cost estimation which also include the evaluation of risks. In terms of financial/portfolio management, risks are sometimes cannot be controlled and sometimes are passed over.

E.3 Resources

The company was evaluated at a low score of 2 with its resources attribute, hardly providing a Level 2 maturity. There is no consistent allocation of a risk management budget within the organization; it depends on project. Top management deals with risk management within the company, involving managers not formally trained on risk management but having experience. As claimed by the respondent, external support is not used, since it would take time for the expert to grab the internal structure and approaches of the company. No regular risk management training exists for staff.

E.4 Processes

The *processes* attribute was also evaluated as weak as the *resources* attribute, with 2.3 points score and Level 2 maturity. As mentioned before, risks are identified via a form used in cost estimation and also via brainstorming sessions, especially for large projects. In identification of risks, tangible objectives such as time and cost, quality, health and safety, and environment are considered. Risks identified cover the technical risks related with the project, country risks, organizational risks and risks related with the supply chain parties. Subsequent to risk identification, risk assessments are based on intuition; in other words, not a systematic approach is used. Although currently there is no risk information database within the company, an Enterprise Resource Planning (ERP) system, which would also cover the risk information, is in stage of development. Thus, the respondent believes that a particular risk information database is also to be established in the near future. For the risks identified, they think of mitigation strategies by informal gatherings, but plans are not prepared on a systematic basis. Likewise, there is no formal process used for risk monitoring. A documentation system exists just for the area of health and safety. Reports are always prepared, stored as hard copy and used for future cases for the health and safety risks.

4.2 Statistical Tests

Statistical analysis methods were utilized in order to make comparative inferences from the data gathered. With the received scores of each attribute, a bar-chart was formed as in Figure 4.6, to facilitate easy comparison among the company results. The crucial point here is that the aim was not to obtain generalizations about the Turkish Construction Industry. Instead, by the help of statistical analysis, it was intended to obtain more robust interpretations of the data gathered and test the capability of the model to differentiate between different levels of maturity.

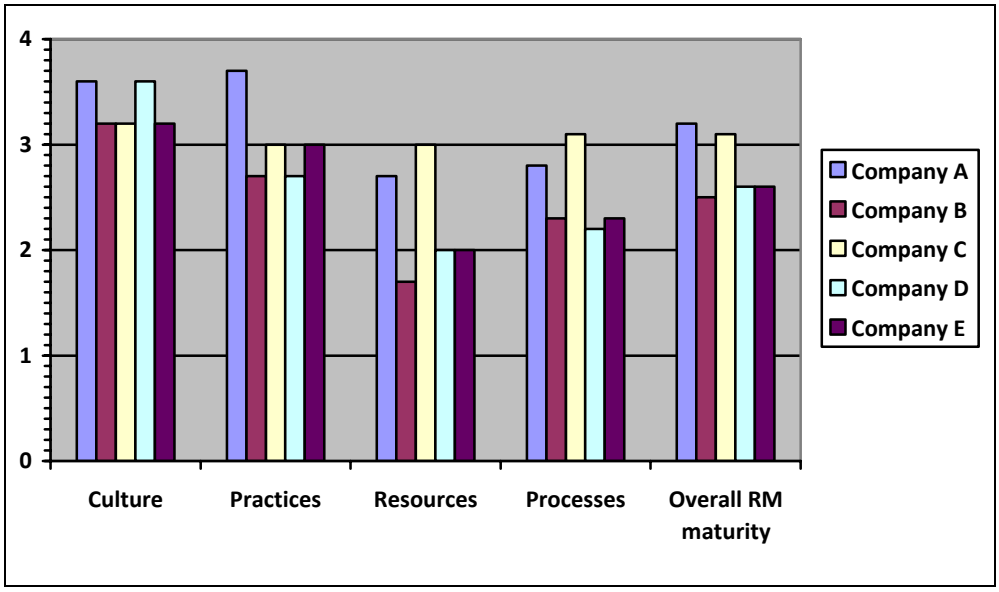

Figure 4.6. Comparison of the maturity levels among five case study organizations

4.2.1 Comparisons of the Attribute Scores

Randomized Complete Block Design was used in order to determine whether there were any differences or not in terms of the attribute (*i.e. culture*, *practices*, *resources* and *processes*) scores among the case study organizations at the 10% level of significance ($\alpha = 0.10$). Company and question effects were taken as fixed factors, whereas the question scores were treated as blocks and taken as the dependent

variable. The result of the analysis of variance (ANOVA) for each test is given in Appendix C. Four statistical hypotheses are presented as follows:

Hypothesis I:

Null Hypothesis: There is no difference between the population means of the *culture* scores of the companies.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$

H_A: At least one μ_i is different from the others

Where μ_i (i=1,2,3,4,5) refers to the population mean of *culture* scores for each company. The data lay-out for his hypothesis is tabularized in Table 4.6.

Table 4.6. Data on *culture* scores of the five companies in five randomized blocks (questions)

	Attribute 1: Culture				
	Q1	Q2	Q3	Q4	Q5
Company A	4	4	4	3	3
Company B	3	3	3	3	4
Company C	4	3	3	3	3
Company D	4	3	4	3	4
Company E	4	3	3	3	3

ANOVA result, which is outlined in Table C.1 of Appendix C, gives us a p-value of 0.325. Since this p-value is greater than $\alpha = 0.10$ significance level, the null hypothesis, H_0, was accepted and it was concluded that there was no significant difference between companies in terms of their *culture* scores. This similarity can be attributed to high belief and awareness of risk management among the case study organizations. Four out of five respondents considered risk management as necessary and stated that value and benefits are recognized inside the organization even if there is no consistent application. Moreover, it was evaluated for one company as a critical success factor and being applied accordingly. The respondents all received Level 3 or Level 4 average scores from the awareness question dealing with impact of risk

management on the various success criteria. The highest impact of risk management was rated to be seen on the increase in client satisfaction, whereas the second highest one was rated to be seen on the increase in safety and reliability, and the third ones were enhanced reputation and minimized conflicts/legal disputes. The lowest impact of risk management was rated to be seen on the increase in communication level. All respondents reported that risk management is supported by their top management, although not with full commitment. Mostly, risk information is communicated within the company, whereas for some cases, it is communicated also within the supply chain when needed. To sum up, medium or high rates in belief, awareness, top management commitment and risk communication were resulted in Level 3 maturity in terms of *culture* attribute among all of the case study companies.

Hypothesis II:

Null Hypothesis: There is no difference between the population means of the *practices* scores of the companies.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$

H_A: At least one μ_i is different from the others

Where μ_i (i=1,2,3,4,5) refers to the population mean of *practices* scores for each company. The data lay-out for this hypothesis is given in Table 4.7.

Table 4.7. Data on *practices* scores of the five companies in three randomized blocks (questions)

	Attribute 2: Practices		
	Q1	Q2	Q3
Company A	3	4	4
Company B	2	2	4
Company C	3	3	3
Company D	3	2	3
Company E	3	2	4

A p-value of 0.364 was derived from the ANOVA test, of which results are given in Table C.2 of Appendix C. Since this p-value is greater than $\alpha = 0.10$ significance level, the null hypothesis, H_0, was accepted and it was concluded that there was no significant difference between companies in terms of their *practices* scores. Although statistically not significant, it was perceived that Company A differs from the others with a score of 3.7, whereas others got close scores of 2.7 or 3. This distinction is also apparent from Figure 4.6 and the statistical insignificance was attributed to lower number of questions in this section (three questions). Four of the respondents reported a practice of risk management on most projects and efforts in standardization of practices, instead of the respondent of Company B, who stated a risk management practice only on selected projects. Scope of risk management practices varies between project basis and organizational basis, whereas Company A differentiates here with its supply chain based practices. All respondents evaluated the integration of risk management practices with other management tasks in their organizations as medium or high in average, whereas Company A possessed the highest point. When answers to the integration question were examined as a whole, it was seen that the highest integration was perceived on cost estimation, contract management and business development, whereas the lowest on supply chain management and human resources management. In general, it was concluded that Company A got a relatively higher *practices* score when compared with the other companies owing to the consistency among its formal risk management practices, the broad scope of its practices and the high integration with other management tasks.

Hypothesis III:

Null Hypothesis: There is no difference between the population means of the *resources* scores of the companies.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$

H_A: At least one μ_i is different from the others

Where μ_i (i=1,2,3,4,5) refers to the population mean of *resources* scores for each company. The data lay-out for his hypothesis is tabularized in Table 4.8.

Table 4.8. Data on *resources* scores of the five companies in three randomized blocks (questions)

	Attribute 3: Resources		
	Q1	Q2	Q3
Company A	2	3	3
Company B	2	2	1
Company C	3	3	3
Company D	2	2	2
Company E	2	2	2

ANOVA result, as it is outlined in Table C.3 of Appendix C, gives us a p-value of 0.016. Since this p-value is smaller than $\alpha = 0.10$ significance level, the null hypothesis, H_0, was rejected and it was concluded that at least one company is different from the others in terms of its *resources* score. For that reason, the next step was to investigate which company differs from the others. To compare the population means as pairs, Fisher's Least Significant Difference (LSD) test was used. The pairs of group means μ_i and μ_{i*} was declared significantly different if

$$\left|\bar{Y}_i - \bar{Y}_{i*}\right| > t^{\alpha/2} * \sqrt{\frac{2MSE}{n}},$$

where $t^{\alpha/2} * \sqrt{\frac{2MSE}{n}}$ is called as LSD, MSE is the estimate of the population variance (Mean Square Error) which is obtained from the ANOVA table, n is common group size for each company, and $t^{\alpha/2}$ is the corresponding percentage point of the *t*-distribution obtained from the significance level 0.10. For our data,

$$LSD = t_8^{0.95} * \sqrt{\frac{2(MSE)}{n}} = 1.860 * \sqrt{\frac{2(0.15)}{3}} = 1.860 * 0.316 = 0.588.$$

The result of multiple comparisons obtained from the SPSS is presented in Table C.4 of Appendix C. Mean differences bigger than the LSD value of 0.588 were declared as significant at the 0.10 level. When interpreted altogether, it was concluded that Company A and C are similar to each other, while Companies B, D and E also have a

similarity among themselves with respect to their *resources* scores. On the other hand, the two groups are different from each other. This result can also be checked against Figure 4.6, where the relationship is simply demonstrated. The distinction of Company A and C from the others was engaged to more than one feature. For Companies A and C, risk management is not a sole practice of top management; instead, project staff also deals with it. In Company A, project managers and tender managers are all active in the process, whereas in Company C there are in-house experts with formal training on basic risk management skills. Another differentiating point is training, since both companies give training on risk management when required. Moreover, Company C allocates a budget for the risk management activities in all projects, especially for country risk assessments and training. As a result, it can be inferred with confidence that the model is capable of differentiating between different levels of maturity, when various *resources* maturity levels ranging from Level 1 to Level 3 detected are considered.

Hypothesis IV:

Null Hypothesis: There is no difference between the population means of the *processes* scores of the companies.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$

H_A: At least one μ_i is different from the others

Where μ_i (i=1,2,3,4,5) refers to the population mean of *processes* scores for each company. The data lay-out for his hypothesis is tabularized in Table 4.9.

Table 4.9. Data on *processes* scores of the five companies in nine randomized blocks (questions)

	Attribute 4: Processes								
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
Company A	2	3	4	2	2	3	2	3	4
Company B	2	4	4	3	1	2	2	2	2
Company C	3	4	4	2	3	3	3	3	3
Company D	2	4	4	2	1	1	2	2	2
Company E	2	3	4	2	1	2	2	2	3

ANOVA result, outlined in Table C.5, gives us a p-value of 0.002. Since this p-value is smaller than $\alpha = 0.10$ significance level, the null hypothesis, H_0, was rejected and it was concluded that at least one company is different from the others in terms of its *processes* score. As a next step, pairwise comparisons were carried out through LSD test as mentioned above. For our data,

$$LSD = t_{32}^{0.95} * \sqrt{\frac{2(MSE)}{n}} = 1.693 * \sqrt{\frac{2(0.24)}{9}} = 1.693 * 0.23 = 0.389$$

The result of multiple comparisons obtained from the SPSS is presented in Table C.7 of Appendix C. Mean differences bigger than the LSD value 0.389 were declared as significant at the 0.10 level. When interpreted altogether, it was seen that the results are similar to the case in *resources* attribute. It was concluded that Company A and C were similar to each other, while Companies B, D and E also have a similarity among themselves according to their *processes* scores. On the other hand, the two groups are different from each other, just like the previous test results. Company C is the only company that possessed a Level 3 maturity in this section, whereas Company A got also a high score of 2.8. Other three companies were rated at a score around 2.3. Company C is the only company that undertakes a formalized risk identification process in most of its projects, whereas the others apply some formal methods in risk identification only for large projects. A main distinction was seen in risk analysis, as Company A utilizes risk checklists and carries out qualitative risk assessments. Moreover, Company C uses qualitative and quantitative methods in conjunction. On the other hand, Companies B, D and E do not apply a systematic process of risk analysis; instead, perform with intuition. Both Companies A and C utilize a historical database where typical risks encountered are collected. Company C is also mature in terms of risk response development and develops contingency plans for the risks in most of its projects. Companies A and C have formalized risk monitoring and control processes for routinely tracking risks. In terms of risk reporting, Company A comes to the fore with its documentation system for the area of health and safety, as the reports are stored on the computer and used for forthcoming projects. To sum up, it can be inferred that the model was capable of identifying different levels of *process* maturity.

4.2.2 Comparison of the Overall Maturity Scores

In a similar manner with the previous case, Randomized Complete Block Design was used in order to determine whether there were any differences or not in terms of the overall maturity scores among the case study organizations at 10% level of significance ($\alpha = 0.10$). Statistical hypothesis was proposed as:

Null Hypothesis: There is no difference between the population means of attribute scores of the companies.

Alternative Hypothesis: At least one population mean is different from the others.

H_0: $\mu_1 = \ldots = \mu_5$

H_A: At least one μ_i is different from the others

Where μ_i (i=1,2,3,4,5) refers to the population mean of attribute scores for each company. The data lay-out for his hypothesis is tabularized in Table 4.10.

Table 4.10. Data on attribute scores of the five companies in four randomized blocks

	Attributes			
	Culture	Practices	Resources	Processes
Company A	3.6	3.7	2.7	2.8
Company B	3.2	2.7	1.7	2.3
Company C	3.2	3.0	3.0	3.1
Company D	3.6	2.7	2.0	2.2
Company E	3.2	3.0	2.0	2.3

ANOVA result, as it is presented in Table C.6, gives us a p-value of 0.018. Since this p-value is smaller than $\alpha = 0.10$ significance level, the null hypothesis, H_0, was rejected and it was concluded that at least one company is different from the others in terms of its overall maturity score. As a next step, pairwise comparisons were carried out through LSD test. For our data,

$$LSD = t_{12}^{0.95} * \sqrt{\frac{2(MSE)}{n}} = 1.782 * \sqrt{\frac{2(0.088)}{4}} = 1.782 * 0.23 = 0.210.$$

The result of multiple comparisons obtained from the SPSS is presented in Table C.8. Mean differences bigger than the LSD value of 0.210 were declared as significant at the 0.10 level. The results showed a similarity with the *resources* and *processes* attributes. When interpreted altogether, it was concluded that Company A and C are similar to each other, while Companies B, D and E also have a similarity among themselves according to their overall maturity scores. On the other hand, the two groups are different from each other. When overall maturity is examined in terms of the maturity levels, it was seen that Companies A and C were ranked at a Level 3 maturity, whereas the others remained at Level 2. This difference is a reflection of the scores that companies took from the *resources* and *processes* attributes. Overall, it can be inferred that differences in each attribute affect the overall maturity level of the organization and different maturity levels can be identified with the developed maturity model.

4.2.3 Test for Correlations between the Attributes

In order to find out if any relationship exists among the attributes (*i.e. culture*, *practices*, *resources*, *processes*) or not, Pearson correlation was utilized. Pearson correlation coefficient is mainly sensitive to a linear relationship between at least two continuous variables. The Pearson correlation value can fall between 0.00 and 1.00, where 1.00 indicates a perfect correlation and 0.00 no correlation. Also the p-value can be utilized to define the correlation. If the p-value is smaller than 0.05, it can be inferred that there is a significant correlation between the variables, whereas a p-value bigger than 0.05 indicates no significant correlation. For this study, the results for correlation between the attributes are given in Table C.9 of Appendix C. Accordingly, only significant correlation exists between *resources* and *processes* attributes, with a Pearson correlation value of 0.955, which is very close to 1.00, and a p-value 0.012, which is smaller than 0.05. From this high positive correlation between *resources* and *processes* attributes, it was inferred that companies which allocate resources for risk management in terms of budget, personnel and training, also possess systematic and mature processes. In terms of the case study organizations with relatively high *resources* scores, the budget allocation is in terms

of performing country risk assessments and training, and risk management is not a sole practice of the top management, but also dealt by experienced people involved in project. Since two of these are directly related with executing systematic processes, this correlation is deemed reasonable. Also, in both companies with high *resources* scores, there is the implementation of a risk information database, which also requires a budget. Therefore, it was concluded that the companies which do not give the required risk management training, not allocate a budget for risk management and which do not allocate responsibility for risk management activities among its staff, carry out immature risk management processes.

4.3 Revision of the Model

On the basis of conducted case studies, some points were identified that would lead for the improvement of the model and some revisions were applied accordingly. The final version of the questionnaire is presented in Appendix D. The revisions and reasons prompted them are explained herein.

It was seen that the respondents could not distinguish that the answer choices have a gradually increasing scale and that each choice comprises the previous one. There were some cases of questions that the respondents wanted to select two or more consecutive answers at the same time. From this point, it was inferred that it should be denoted in the introductory part of the questionnaire that only one choice can be selected for each question. In general, it was seen that the questions were easily understood and answered. Instead, for questions 3.1 and 4.3, some explanatory elaborations were made with some examples to increase comprehensibility.

It was seen that question 1.5, related with communication of risk information, was not perceived by the respondents as it was intended. Since some risk related information could be confidential, sharing of information related with each risk cannot be considered as beneficial for the company. The point here is that to communicate risk related information (which is not confidential) at the project initiation phase increases awareness of risks among the project parties. Accordingly,

the question was revised as examining the belief in the benefits of risk communication and confidentiality term was added to its content.

A major revision was formed as the respondents gave their answers according to some specific areas, *e.g.* health and safety, and pointed out that they have different approaches for each category. This point was also declared by Loosemore, *et al*. (2006), as a result of experience in using the audit tool presented as Model 6 in Section 2.3.6 of Chapter 2. For question 2.1, which is the initial question of the *practices* section, a grouping was formed among the answer choices by using project performance criteria (*i.e.* cost and time, quality, health and safety, and environment). It was observed with the questionnaire administration that in practice, companies can possess practices in different maturity levels for each of these areas. As an initial and main question for the *practices* section, now this question would measure the maturity level of practices, related with each project performance criterion. Question 4.6, examining the existence of a risk information database, was also reorganized with subgroups of project performance criteria. The reason was that, in this question, the respondents again expressed different application levels for different criteria.

Another inference obtained from the questionnaire implementation was that risk management practices of companies may vary with respect to the project location. For question 2.2, which is dealing with the scope of risk management practices, again the answer choices were grouped, but this time according to the project location (*i.e.* domestic or overseas).

It was also seen that the answer choices of question 3.2, which is related with the staff dealing with risk management, were confusing for the respondents, since in most of the companies top management deals with risk management and external support is not used. Respondents claimed that their top management has the required knowledge coming together with experience but have not taken formal training. So there were respondents who were not able to choose between Level 2 and Level 3. A revision was made among the choices according to the perceived answers.

CHAPTER 5

CONCLUSION

In this chapter is first presented a summary of the study, through a succinct explanation of its aim and the principal stages. Then a discussion on how this study can be utilized for practical purposes and the main research findings are given. The chapter is concluded with limitations of the study and recommendations for future research.

5.1 Summary of the Research

With its value and benefits being increasingly recognized by the construction companies, risk management applications are rapidly growing in the construction sector. Risk management is accepted as the major agent in ensuring successful project management and as a critical success factor for the construction companies, aiming at proper functioning of the projects and therefore, organizations. There is a growing amount of research on risk management, although some areas are still open to improvement. There is not much research conducted on “maturity” in construction risk management, although various generic maturity models and models specific to other industries in the area of risk management have been developed. Maturity models are aimed to assess the current capability maturity of an organization in a particular area, aid in the determination of strengths and weaknesses, and by that means, assist in the development of targeted improvement strategies for companies. Improved risk management maturity would mean enhanced risk management practices, a mature organizational culture with risk awareness and advanced communication within the company and among project parties, better use of organizational resources for risk management and all in all, a stronger structure in terms of risk management. From this point, this study was intended to investigate risk management maturity with respect to construction.

Initially, previously developed risk management maturity models were investigated with a thorough literature review. As a result, six of them were identified as being competent and further examined in terms of their usability and effectiveness. According to the comparisons made among the models, several advantageous and disadvantageous points were inferred. The main determination was that most of these models were in the form of a framework intended to indicate the topics to be examined for a maturity assessment. It was believed that there was a need to enhance the usability of these models. Another problematic point was related with the applicability and comprehensibility of these models for the Turkish construction industry. From here, the major aim of this study was to develop a risk management maturity framework, which also provides a practical and effective questionnaire, and which is also applicable to the Turkish construction organizations. The existing models were utilized in the development of the new model, as well as the relevant information searched from the literature. Construction-specific attributes and related studies were reviewed and the major barrier against application of a maturity model to the construction industry was specified as the multi-firm collaboration in construction. Accordingly, issues related with construction supply chain were investigated through a literature survey and utilized in model development. As a result, the framework of the model was constructed with four attributes and their relative dimensions, as presented in the material section of Chapter 3. The questionnaire based on the framework is composed of twenty main questions and given in Appendix A.

Subsequent to model development, the applicability of the model was examined through case studies. Five construction companies were selected among the 125 members of Turkish Contractors Association (TCA) and questionnaires were administered via face-to-face interviews to respondents belonging to top management or relevant management departments of the companies. To be utilized for the improvement of the model and interpretations, commentaries of the respondents were taken related with the questions and also on relevant issues of risk management. Also, some vague questions were identified.

As the next step, the results of the questionnaire survey were interpreted for each company and demonstrated with tables and bar-charts. Certain comparisons among the attribute scores and among the overall maturity scores of the organizations, and correlations between the attributes were investigated through statistical tests, to facilitate more robust interpretations of the gathered data and to test the capability of the model in identifying different maturity levels. Finally, the questionnaire was revised in light of the feedback received from the case study applications, as presented in Appendix D.

5.2 Main Results

This framework and questionnaire can be used by construction organizations wishing to enhance their risk management approach. It can serve for determining the weaknesses possessed in the area of risk management. The model can also aid in developing risk management awareness and familiarity with the concept by presenting the perspective, practices, use of resources and processes that a construction organization should possess to have an advanced capability in risk management.

The findings of the statistical tests revealed that the model is capable of differentiating attributes of different maturity and hence different levels of organizational maturity. It was seen through the case studies that the questionnaire was easy to comprehend and easy to apply.

One finding of the study was that, since construction is a project-based industry, risk management practices of an organization, its usage of risk management resources and application of risk management processes might differ according to project type and project location. An organization might possess different maturity levels in terms of different project performance criteria, as also claimed by Loosemore, *et al.* (2006). These criteria were specified as cost and time, quality, health and safety, and environment. Accordingly, an organization might possess a level 3 maturity in terms of its risk management practices related with health and safety, but might have no

formal application of risk management for quality risks. Therefore, different project performance criteria should be examined for a comprehensive assessment. This finding was reflected to the final version of the model, by integrating such criteria in the initial question of the practices section (question 2.1). This question now acts as a monitoring question that aids in the interpretation of the subsequent ones. Similarly, it was seen that in organizations, the use of a historical database might also vary in terms of different project performance criteria (*i.e.* cost and time, quality, health and safety, and environment). Hence, the question 4.6 was also reorganized accordingly. Another finding was that organizations might carry out different risk management practices in their domestic and overseas projects. For example, in domestic projects the scope of risk management practices might have a project basis, whereas for overseas projects, risks related with the organization and related with the supply chain members might also be taken into account, as well as the project risks. Therefore, a distinction should also be made to cover the variation between the risk management practices in domestic and overseas works. In the final version of the model, it was reflected to question 2.2 examining the scope of risk management practices, and the question was rearranged by integrating the project location.

It was observed that all of the surveyed companies possess a strong risk management culture, with its value and benefits widely recognized. But there was a marked weakness in terms of the resources and processes scores among the companies when compared to culture and practices attribute scores. This relationship was further investigated with statistical analysis and a high positive correlation was found between the resources and processes attributes. It was inferred that companies which do not allocate a budget for its risk management activities also possess immature risk management processes.

5.3 Limitations of the Study

There were some limitations to this study, with respect to the restricted time and availability of the construction organizations. The number of case studies was limited to five, whereas more case studies would have been provided enhanced feedback on

the questionnaire and therefore contributed to the revision of the model. Another limitation was that the questionnaire administration was conducted with a single representative of the companies (except the case of Company A, where two respondents decided together on the answers). Instead, application of the questionnaire on several people from a single company and taking the average score of their answers to determine the final score would provide a more objective picture of that company. Furthermore, the credibility of the results would have been improved if documentation, resources and processes of each company had been observed in detail concurrently with the questionnaire administration and interviews.

5.4 Recommendations for Future Research

For future studies, this study provides a compilation of the research that has been carried out on risk management maturity. Further work might be of value to elaborate the questionnaire with more case studies conducted. Also, the maturity questionnaire can be used to provide a picture of the current risk management maturity in the construction sector, by applying it extensively among organizations through mail or internet. Moreover, the rating system can be developed in a way that interrelations and fuzzy borders between the attributes are taken into account.

LITERATURE CITED

AKINTOYE, A. and M. J. MacLeod. 1997. Risk analysis and management in construction, in: *International Journal of Project Management* (p. 31-38, v. 15, n.1).

AKINTOYE, A., G. McIntosh and E. Fitzgerald. 2000. A survey of supply chain collaboration and management in the UK construction industry, in: *European Journal of Purchasing & Supply Management* (p. 159-168, v. 6).

AL-BAHAR, J. and K. C. Crandall. 1990. Systematic risk management approach for construction projects, in: *Journal of Construction Engineering and Management* (p. 533-546, v. 116, n. 3). September, 1990.

ALLEN, D. 1995. *Risk Management in Business.* Cambridge University Press, Cambridge.

ANDERSEN, S. and S. A. Jessen. 2003. Project maturity in organizations, in: *International Journal of Project Management* (p. 457-461, v. 21).

BRADY, T., A. Davies and M. Hobday. 2003. Building an organizational capability model to help deliver integrated solutions in complex products and systems, in: *Proceedings of the Annual Meeting of the European Academy of Management (EURAM)*. 3-5 April, 2003. Bocconi University, Milan.

BURTONSHAW-GUNN, S. A. 2009. *Risk and Financial Management in Construction*. Gower Publishing Limited, Surrey.

CHAPMAN, C. B. and S. C. Ward. 1997. *Project Risk Management: Processes, Techniques and Insights*. John Wiley and Sons, Chichester.

CHAPMAN, C. B. and S. C. Ward. 2003. *Project Risk Management: Processes, Techniques and Insights*, 2nd edition. John Wiley and Sons, Chichester.

CHRISTOPHER, M. 1992. *Logistics and supply chain management*, Pitman Publishing, London.

CMMI Product Team. 2002. *Capability Maturity Model Integration (CMMI) Version 1.1.* Carnegie Mellon Software Engineering Institute, Pittsburgh, PA.

COOKE-DAVIES, T. 2004. Project management maturity models, in: *The Wiley Guide to Managing Projects* (Chapter 49). J. K. Pinto and P. W. G. Morris, eds. Wiley, New York.

COOKE-DAVIES, T. 2005. Measurement of organizational maturity: questions for further research, in: *Innovations: Project Management Research 2004*. Project Management Institute, Newtown Square, PA.

CRAWFORD, J. K. 2002. *PM Solutions Project Management Maturity Model: Providing a Proven Path to Project Management Excellence*. Marcel Dekker, Inc., New York.

DALLAS, M. F. 2006. *Value & Risk Management: A Guide to Best Practice*. Blackwell Publishing, Oxford.

DİKMEN, I., M. T. Birgönül and A. E. Arıkan. 2004. A critical review of risk management support tools, in: *20th Annual Conference of Association of Researchers in Construction Management (ARCOM)* (p. 1145-1154, v. 1). 1-3 September. Heriot-Watt University, UK.

DİKMEN, I., M. T. Birgönül, C. Anaç, J. H. M. Tah and G. Aouad. 2008. Learning from risks: a tool for post-project assessment, in: *Automation in Construction* (p. 42-50, v. 18).

EGAN, J. 1998. *Rethinking Construction*. HMSO, London.

Engineering News Record (ENR). 2009. http://enr.construction.com, retrieved October 16, 2009.

FENGYONG, Z. and L. Renhui. 2007. Study on framework of construction project management maturity model, in: *2007 International Conference on Service Systems and Service Management* (p. 1-5).

FLANAGAN, R. and G. Norman. 1993. *Risk Management and Construction*. Blackwell Science, Oxford.

FOTI, R. 2002. "Maturity" noun, 21st century. Synonym: survival, in: *PM Network* (p. 39-43, v. 16).

GINN, R. D. 1989. *Continuity Planning: Preventing, Surviving and Recovering from Disaster*. Elsevier Science Publishers Ltd, Oxford, UK.

GIUNIPERO, L. C. and R. A. Eltantawy. 2004. Securing the upstream supply chain: a risk management approach, in: *International Journal of Physical Distribution & Logistics Management* (p. 698-713, v. 34, n. 9).

GUANGSHE, J., C. Li, C. Jianguo, Z. Shuisen and W. Jin. 2008. Application of organizational project management maturity model (OPM3) to construction in China: an empirical study, in: *2008 International Conference on Information Management, Innovation Management and Industrial Engineering*.

HAYES, R., J. Perry, J. Thompson and G. Willmer. 1986. *Risk Management in Engineering Construction: A Guide to Project Risk Analysis and Risk Management*. Thomas Telford, London.

HELDMAN, K. 2005. *Project Manager's Spotlight on Risk Management*. Jossey Bass, San Francisco.

HENDRICKSON, C. and T. Au. 1989. *Project Management for Construction*. Prentice-Hall, Inc., New Jersey.

HILLSON, D. A. 1997. Towards a risk maturity model, in: *The International Journal of Project and Business Risk Management* (p. 35-45, v. 1, n. 1). Spring, 1997.

HILLSON, D. A. 2000. Benchmarking risk management capability, in: *PMI Europe 2000 Symposium Proceedings*. January, 2000.

HILLSON, D. 2001. Benchmarking organizational project management capability, in: *Proceedings of the 32nd Annual Project Management Institute 2001 Seminars and Symposium.*

HILLSON, D. 2003. Assessing organizational project management capability, in: *Journal of Facilities Management* (p. 298-311, v. 2, n. 3).

HOBDAY, M. 1998. Product complexity, innovation and industrial organization, in: *Research Policy* (p. 689-710, v. 26).

HOPKINSON, M. 2000. Using risk maturity models, in: *Kluwer's Risk Management Briefing*.

HOPKINSON, M. and G. Lovelock. 2004. The project risk maturity model: assessment of the UK mod's top 30 acquisition projects, in: *PMI Europe Congress*, Prague.

HUMPHREY, W. 1989. *Managing the Software Process.* Addison-Wesley, Massachusetts.

IACCM Business Risk Management Working Group. 2003. Organisational maturity in business risk management: The IACCM business risk management maturity model (BRM3). Available from: http://www.risk-doctor.com/pdf-files/brm1202.pdf, retrieved 10 February, 2009.

IBBS, C. W. and Y. H. Kwak. 2000. Assessing project management maturity, in: *Project Management Journal* (p. 32-43, v. 31, n. 1).

IYER, G. R. 1996. Strategic decision making in industrial procurement: implications for buying decision approaches and buyer-seller relationships, in: *The Journal of Business & Industrial Marketing* (p. 80, v. 11).

JÜTTNER, U. 2005. Supply chain risk management: understanding the business requirements from a practitioner perspective, in: *The International Journal of Logistics Management* (p. 120-141, v. 16, n. 1).

KERZNER, H. 2000. *Project Management: A Systems Approach to Planning, Scheduling, and Controlling*, 7th edition. Wiley, New York.

KERZNER, H. 2005. *Using the Project Management Maturity Model*, 2nd edition. John Wiley & Sons, Inc., New Jersey.

KOSKELA, L., G. Ballard and G. Howell. 2003. *Achieving Change in Construction*. International Group of Lean Construction, Virginia.

KUMAR, V. and N. Viswanadham. 2007. A CBR-based decision support system framework for construction supply chain risk management, in: *Proceedings of the 3rd Annual IEEE Conference on Automation Science and Engineering*. 22-25 September, 2007. Scottsdale, AZ, USA.

LARSON, P. and J. Kulchitsky. 1998. Single sourcing and supplier certification: performance and relationship implications, in: *Industrial Marketing Management* (p. 73-81, v. 27, n. 1).

LATHAM, M. 1994. *Constructing the Team: Joint Review of Procurement and Contractual Arrangements in the UK Construction Industry*. Department of the Environment, London.

LEE, H., V. Padmanabhan and S. Wang. 1997. Information distortion in a supply chain: the bullwhip effect, in: *Management Science* (p. 546-558, v. 43, n. 4).

LERBINGER, O. 1997. *The Crisis Manager: Facing Risk and Responsibility*. Lawrence Erlbaum Associates Publishers, New Jersey, USA.

LONDON, K. A. and R. Kenley. 2001. An industrial organization economic supply chain approach for the construction industry: a review, in: *Construction Management and Economics* (p. 777-788, v. 19).

LOOSEMORE, M. 2000. *Crisis Management in Construction Projects*. American Society of Civil Engineers Press, New York, USA.

LOOSEMORE, M., J. Raftery, C. Reilly and D. Higgon. 2006. *Risk Management in Projects*, 2nd edition. Taylor & Francis, Oxon.

LOVE, P. E. D., Z. Irani and D. Edwards. 2004. A seamless supply chain management model for construction, in: *Supply Chain Management: An International Journal* (p. 43-56, v. 9, n. 1).

LOVE, D. and H. Li. 1998. From BPR to CPR – conceptualising re-engineering in construction, in: *Business Process Management Journal* (p. 291-305, v. 4, n. 4).

MACKINNON, M. 2002. The security team: these online services back up B2B security, in: *Purchasing B2B*.

MASON-JONES, R. and D. R. Towill. 1998. Shrinking the supply chain uncertainty cycle, in: *Control* (p. 17-22).

MC CORMACK, K. and A. Lockamy III. 2004. The development of a supply chain management process maturity model using the concepts of business process orientation, in: *Supply Chain Management: An International Journal* (p. 272-278, v.9, n.4).

MENTZER, J., W. DeWitt, J. Keebler, S. Min, N. Nix, C. Smith and Z. Zacharia. 2001. Defining supply chain management, in: *Journal of Business Logistics* (p. 1-25, v. 22, n. 2).

MERNA, A. and N. J. Smith. 1996. *Projects Procured by Privately Financed Concession Contracts* (v. 1 and 2). Asia Law & Practice, Hong Kong.

MERNA, T. and F. F. Al-Thani. 2005. *Corporate Risk Management: An Organisational Perspective*. John Wiley & Sons Ltd., Chichester.

MILLS, A. 2001. A systematic approach to risk management for construction, in: *Structural Survey* (p. 245-252, v. 19, n. 5).

MITROFF, I. and C. Pearson. 1993. *Crises Management: A Diagnostic Guide for Improving Your Organisation's Crises Preparedness*. Jossey-Bass Publishers, San Francisco, USA.

MORE, E. 1995. Crisis management and communication in Australian organisations, in: *Australian Journal of Communication* (p. 31-47, v. 22, n. 1).

NEWLAND, K. E. 1992. *On behalf of the APM SIG for Risk Management Benefits of Risk Analysis and Management*, Project, November.

O'BRIEN, W. J. 1999. Construction supply chain management: a vision for advanced co-ordination, costing and control, in: *Proceedings of the Berkeley-Stanford Construction Engineering and Management Workshop: Defining a Research Agenda for AEC Process/Product Development in 2000 and Beyond*. 26-28 August, 1999. University of California, Berkeley, CA.

O'BRIEN, W. 2001. Enabling technologies for project supply chain collaboration, in: *NSF/ICIS Infrastructure and Information Technology Workshop*. Arlington, VA.

PAULK, M. C., C. V. Weber, B. Curtis and M. B. Chrissis. 1995. *The Capability Maturity Model: Guidelines for Improving the Software Process*. Addison-Wesley, Massachusetts.

PEARSON, C. M., S. K. Misra, J. A. Clair and I. Mitroff. 1997. Managing the unthinkable, in: *Organisational Dynamics* (p. 51-64, v. 26, n. 2). Autumn, 1997.

PMI. 1992. *Project & Program Risk Management: A Guide to Managing Project Risks and Opportunities*. Project Management Institute, Inc.

PMI. 1996. *A Guide to the Project Management Body of Knowledge (PMBoK Guide)*. Project Management Institute, Newtown Square, PA.

PMI. 2002. *Risk Management Maturity Level Development*. Project Management Institute, London, UK. Available from: http://www.pmi-switzerland.ch/fall05/riskmm.pdf, retrieved 10 February, 2009.

PMI. 2003. *Organizational Project Management Maturity Model (OPM3): Knowledge Foundation*. Project Management Institute, Newtown Square, PA.

PMI. 2004. *A Guide to the Project Management Body of Knowledge (PMBoK Guide)*, 3rd edition. Project Management Institute, Newtown Square, PA.

RAFTERY, J. 1994. *Risk Analysis in Project Management.* E & FN Spon, London.

RAZ, T. and E. Michael. 2001. Use and benefits of tools for project risk management, in: *International Journal of Project Management* (p. 9-17, v. 19).

REMY, R. 1997. Adding focus to improvement efforts with PM3, in: *PM Network*. July, 1997.

REN, Y. T. and K. T. Yeo. 2004. Risk management capability maturity model for complex product systems (CoPS) projects, in: *International Engineering Management Conference 2004* (p. 807-811).

REN, Y. T. and K. T. Yeo. 2009. Risk management capability maturity model for complex product systems (CoPS) projects, in: *Systems Engineering* (v. 12, n. 4).

Royal Society. 1991. *Report of the Study Group on Risk: Analysis, Perception, and Management* (group coordinator Sir F. Warner). Royal Society, London.

SANTOS, A. and J. Powell. 2001. Assessing the level of teamwork in Brazilian and English Construction sites, in: *Leadership and Organization Development Journal* (p. 166-174, v. 22, n. 4).

SARSHAR, M., M. Finnemore, R. Haigh and J. Goulding. 1999. SPICE: Is a capability maturity model applicable in the construction industry?, in: *Information Technology in Construction* (v. 4). 30 May-3 June, 1999. M. A. Lacasse and D. J. Vanier, eds. Vancouver, Canada.

SARSHAR, M., R.Haigh, M.Finnemore, G.Aouad, P. Barrett, D. Baldry, M. Sexton. 2000. SPICE: a business process diagnostics tool for construction projects, in: *Engineering, Construction and Architectural Management* (p. 241-250, v. 7, n. 3).

SHAOYAN, W. 2008. Collaborative knowledge creation in construction supply chain, in: *IEEE Symposium on Advanced Management of Information for Globalized Enterprises, 2008* (p. 1-3). AMIGE.

SIMISTER, S. J. 1994. The usage and benefits of project risk analysis and management, in: *International Journal of Project Management* (v. 12).

SINGH, K. 1998. The impact of technological complexity and interfirm cooperation on business survival, in: *Academy of Management Journal* (p. 339-369, v. 40, n. 2).

SMITH, N. 1995. *Engineering Project Management*. Blackwell Science, Oxford.

SMITH, N. J., T. Merna and P. Jobling. 2006. *Managing Risk in Construction Projects*, 2nd Edition. Blackwell Publishing, Oxford.

Software Engineering Institute's web-site. http://www.sei.cmu.edu, retrieved 15 February, 2009.

SVENSSON, G. 2002. A conceptual framework of vulnerability in firms' inbound and outbound logistics flows, in: *International Journal of Physical Distribution & Logistics Management* (p. 110-134, v. 32, n. 2).

TAH, J. H. M. 2005. Towards an agent-based construction supply network modelling and simulation platform, in: *Automation in Construction* (p. 353-359, v. 14).

TAYLOR, J. and H. Bjornsson. 1999. Construction supply chain improvements through internet pooled procurement, in: *Proceedings of IGLC-7* (p. 207-217). July, 1999. Berkeley, CA.

WHARTON, F. 1992. *Risk: Analysis, Assessment, and Management.* John Wiley & Sons, Chichester.

WISEMAN, R. M. and L. R. Gomez-Mejia. 1998. A Behavioral agency model of managerial risk taking, in: *Academy of Management Review* (p. 133-155, v. 23, n. 1).

WONG, A. and P. Fung. 1999. Total quality management in the construction industry in Hong Kong: a supply chain management perspective, in: *Total Quality Management* (p. 199-208, v. 10, n. 2).

VAIDYANATHAN, K. and G. Howell. 2007. Construction Supply Chain Maturity Model-Conceptual Framework, in: *Proceedings IGLC-15*. July, 2007. Michigan, USA.

VRIJHOEF, R. and L. Koskela. 2000. The four roles of supply chain management in construction, in: *European Journal of Purchasing & Supply Management* (p. 169-178, v. 6).

VRIJHOEF, R. and L. Koskela. 2001. Understanding construction chains: an alternative interpretation, in: *Proceedings of 9th Annual Conference International Group for Lean Construction*. Singapore.

ZAHRAN, S. 1998. *Software Process Improvement: Practical Guidelines for Business Success*. Addison-Wesley, Massachusetts.

APPENDIX A

CONSTRUCTION RISK MANAGEMENT MATURITY QUESTIONNAIRE

This questionnaire was developed with respect to the master's thesis "Assessing Risk Management Maturity: A Framework for the Construction Companies", which is an on-going study at Graduate Program in Building Science of Architecture Department, Middle East Technical University. It is intended to provide a methodology to measure the risk management maturity of construction organizations. Using the framework, organizations may identify their strengths and weaknesses in the area of risk management, and develop improvement plans accordingly. By participating in this study, you will contribute to the validation and refinement of the questionnaire, and provide research data.

Initially, it is expected from you to fill out general information about you and your company. The main body of the questionnaire is composed of four parts, each with sub-components, as follows:

1. Awareness/Culture
- Belief in value of risk management
- Attitude towards risk management
- Impact of risk management on project and company success criteria
- Top management commitment
- Communication of risk information

2. Practices
- Formalization of risk management practices
- Scope of risk management practices
- Integration of risk management with other project management tasks

3. Resources
- Budget for risk management
- Staff dealing with risk management
- Risk management training

4. Processes
- Risk identification
- Risk analysis
- Risk information database
- Risk response development
- Risk monitoring and control
- Risk evaluation

Any information provided from participators on behalf of their companies will be confidential and used only for academic purposes. We would like to thank for your time and your contribution to our study.

Begüm ÖNGEL
Thesis Supervisors: Assist. Prof. Ali Murat TANYER, Assoc. Prof. İrem DİKMEN

GENERAL INFORMATION ABOUT THE COMPANY AND THE RESPONDENT

1. Please state the full name of your company …….....

2. Please state your current position in the company ……..…….....

3. Please state the number of years that your company has been in the construction sector ……..

4. What kind of projects does your organization predominantly pursue? Please check the appropriate boxes.

- ❒ **Residential**
- ❒ **Building construction (Commercial buildings, hospitals, hotels, universities, governmental buildings, etc.)**
- ❒ **Industrial (Factories, refineries, powerhouses, etc.)**
- ❒ **Infrastructure (Sewerages, pipe lines, city infrastructure, etc.)**
- ❒ **Transportation (Roads, tunnels, bridges, etc.)**
- ❒ **Water structures (Dams, irrigation systems, etc.)**
- ❒ **Other** (Please state) …….

5. Yearly average turnover of your organization, please state …….....

6. Number of employees within the organization, please check the appropriate box.

❒ **< 100** ❒ **100-500** ❒ **> 500**

7. Does your organization carry out projects abroad? Please check the appropriate box.

❒ **No** ❒ **Yes**

8. Does your organization perform works instead of construction? (Material sale, tourism, *etc.*) Please check the appropriate box.

❒ **No** ❒ **Yes**

INFORMATION ON ORGANIZATIONAL RISK MANAGEMENT MATURITY

1. AWARENESS / CULTURE

Belief in value of risk management

1.1 Do you think that risk management is necessary for your organization? *Please check the appropriate box.*

- ❒ Not at all
- ❒ Not sure
- ❒ Yes
- ❒ Definitely

Attitude towards risk management

1.2 Which one better describes your organization's attitude towards risk management? *Please check the appropriate box.*

- ❒ Risk management is not essential to achieve our targets, it is even perceived as a distraction and waste of time.
- ❒ Although risk management may have some benefits, the extra expenses it creates and value it adds to our organization are questionable.
- ❒ Although not all the benefits are consistently gained, we are aware of the value and benefits of risk management.
- ❒ Risk management is a critical success factor and it can significantly improve business performance, benefits of risk management demonstrated by various applications.

1.3 Impact of risk management on below success criteria:
Please check the appropriate box for each criterion.

Project and company related criteria	None	Low	Medium	High
Minimize cost/Increase profitability	❒	❒	❒	❒
Reduce time of projects	❒	❒	❒	❒
Increase quality of projects	❒	❒	❒	❒
Increase safety and reliability	❒	❒	❒	❒
Enhance reputation	❒	❒	❒	❒
Increase organizational learning	❒	❒	❒	❒
Increase communication level	❒	❒	❒	❒
Enhance team spirit	❒	❒	❒	❒
Ensures better relations with project parties	❒	❒	❒	❒
Minimize conflicts/legal disputes	❒	❒	❒	❒
Increase client satisfaction	❒	❒	❒	❒
Other *(Please specify)*…….. ……..	❒	❒	❒	❒

Top management commitment

1.4 How do you consider top management's approach towards risk management? *Please check the appropriate box.*

- ❒ No awareness, no support
- ❒ Gives partial encouragement and passive support
- ❒ Supports risk management
- ❒ Full commitment to risk management, gives promotion, support and requires risk reporting

Communication of risk information

1.5 Do you communicate/share risk related information? *Please check the appropriate box.*

- ❒ No
- ❒ Within the project team only
- ❒ Within the company
- ❒ Within the supply chain

2. PRACTICES

Formalization of practices

2.1 How do you describe the risk management practices in your organization? *Please check the appropriate box.*

- ❒ Risks are not dealt with until they become a current problem, no risk management practice
- ❒ Risk management practiced only on selected projects, usually in response to client demands
- ❒ Risk management practiced on most projects and there are efforts to standardize practices
- ❒ Risk management practiced on all projects, it is systematic, routine and standardized

Scope of risk management practices

2.2 What is the scope of risk management practices in your organization? *Please check the appropriate box.*

- ❒ Not applicable
- ❒ Project basis (Total project risks are covered, but no risk management planning across projects)
- ❒ Organizational basis (Total project risks, the risks on other projects and other parts of the organization are all covered)
- ❒ Supply chain basis (Besides the organizational basis, risks related with the supply chain members are also taken into account)

Integration of risk management with other project management tasks

2.3 How do you consider the integration of risk management with other management tasks in your organization? *Please check the appropriate box for each task.*

Integration with other project management tasks	**Level of integration**			
	None	Low	Medium	High
Scheduling	❒	❒	❒	❒
Cost estimation	❒	❒	❒	❒
Resource management	❒	❒	❒	❒
Quality assurance and management	❒	❒	❒	❒
Supply chain management	❒	❒	❒	❒
Contract management	❒	❒	❒	❒
Health and safety management	❒	❒	❒	❒
Environmental impact management	❒	❒	❒	❒
Value management	❒	❒	❒	❒
Other *(Please specify)*…….. ……..	❒	❒	❒	❒

Integration with corporate management tasks	**Level of integration**			
	None	Low	Medium	High
Business development	❒	❒	❒	❒
Strategic planning	❒	❒	❒	❒
Financial/portfolio management	❒	❒	❒	❒
Procurement management	❒	❒	❒	❒
Human resources management	❒	❒	❒	❒
Other *(Please specify)*…….. ……..	❒	❒	❒	❒

3. RESOURCES

Budget for risk management

3.1 Does your organization have a dedicated budget for risk management? *Please check the appropriate box.*

- ❒ No budget and time allocated for risk management
- ❒ Budget allocation is not consistent, depends on project
- ❒ Budget allocated for all projects
- ❒ Budget allocated for risk management and improvement of risk management practices

Staff dealing with risk management

3.2 Who is dealing with risk management in your organization? *Please check the appropriate box.*

- ❒ There are no skills and capabilities relevant to risk management
- ❒ Individuals who have limited knowledge. External support is needed for risk management.
- ❒ In-house experts with formal training on basic risk management skills. Limited need for external support.
- ❒ Risk management unit or team with advanced training on risk management.

Risk management training

3.3 Is there training/personal development in the area of risk management in your organization? *Please check the appropriate box.*

- ❒ None
- ❒ Sometimes/not frequently
- ❒ Training on risk management when required
- ❒ Regular training to enhance risk management skills, training encouraged

4. PROCESSES

Risk identification

4.1 At the beginning of each project, do you identify risks as a standard activity? *Check the option that suits your organization most.*

- ❒ Sometimes we have some risk discussions on the project scope and milestone information, but we do not have a regular process as such.
- ❒ Our organization has some formal methods (usage of checklists, automated forms, influence diagrams, brainstorming sessions, etc.) for identifying project risks, but it is considered standard practice only for large projects.
- ❒ We apply a formalized risk identification process to most of our projects.
- ❒ A documented, repeatable process for identifying project risks and an improvement process to completely identify the risks as early as possible are in place.

4.2 When identifying risks, which project objectives do you consider? *Please check the appropriate box.*

- ❒ Only profitability considered (Impact on cost only)
- ❒ Impact on time and cost
- ❒ Impact on quality, health and safety, environment, *etc.* as well as time and cost
- ❒ Long-term objectives such as reputation, *etc.* as well as all tangible and intangible objectives

Scope of risk identification

4.3 Which one better describes the risks identified? *Check the option that suits your organization most.*

- ❒ Risks related with the project itself (technical risk assessment)
- ❒ Risks related with macro environment (country factors such as political, economic, *etc.*) as well as project risks
- ❒ Risks related with company (organizational risk assessment) as well as project and country
- ❒ Risks related with supply chain (supply chain risk assessment; all parties such as client, joint venture partners, subcontractors, etc.) as well as project, country and company

Participation in risk identification

4.4 Who are involved in the risk identification process? *Check the option that suits your organization most.*

- ❒ Individuals responsible for risk management
- ❒ Experienced people involved in project
- ❒ A risk identification team composed of experienced people in the company
- ❒ Key external stakeholders and suppliers participate in risk identification as well as company professionals

Risk analysis

4.5 Do you carry out systematic risk analysis? *Choose the option that suits your organization most.*

- ❒ Systematic approach does not exist, impacts assessed intuitively
- ❒ Risk assessment using qualitative methods such as risk rating technique (risk checklists), probability-impact matrices
- ❒ Risk analysis using statistical tools as well as qualitative methods
- ❒ Risk analysis using advanced methods (simulation, sensitivity testing, *etc*.) and related software / decision support tools

Risk information database

4.6 Does your organization have a database on typical risks encountered and related experiences? *Please check the appropriate box.*

- ❒ No, team members take decisions based on their own past experiences and discussions with the project team.
- ❒ No specific method to collect historical information, although some historical information about general trends in risk on similar projects may have been collected.
- ❒ Historical information such as common risk items and risk triggers are collected and organized in the historical database.
- ❒ Besides collecting the information such as common risk items and risk triggers, our historical database is subject to a continuous improvement process.

Risk response development

4.7 Does your organization determine mitigation strategies or contingency plans for the future risk events? *Please check the appropriate box.*

- ❒ No, in large part, there is consideration of risks as they emerge.
- ❒ We have some informal gatherings on the strategies to deal with the future risk events. In large projects, we make contingency plans for near-term risks and mitigation strategies.
- ❒ For most projects, contingency plans and mitigation strategies are developed for each risk item, so that project reserves can be allocated to cover such items when needed.
- ❒ In all projects, risk management plans, contingency plans and risk allocation plans are prepared and risk control strategies are formulated as well as risk finance strategies.

Risk monitoring and control

4.8 Does your organization have a process for risk monitoring? *Please check the appropriate box.*

- ❒ No
- ❒ Our project teams apply their own approach to managing and controlling risks, but not as a formal process. Responsibility is assigned for each risk item as it occurs.
- ❒ Yes, we have a formalized generic process for actively and routinely tracking risks, applied to most of our projects.
- ❒ A formalized generic process for risk monitoring is used in every project and risk management plans are updated periodically.

Risk evaluation

4.9 Do you have a documentation system for risk management activities? *Please check the appropriate box.*

- ❒ None
- ❒ Reports prepared on an ad-hoc basis and filed
- ❒ Reports always prepared, stored as hard-copy and shared
- ❒ Reports prepared, stored on the computer, shared and used for forthcoming projects

APPENDIX B

QUESTIONAIRE RESPONSES

Table B.1. Questionnaire responses for Company A

Company A			Level 1	Level 2	Level 3	Level 4
Culture / awareness	1.1	Belief in value of risk management				☑
	1.2	Attitude towards risk management				☑
	1.3	Impact of risk management				
	Project and company related criteria	• Minimize cost/Increase profitability				☑
		• Reduce time of projects				☑
		• Increase quality of projects				☑
		• Increase safety and reliability				☑
		• Enhance reputation				☑
		• Increase organizational learning				☑
		• Increase communication level			☑	
		• Enhance team spirit			☑	
		• Ensures better relations with project parties			☑	
		• Minimize conflicts/legal disputes				☑
		• Increase client satisfaction				☑
	1.4	Top management commitment			☑	
	1.5	Communication of risk information			☑	
Practices	2.1	Formalization of RM practices				
	2.2	Scope of RM practices				☑
	2.3	Integration of RM with other man. tasks				
	Project Management	• Scheduling			☑	
		• Cost estimation				☑
		• Resource management				☑
		• Quality assurance and management			☑	
		• Supply chain management				☑
		• Contract management				☑
		• Health and safety management				☑
		• Environmental impact management				☑
		• Value management			☑	
	Corporate Management	• Business development				☑
		• Strategic planning				☑
		• Financial/portfolio management				☑
		• Procurement management				☑
		• Human resources management				☑
Reso-urces	3.1	Budget for RM		☑		
	3.2	Staff dealing with RM			☑	
	3.3	RM training			☑	
Processes	4.1	Risk identification		☑		
	4.2	Consideration of project objectives			☑	
	4.3	Scope of risk identification				☑
	4.4	Participation in risk identification		☑		
	4.5	Risk analysis		☑		
	4.6	Risk information database			☑	
	4.7	Risk response development		☑		
	4.8	Risk monitoring and control			☑	
	4.9	Risk evaluation				☑

Table B.2. Questionnaire responses for Company B

Company B			Level 1	Level 2	Level 3	Level 4
Culture / awareness	1.1	Belief in value of risk management			☑	
	1.2	Attitude towards risk management			☑	
	1.3	Impact of risk management				
	Project and company related criteria	• Minimize cost/Increase profitability				☑
		• Reduce time of projects				☑
		• Increase quality of projects			☑	
		• Increase safety and reliability			☑	
		• Enhance reputation		☑		
		• Increase organizational learning		☑		
		• Increase communication level			☑	
		• Enhance team spirit			☑	
		• Ensures better relations with project parties			☑	
		• Minimize conflicts/legal disputes			☑	
		• Increase client satisfaction			☑	
	1.4	Top management commitment			☑	
	1.5	Communication of risk information				☑
Practices	2.1	Formalization of RM practices		☑		
	2.2	Scope of RM practices		☑		
	2.3	Integration of RM with other man. tasks				
	Project Management	• Scheduling				☑
		• Cost estimation				☑
		• Resource management			☑	
		• Quality assurance and management			☑	
		• Supply chain management			☑	
		• Contract management				☑
		• Health and safety management				☑
		• Environmental impact management				☑
		• Value management				☑
	Corporate Management	• Business development				☑
		• Strategic planning				☑
		• Financial/portfolio management				☑
		• Procurement management			☑	
		• Human resources management			☑	
Reso-urces	3.1	Budget for RM		☑		
	3.2	Staff dealing with RM		☑		
	3.3	RM training	☑			
Processes	4.1	Risk identification		☑		
	4.2	Consideration of project objectives				☑
	4.3	Scope of risk identification				☑
	4.4	Participation in risk identification		☑		
	4.5	Risk analysis	☑			
	4.6	Risk information database		☑		
	4.7	Risk response development		☑		
	4.8	Risk monitoring and control		☑		
	4.9	Risk evaluation		☑		

Table B.3. Questionnaire responses for Company C

Company C			Level 1	Level 2	Level 3	Level 4
Culture / awareness	1.1	Belief in value of risk management				☑
	1.2	Attitude towards risk management			☑	
	1.3	Impact of risk management				
	Project and company related criteria	• Minimize cost/Increase profitability				☑
		• Reduce time of projects				☑
		• Increase quality of projects			☑	
		• Increase safety and reliability			☑	
		• Enhance reputation			☑	
		• Increase organizational learning			☑	
		• Increase communication level		☑		
		• Enhance team spirit		☑		
		• Ensures better relations with project parties		☑		
		• Minimize conflicts/legal disputes			☑	
		• Increase client satisfaction				☑
	1.4	Top management commitment			☑	
	1.5	Communication of risk information			☑	
Practices	2.1	Formalization of RM practices			☑	
	2.2	Scope of RM practices			☑	
	2.3	Integration of RM with other man. tasks				
	Project Management	• Scheduling				☑
		• Cost estimation				☑
		• Resource management			☑	
		• Quality assurance and management			☑	
		• Supply chain management		☑		
		• Contract management				☑
		• Health and safety management		☑		
		• Environmental impact management		☑		
		• Value management			☑	
	Corporate Management	• Business development				☑
		• Strategic planning				☑
		• Financial/portfolio management				☑
		• Procurement management				☑
		• Human resources management		☑		
Reso-urces	3.1	Budget for RM			☑	
	3.2	Staff dealing with RM			☑	
	3.3	RM training			☑	
Processes	4.1	Risk identification			☑	
	4.2	Consideration of project objectives				☑
	4.3	Scope of risk identification				☑
	4.4	Participation in risk identification		☑		
	4.5	Risk analysis			☑	
	4.6	Risk information database			☑	
	4.7	Risk response development			☑	
	4.8	Risk monitoring and control			☑	
	4.9	Risk evaluation			☑	

Table D.1. Questionnaire responses for Company D

Company D			Level 1	Level 2	Level 3	Level 4
Culture / awareness	1.1	Belief in value of risk management				☑
	1.2	Attitude towards risk management			☑	
	1.3	Impact of risk management				
	Project and company related criteria	• Minimize cost/Increase profitability				☑
		• Reduce time of projects				☑
		• Increase quality of projects			☑	
		• Increase safety and reliability				☑
		• Enhance reputation				☑
		• Increase organizational learning			☑	
		• Increase communication level			☑	
		• Enhance team spirit			☑	
		• Ensures better relations with project parties				☑
		• Minimize conflicts/legal disputes				☑
		• Increase client satisfaction				☑
	1.4	Top management commitment			☑	
	1.5	Communication of risk information				☑
Practices	2.1	Formalization of RM practices			☑	
	2.2	Scope of RM practices		☑		
	2.3	Integration of RM with other man. tasks				
	Project Management	• Scheduling			☑	
		• Cost estimation				☑
		• Resource management		☑		
		• Quality assurance and management				☑
		• Supply chain management		☑		
		• Contract management				☑
		• Health and safety management				☑
		• Environmental impact management				☑
		• Value management			☑	
	Corporate Management	• Business development				☑
		• Strategic planning			☑	
		• Financial/portfolio management				☑
		• Procurement management			☑	
		• Human resources management		☑		
Reso-urces	3.1	Budget for RM		☑		
	3.2	Staff dealing with RM		☑		
	3.3	RM training		☑		
Processes	4.1	Risk identification		☑		
	4.2	Consideration of project objectives				☑
	4.3	Scope of risk identification				☑
	4.4	Participation in risk identification		☑		
	4.5	Risk analysis	☑			
	4.6	Risk information database	☑			
	4.7	Risk response development		☑		
	4.8	Risk monitoring and control		☑		
	4.9	Risk evaluation		☑		

Table B.5. Questionnaire responses for Company E

Company E			Level 1	Level 2	Level 3	Level 4
Culture / awareness	1.1	Belief in value of risk management				☑
	1.2	Attitude towards risk management			☑	
	1.3	Impact of risk management				
	Project and company related criteria	• Minimize cost/Increase profitability			☑	
		• Reduce time of projects			☑	
		• Increase quality of projects			☑	
		• Increase safety and reliability				☑
		• Enhance reputation				☑
		• Increase organizational learning			☑	
		• Increase communication level			☑	
		• Enhance team spirit				☑
		• Ensures better relations with project parties			☑	
		• Minimize conflicts/legal disputes			☑	
		• Increase client satisfaction				☑
	1.4	Top management commitment			☑	
	1.5	Communication of risk information			☑	
Practices	2.1	Formalization of RM practices			☑	
	2.2	Scope of RM practices		☑		
	2.3	Integration of RM with other man. tasks				
	Project Management	• Scheduling			☑	
		• Cost estimation				☑
		• Resource management				☑
		• Quality assurance and management			☑	
		• Supply chain management			☑	
		• Contract management				☑
		• Health and safety management				☑
		• Environmental impact management			☑	
		• Value management			☑	
	Corporate Management	• Business development				☑
		• Strategic planning				☑
		• Financial/portfolio management			☑	
		• Procurement management				☑
		• Human resources management			☑	
Reso-urces	3.1	Budget for RM		☑		
	3.2	Staff dealing with RM		☑		
	3.3	RM training		☑		
Processes	4.1	Risk identification		☑		
	4.2	Consideration of project objectives			☑	
	4.3	Scope of risk identification				☑
	4.4	Participation in risk identification		☑		
	4.5	Risk analysis	☑			
	4.6	Risk information database		☑		
	4.7	Risk response development		☑		
	4.8	Risk monitoring and control		☑		
	4.9	Risk evaluation			☑	

APPENDIX C

STATISTICAL ANALYSIS TABLES

Table C.1. ANOVA for *culture* scores of the companies

Source	Sum of Squares	df	Mean Square	F	Sig. (P)
Model	284.960[a]	9	31.662	166.643	0.000
Company	0.960	4	0.240	1.263	**0.325**
Question	1.760	4	0.440	2.316	0.102
Error	3.040	16	0.190		
Total	288.000	25			

a. R Squared = 0.989 (Adjusted R Squared = 0.984)

Table C.2. ANOVA for *practices* scores of the companies

Source	Sum of Squares	df	Mean Square	F	Sig. (P)
Model	139.800[a]	7	19.971	49.929	0.000
Company	2.000	4	0.500	1.250	**0.364**
Question	2.800	2	1.400	3.500	0.081
Error	3.200	8	0.400		
Total	143.000	15			

a. R Squared = 0.978 (Adjusted R Squared = 0.958)

Table C.3. ANOVA for *resources* scores of the companies

Source	Sum of Squares	df	Mean Square	F	Sig. (P)
Model	80.800[a]	7	11.543	76.952	0.000
Company	3.600	4	0.900	6.000	**0.016**
Question	0.133	2	0.067	0.444	0.656
Error	1.200	8	0.150		
Total	82.000	15			

a. R Squared = 0.985 (Adjusted R Squared = 0.973)

Table C.4. Multiple comparisons for the *resources* scores with LSD

(I) Company	(J) Company	Mean Difference (I-J)	Std. Error	Sig.	90% Confidence Interval	
					Lower Bound	Upper Bound
A	B	1.0000*	0.31623	0.013	0.4120	1.5880
	C	-0.3333	0.31623	0.323	-0.9214	0.2547
	D	0.6667*	0.31623	0.068	0.0786	1.2547
	E	0.6667*	0.31623	0.068	0.0786	1.2547
B	A	-1.0000*	0.31623	0.013	-1.5880	-0.4120
	C	-1.3333*	0.31623	0.003	-1.9214	-0.7453
	D	-0.3333	0.31623	0.323	-0.9214	0.2547
	E	-0.3333	0.31623	0.323	-0.9214	0.2547
C	A	0.3333	0.31623	0.323	-0.2547	0.9214
	B	1.3333*	0.31623	0.003	0.7453	1.9214
	D	1.0000*	0.31623	0.013	0.4120	1.5880
	E	1.0000*	0.31623	0.013	0.4120	1.5880
D	A	-0.6667*	0.31623	0.068	-1.2547	-0.0786
	B	0.3333	0.31623	0.323	-0.2547	0.9214
	C	-1.0000*	0.31623	0.013	-1.5880	-0.4120
	E	0.0000	0.31623	1.000	-0.5880	0.5880
E	A	-0.6667*	0.31623	0.068	-1.2547	-0.0786
	B	0.3333	0.31623	0.323	-0.2547	0.9214
	C	-1.0000*	0.31623	0.013	-1.5880	-0.4120
	D	0.0000	0.31623	1.000	-0.5880	0.5880

* The mean difference is significant at the 0.10 level.

Table C.5. ANOVA for *processes* scores of the companies

Source	Sum of Squares	df	Mean Square	F	Sig. (P)
Model	323.311 [a]	13	24.870	103.506	0.000
Company	5.111	4	1.278	5.318	**0.002**
Question	24.311	8	3.039	12.647	0.000
Error	7.689	32	0.240		
Total	331.000	45			

a. R Squared = 0.977 (Adjusted R Squared = 0.967)

Table C.6. ANOVA for overall maturity scores of the companies

Source	Sum of Squares	df	Mean Square	F	Sig. (P)
Model	161.910 [a]	8	20.239	231.300	0.000
Company	1.610	4	0.403	4.600	**0.018**
Attribute	3.500	3	1.167	13.333	0.000
Error	1.050	12	0.088		
Total	162.960	20			

a. R Squared = 0.994 (Adjusted R Squared = 0.989)

Table C.7. Multiple comparisons for the *processes* scores with LSD

(I) Company	(J) Company	Mean Difference (I-J)	Std. Error	Sig.	90% Confidence Interval	
					Lower Bound	Upper Bound
A	B	0.4444*	0.23107	0.063	0.0530	0.8359
	C	-0.3333	0.23107	0.159	-0.7247	0.0581
	D	0.5556*	0.23107	0.022	0.1641	0.9470
	E	0.4444*	0.23107	0.063	0.0530	0.8359
B	A	-0.4444*	0.23107	0.063	-0.8359	-0.0530
	C	-0.7778*	0.23107	0.002	-1.1692	-0.3864
	D	0.1111	0.23107	0.634	-0.2803	0.5025
	E	0.0000	0.23107	1.000	-0.3914	0.3914
C	A	0.3333	0.23107	0.159	-0.0581	0.7247
	B	0.7778*	0.23107	0.002	0.3864	1.1692
	D	0.8889*	0.23107	0.001	0.4975	1.2803
	E	0.7778*	0.23107	0.002	0.3864	1.1692
D	A	-0.5556*	0.23107	0.022	-0.9470	-0.1641
	B	-0.1111	0.23107	0.634	-0.5025	0.2803
	C	-0.8889*	0.23107	0.001	-1.2803	-0.4975
	E	-0.1111	0.23107	0.634	-0.5025	0.2803
E	A	-0.4444*	0.23107	0.063	-0.8359	-0.0530
	B	0.0000	0.23107	1.000	-0.3914	0.3914
	C	-0.7778*	0.23107	0.002	-1.1692	-0.3864
	D	0.1111	0.23107	0.634	-0.2803	0.5025

* The mean difference is significant at the 0.10 level.

Table C.8. Multiple comparisons for the overall maturity scores with LSD

(I) Company	(J) Company	Mean Difference (I-J)	Std. Error	Sig.	90% Confidence Interval	
					Lower Bound	Upper Bound
A	B	0.7250*	0.20917	0.005	0.3522	1.0978
	C	0.1250	0.20917	0.561	-0.2478	0.4978
	D	0.5750*	0.20917	0.018	0.2022	0.9478
	E	0.5750*	0.20917	0.018	0.2022	0.9478
B	A	-0.7250*	0.20917	0.005	-1.0978	-0.3522
	C	-0.6000*	0.20917	0.014	-0.9728	-0.2272
	D	-0.1500	0.20917	0.487	-0.5228	0.2228
	E	-0.1500	0.20917	0.487	-0.5228	0.2228
C	A	-0.1250	0.20917	0.561	-0.4978	0.2478
	B	0.6000*	0.20917	0.014	0.2272	0.9728
	D	0.4500*	0.20917	0.053	0.0772	0.8228
	E	0.4500*	0.20917	0.053	0.0772	0.8228
D	A	-0.5750*	0.20917	0.018	-0.9478	-0.2022
	B	0.1500	0.20917	0.487	-0.2228	0.5228
	C	-0.4500*	0.20917	0.053	-0.8228	-0.0772
	E	0.0000	0.20917	1.000	-0.3728	0.3728
E	A	-0.5750*	0.20917	0.018	-0.9478	-0.2022
	B	0.1500	0.20917	0.487	-0.2228	0.5228
	C	-0.4500*	0.20917	0.053	-0.8228	-0.0772
	D	0.0000	0.20917	1.000	-0.3728	0.3728

* The mean difference is significant at the 0.10 level.

Table C.9. Correlation matrix among the attribute scores

		Culture	Practices	Resources	Processes
Culture	Pearson Correlation	1	0.402	0.117	-0.093
	Sig. (P)		0.502	0.851	0.881
Practices	Pearson Correlation	0.402	1	0.620	0.557
	Sig. (P)	0.502		0.265	0.330
Resources	Pearson Correlation	0.117	0.620	1	0.955*
	Sig. (P)	0.851	0.265		0.012
Processes	Pearson Correlation	-0.093	0.557	0.955*	1
	Sig. (P)	0.881	0.330	0.012	

* Correlation is significant at the 0.05 level.

APPENDIX D

REVISED RISK MANAGEMENT MATURITY QUESTIONNAIRE

1. AWARENESS / CULTURE

Belief in value of risk management

1.1 Do you think that risk management is necessary for your organization? *Please check the appropriate box.*

- ❒ Not at all
- ❒ Not sure
- ❒ Yes
- ❒ Definitely

Attitude towards risk management

1.2 Which one better describes your organization's attitude towards risk management? *Please check the appropriate box.*

- ❒ Risk management is not essential to achieve our targets, it is even perceived as a distraction and waste of time.
- ❒ Although risk management may have some benefits, the extra expenses it creates and value it adds to our organization are questionable.
- ❒ Although not all the benefits are consistently gained, we are aware of the value and benefits of risk management.
- ❒ Risk management is a critical success factor and it can significantly improve business performance, benefits of risk management demonstrated by various applications.

1.3 Impact of risk management on below success criteria:

Please check the appropriate box for each criterion.

Project and company related criteria	None	Low	Medium	High
Minimize cost/Increase profitability	❒	❒	❒	❒
Reduce time of projects	❒	❒	❒	❒
Increase quality of projects	❒	❒	❒	❒
Increase safety and reliability	❒	❒	❒	❒
Enhance reputation	❒	❒	❒	❒
Increase organizational learning	❒	❒	❒	❒
Increase communication level	❒	❒	❒	❒
Enhance team spirit	❒	❒	❒	❒
Ensures better relations with project parties	❒	❒	❒	❒
Minimize conflicts/legal disputes	❒	❒	❒	❒
Increase client satisfaction	❒	❒	❒	❒
Other *(Please specify)*…….. ……..	❒	❒	❒	❒

Top management commitment

1.4 How do you consider top management's approach towards risk management? *Please check the appropriate box.*

- ❒ No awareness, no support
- ❒ Gives partial encouragement and passive support
- ❒ Supports risk management
- ❒ Full commitment to risk management, gives promotion, support and requires risk reporting

Communication of risk information

1.5 Do you think that communication/sharing of risk related information (if it is not confidential) minimizes the risks? *Please check the appropriate box.*

- ❒ Not at all
- ❒ Not sure
- ❒ Yes
- ❒ Definitely

2. PRACTICES

Formalization of practices

2.1 How do you describe the risk management practices in your organization? *Please check the appropriate box for each project performance criterion.*

	Cost& time	Quality	H&S*	Env*
Risks are not dealt with until they become a current problem, no risk management practice	❒	❒	❒	❒
Risk management practiced only on selected projects, usually in response to client demands	❒	❒	❒	❒
Risk management practiced on most projects and there are efforts to standardize practices	❒	❒	❒	❒
Risk management practiced on all projects, it is systematic, routine and standardized	❒	❒	❒	❒

* *H&S: Health and Safety, Env: Environment*

Scope of risk management practices

2.2 What is the scope of risk management practices in your organization? *Please check the appropriate box for each project type.*

	Domestic projects	Overseas projects
Not applicable	❒	❒
Project basis (Total project risks are covered, but no risk management planning across projects)	❒	❒
Organizational basis (Total project risks, the risks on other projects and other parts of the organization are all covered)	❒	❒
Supply chain basis (Besides the organizational basis, risks related with the supply chain members are also taken into account)	❒	❒

Integration of risk management with other project management tasks

2.3 How do you consider the integration of risk management with other management tasks in your organization? *Please check the appropriate box for each task.*

		Level of integration			
		None	Low	Medium	High
Project Management Tasks	Scheduling	❒	❒	❒	❒
	Cost estimation	❒	❒	❒	❒
	Resource management	❒	❒	❒	❒
	Quality assurance and management	❒	❒	❒	❒
	Supply chain management	❒	❒	❒	❒
	Contract management	❒	❒	❒	❒
	Health and safety management	❒	❒	❒	❒
	Environmental impact management	❒	❒	❒	❒
	Value management	❒	❒	❒	❒
	Other *(Please specify)*…… ……	❒	❒	❒	❒
Corporate Management Tasks	Business development	❒	❒	❒	❒
	Strategic planning	❒	❒	❒	❒
	Financial/portfolio management	❒	❒	❒	❒
	Procurement management	❒	❒	❒	❒
	Human resources management	❒	❒	❒	❒
	Other *(Please specify)*…… ……	❒	❒	❒	❒

3. RESOURCES

Budget for risk management

3.1 Does your organization have a dedicated budget for risk management (Budget for training, tools, experts, *etc.*)? *Please check the appropriate box.*

- ❒ No budget and time allocated for risk management
- ❒ Budget allocation is not consistent, depends on project
- ❒ Budget allocated for all projects
- ❒ Budget allocated for risk management and improvement of risk management practices

Staff dealing with risk management

3.2 Who is dealing with risk management in your organization? *Please check the appropriate box.*

- ❒ External consultants
- ❒ Top management
- ❒ In regular domestic projects, experienced people involved in project deal with it, whereas for international or risky projects, a risk management unit or team is assigned
- ❒ Risk management unit or team with advanced training on risk management.

Risk management training

3.3 Is there training/personal development in the area of risk management in your organization? *Please check the appropriate box.*

- ❒ None
- ❒ Sometimes/not frequently
- ❒ Training on risk management when required
- ❒ Regular training to enhance risk management skills, training encouraged

4. PROCESSES

Risk identification

4.1 At the beginning of each project, do you identify risks as a standard activity? *Check the option that suits your organization most.*

- ❒ Sometimes we have some risk discussions on the project scope and milestone information, but we do not have a regular process as such.
- ❒ Our organization has some formal methods (usage of checklists, automated forms, influence diagrams, brainstorming sessions, etc.) for identifying project risks, but it is considered standard practice only for large projects.
- ❒ We apply a formalized risk identification process to most of our projects.
- ❒ A documented, repeatable process for identifying project risks and an improvement process to completely identify the risks as early as possible are in place.

4.2 When identifying risks, which project objectives do you consider? *Please check the appropriate box.*

- ❒ Only profitability considered (Impact on cost only)
- ❒ Impact on time and cost
- ❒ Impact on quality, health and safety, environment, *etc.* as well as time and cost
- ❒ Long-term objectives such as reputation, *etc.* as well as all tangible and intangible objectives

Scope of risk identification

4.3 Which one better describes the risks identified? *Check the option that suits your organization most.*

- ❒ Risks related with project itself, *e.g.* design changes, technical problems, low productivity of labor (technical risk assessment)
- ❒ Risks related with macro environment, *e.g.* unforeseen weather conditions, risks related with social, political, economic country factors, as well as project risks
- ❒ Risks related with company, *e.g.* lack of experience or staff in a particular area (organizational risk assessment) as well as project and country risks
- ❒ Risks related with supply chain, *e.g.* poor information flow between the parties, inexperience of subcontractor (supply chain risk assessment; client, joint venture partners, subcontractors) as well as project, country and company risks

Participation in risk identification

4.4 Who are involved in the risk identification process? *Check the option that suits your organization most.*

- ❒ Individuals responsible for risk management
- ❒ Experienced people involved in project
- ❒ A risk identification team composed of experienced people in the company
- ❒ Key external stakeholders and suppliers participate in risk identification as well as company professionals

Risk analysis

4.5 Do you carry out systematic risk analysis? *Choose the option that suits your organization most.*

- ❒ Systematic approach does not exist, impacts assessed intuitively
- ❒ Risk assessment using qualitative methods such as risk rating technique (risk checklists), probability-impact matrices
- ❒ Risk analysis using statistical tools as well as qualitative methods
- ❒ Risk analysis using advanced methods (simulation, sensitivity testing, *etc*.) and related software / decision support tools

Risk information database

4.6 Does your organization have a database on typical risks encountered and related experiences? *Please check the appropriate box for each project performance criterion.*

	Cost& time	Quality	H&S	Env.
No, team members take decisions based on their own past experiences and discussions with the project team.	❒	❒	❒	❒
No specific method to collect historical information, although some historical information about general trends in risk on similar projects may have been collected.	❒	❒	❒	❒
Historical information such as common risk items and risk triggers are collected and organized in the historical database.	❒	❒	❒	❒
Besides collecting the information such as common risk items and risk triggers, our historical database is subject to a continuous improvement process.	❒	❒	❒	❒

* *H&S: Health and Safety, Env: Environment*

Risk response development

4.7 Does your organization determine mitigation strategies or contingency plans for the future risk events? *Please check the appropriate box.*

- ❒ No, in large part, there is consideration of risks as they emerge.
- ❒ We have some informal gatherings on the strategies to deal with the future risk events. In large projects, we make contingency plans for near-term risks and mitigation strategies.
- ❒ For most projects, contingency plans and mitigation strategies are developed for each risk item, so that project reserves can be allocated to cover such items when needed.
- ❒ In all projects, risk management plans, contingency plans and risk allocation plans are prepared and risk control strategies are formulated as well as risk finance strategies.

Risk monitoring and control

4.8 Does your organization have a process for risk monitoring? *Please check the appropriate box.*

- ❒ No
- ❒ Our project teams apply their own approach to managing and controlling risks, but not as a formal process. Responsibility is assigned for each risk item as it occurs.
- ❒ Yes, we have a formalized generic process for actively and routinely tracking risks, applied to most of our projects.
- ❒ A formalized generic process for risk monitoring is used in every project and risk management plans are updated periodically.

Risk evaluation

4.9 Do you have a documentation system for risk management activities? *Please check the appropriate box.*

- ❒ None
- ❒ Reports prepared on an ad-hoc basis and filed
- ❒ Reports always prepared, stored as hard-copy and shared
- ❒ Reports prepared, stored on the computer, shared and used for forthcoming projects