Investigation of Risk Management in Iranian Construction Industry

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ABSTRACT

In recent years, managing risk in construction projects has been extremely examined in the field of project management. Many industries established their risk management approaches in order to enhance performance and benefit from advantages. But still structured approaches and methods are not commonly used and also absence of knowledge is another issue, which must be considered to managing risk.

In this thesis, Iranian construction industry was selected as the case study in order to investigate how risk management is perceived and practiced in this specific area. Implementation of risk management in construction projects is thus presented in this study. A questionnaire survey was administered among a number of construction companies. Probability and impact matrices were calculated for identifying potential risks and also analyzing them respectively as qualitative technique. As a result twenty-three potential risks were found and apart from political issues and international sanctions, those risks are mostly related to the individuals and lack of sufficient experience in a field of risk management. Similar to previous studies, this research shows that Iranian companies most commonly use past experience, discussions, checklists and brainstorming to identify potential risks. However, they still use those methods for risk assessment rather than formal ones like qualitative or quantitative techniques and that is because of lack of education and training. At the end obstacles and drives for effective risk management are focused upon.

Keywords: Iranian construction industry, Qualitative method, Risk, Risk management process.

ÖZ

Son yıllarda inşaat projelerindeki risk yönetimi, sıradışı bir biçimde proje yönetimi bilim dalı kapsamında sorgulanmaktadır. Çoğu sektör, performans artışı ve benzeri avantajlar sağlamak amacıyla kendi risk yönetimi yaklaşımlarını oluşturmuşlardır. Fakat, oluşturulmuş yaklaşımlar ve yöntemler halen tam anlamıyla kullanılamamakta ve aynı zamanda bilgi eksikliği risk yönetiminde hesaba katılması gereken bir konu olarak durmaktadır.

Bu tez kapsamında, İran inşaat sektörü örnek çalışma konusu olarak seçilerek risk yönetimi algısının ve uygulamalarının bu belirli alanda nasıl olduğu araştırılmıştır. Böylelikle, inşaat sektöründeki risk yönetimi uygulamalarınının nasıl hayata geçirildiği gösterilmiştir. Bir gurup inşaat şirketinin dahil edildiği bir anket çalışması yürütülmüştür. Olasılık – etki matrisleri hesaplanarak potansiyel riskler niteliksel bir yaklaşımla tanımlanmış ve sırasıyla analiz edilmiştir. Sonuç olarak, yirmi-üç potansiyel risk bulunmuş, politik konular ve uluslararası yaptırımlar dışında bu risklerin çoğunlukla kişilere ve risk yönetimi konusundaki tecrübe yetersizliğine bağlı olduğu saptanmıştır. Bu çalışma önceki çalışmalara benzer olarak, İran inşaat şirketlerinin genelde tecrübe, tartışma, kontrol listeleri ve brain-storming yaklaşımlarıyla potansiyel riskleri tanımladıklarını göstermiştir. Bununla birlikte, İran inşaat şirketleri eğitim ve pratik eksiklikleri nedeniyle risk değerlendirmesi yaparken usule uygun nitel ve nicel yöntemler kullanmak yerine bu yöntemleri kullanmaktadır. Sonuçta, etkin bir risk yönetimi için var olan engeller ve teşfik edici faktörler üzerine odaklanılmıştır.

Anahtar Kelimeler: İran İnşaat Sektörü, Niteliksel Yöntem, Risk, Risk Yönetimi Prosesi.

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Chapter 1

INTRODUCTION

1.1 Introduction

Background information as well as problem description are presented in this chapter. Therefore, a short description of risk, methodology as well as objectives and achievements are explained and at the end, thesis guideline is included to provide comprehensive understanding of context of this master thesis.

1.2 Background Information

Intensive studies and growth has been carried out recently in the territory of risk management. A concept of risk management is used in all industries and construction is no exception since it is one of the nine fundamental knowledge areas of project management institute (PMBOK, 2008). Project management institute pointed out that, risk is an uncertain event that, if happens, has two effects (positive and negative) on a project's purpose and the main aim of risk management is to reduce its negative probability and impact on project. In addition, Winch (2002) described that the most crucial and difficult part of construction management is risk management. Hence, the systematic ways of risk management consist of risk identification, risk assessment and risk response planning (PMBOK, 2008; Telford, 2005; Cooper et al., 2005). These systematic ways are known as risk management process which each of them has number of methods and techniques depending on the project complexity, size, time constraint and similar issues which will be completely described in next chapter.

All participants (e.g., client, contractor, supplier, consultant) have crucial role on project completion; so their interest can negatively or positively influence on project execution. In the other words, participants with different skills and background experience have different interest and assumption (Dey and Ogunlana, 2004). The significance of risk management still have not been realized by many people and some organizations are not motivated with using structured and formal methods in order to mitigate negative impact of risk on project objectives (Smith et al., 2006). Generally speaking, construction risk management is realized as event, which affects on time, cost and quality as well as finance and health and safety.

For the purpose of this research, Iranian construction industry was selected as the case study. Similar to other countries, Iranian companies encounter with different types of threats such as organizational, financial, technical or environmental. This research will show that how Iranian companies handle risks to avoid losses and will find out participants knowledge level about the concept of risk management.

A number of researches have been performed in a field of risk management (Lyons and Skitmore, 2002; Klemetti, 2006; Zou et al., 2006) and described different techniques and methods related to this issue. But this research has focused on a case study to investigate how risk management is practiced in Iran. Therefore, questionnaire survey and interviews were selected as the research method in order to collecting information and then the application of Probability and impact matrix (PIM) was performed in order to qualitative risk assessment.

1.3 Aims and Objectives

This research aims to improve the implementation of risk management process within Iranian construction industry through the evaluation of Iranians' perception of risk management. To do so, the main objectives of this research have been recognized as:

- To identify and classify the most major and common risks in the Iranian construction project,
- To evaluate how the risk management process is practically used in the Iranian construction industry,
- To propose a theoretical framework in order to develop the implementation of risk management in construction projects.

In order to achieve these objectives, the research questions have been formulated to support the study:

i. What are the main reasons for the deficiency of risk management?
ii. What kinds of methods are most commonly used in risk management?
iii. What are the main obstacles and drives for risk management?

1.4 Research Methodology

Robson (2002) proposed that designing of research methodology is about turning research questions into the study project. In this study, the type of research methodology is a descriptive one. In this regard, questionnaire survey technique was selected for collecting data and further analysis.

The preparation of questionnaire will be explained later. The questionnaire was prepared as a result of a number of research papers, articles and books in the field of

construction management and a sample of the questionnaire can be found in Appendix A.

The research design was divided into two main sections, which is observable in Figure 1.1. In addition, the process and structure of this research is presented in the next section.

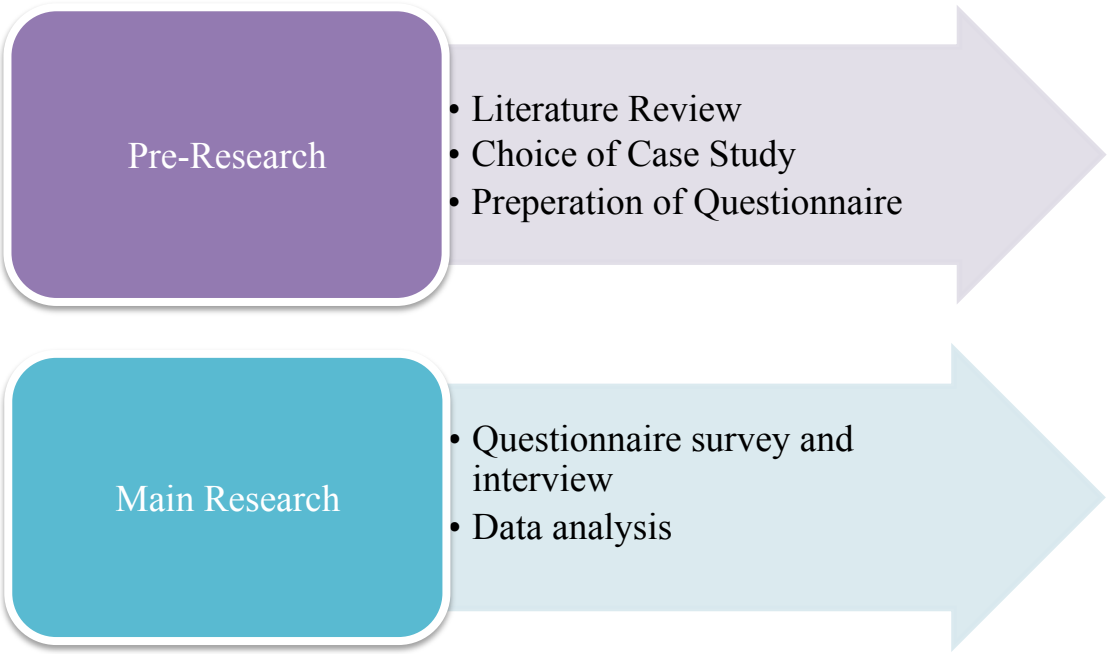


Figure 1.1: Research design for this study

1.5 Achievements

In order to achieve the stated aims and objectives, these following research achievements are presented below:

- The most major risks are divided into four groups: financial, organizational, management and technical. As the results from interviews and questionnaires survey, there are 23 risks, which commonly occurred during construction

plan. Among identified risks, “Price inflation in construction materials” has the greatest adverse impact on the construction projects.

- In comparison to developed countries, risk management has been used with unstructured approach in Iranian companies. Only minority of them has proper insight into risk management. This gap is due to lack of training, knowledge and motivation in the field of risk management. Iranian companies mostly wait till risks happens and then deal with them by their past experience and discussion or transfer their responsibility to other parties like insurance.
- The graphical framework of risk management are proposed as following:

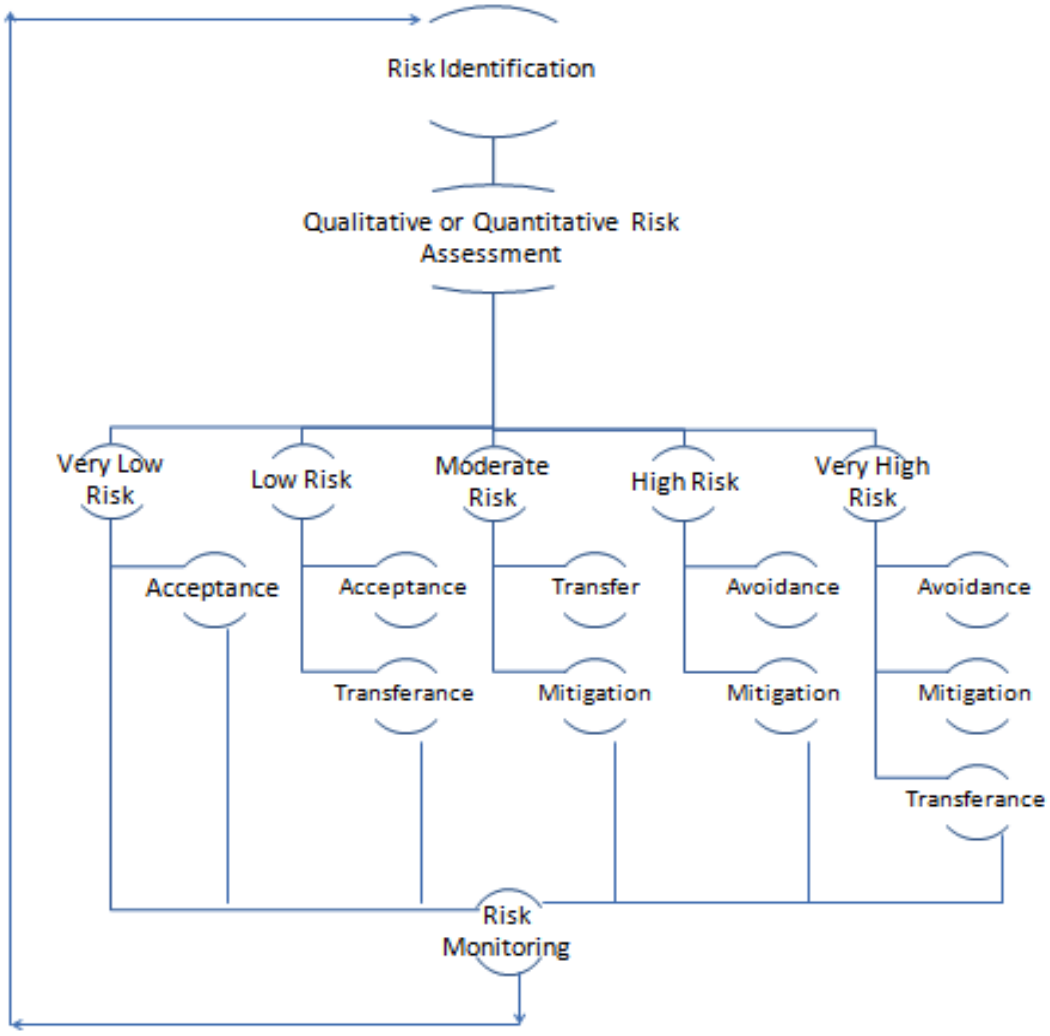


Figure 1.2: Proposed cyclical risk management process

1.6 Structure of the Thesis and Thesis Guideline

The study starts with general information and background information on construction management and objectives and aim of this research were outlined. Then, literature review provides a theoretical framework and methods, which performed in different studies and further, description of how risk management is used in case study in a construction project is provided. Subsequently, data collection and analysis from interview and questionnaire survey are presented. Then, results from questionnaires and interviews are discussed and proposed the recommended actions in order to mitigate problems. Finally, conclusions, answering questions and recommendations for future work are provided.

All these processes are divided generally into six chapters, which are separately described as following:

Chapter 2 provides the theoretical overview and describes the previous research and literature in the field of construction risk management. The theoretical framework used in this research, including three parts is then described in details.

Chapter 3 presents the method applied in this case study. In this chapter, the selected method for gathering information and data is proposed and further, the most proper method of analysis is chosen. It is also completely described how to perform further analysis.

In chapter 4, the collected data form questionnaire survey is presented and also the results of identified risk from the different viewpoint of each respondent are summarized in different figures and tables.

Chapter 5 discusses about data analysis and the result. Therefore, findings from interviews and questionnaire survey are discussed in details. Finally, main causes of threats and recommended actions to mitigate and control the adverse effect of risks are presented.

Chapter 6 presents the conclusions of the study and proposes some recommendations for further studies.

Figure 1.2 provides the graphical outline of the thesis, which presented below:

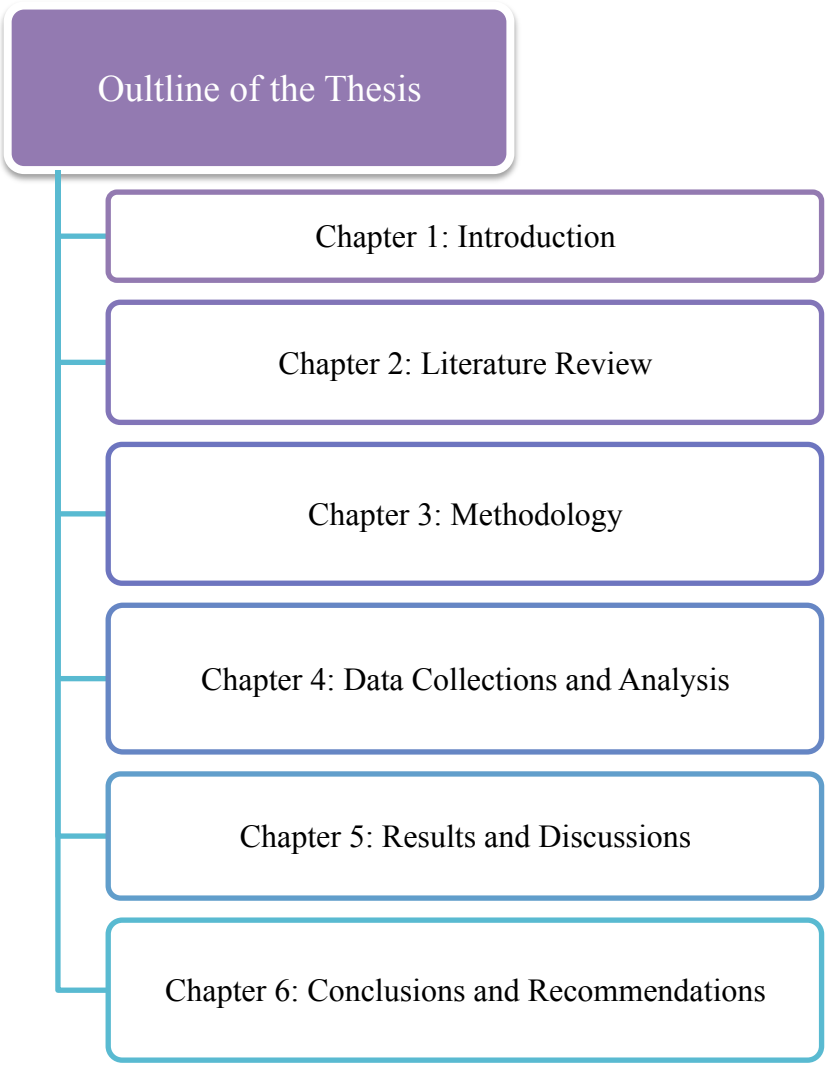


Figure 1.3: Structure of the thesis

Chapter 2

THEORETICAL FRAMEWORK

2.1 Introduction

Risk management is one of the critical components in project management to ensure that a project is completed successfully (Royer, 2000). According to PMBOK (2008), risk management is recognized as one of the nine knowledge areas, which is very crucial in every project. During these days, risk management is most likely a difficult element in each project since the main causes of threats should be traced, recognized and identified through the project (Telford, 2005; PMBOK, 2008).

This chapter will give the theoretical overview and describes the previous research in the field of construction management. The theoretical framework used in this research, includes three parts. In the first part, the definition and the concept of risk is described. The second part describes risk management in construction industry as well as previous research in that field. Finally, the risk management steps and process are described in the third part.

In other words, the purpose of this chapter is summarized into these sections:

- Risk concepts and definitions
- Risk management in construction industry
- Risk management process

2.2 Risk Management Definition

There are numerous risk definitions delivered by researchers and authors. Thus, it is somehow difficult to select one that is always correct. Generally, risk management is very extensive subject and also it can be difficult to apply in all industries. Each author provides his/her own impressions and understanding of what risk means and how to respond and mitigate it (Samson et al., 2009). The Oxford dictionary of current English defines risk as a probability of adverse consequence. To set the scene for the concept of risk management, which selected in this research, the different methodologies to uncertainty are presented. As PMBOK Guide (2008) states, risk is defined as "an uncertain event or that, if happens, has two main effects (positive and negative) on a project's purpose". These effects are called opportunities (upside effect) and threats (downside effect) respectively.

According to the international standard (IEC 62198, 2001), project risk is defined as the "combination of probability of an event occurring and its consequences for project objectives". Flanagan and Norman (1993) emphasized that, "Risk management is a discipline for living with the possibility that future events may cause adverse effects". Furthermore, Cleden (2009) stated that threat is an event, which may occur from proficiency and absence of information, which have an adverse effect on each plans during construction progress.

Darnall and Preston (2010) and Cooper et al. (2005) stated that risk is an exposure to the influence of threats as well as likelihood of damages and harms. For the concept of risk management in construction industry, Cooper et al., (2005) description delivers the substance of this conception: "The risk management process involves the

systematic application of management policies, processes and procedures to the tasks of establishing the context, identifying, analyzing, assessing, treating, monitoring and communicating risks".

According to Smith et al. (2006), with considering the likelihood of incidents and the impacts on project objectives, those events with high probability and high impact are exposed to risk (Figure 2.1).

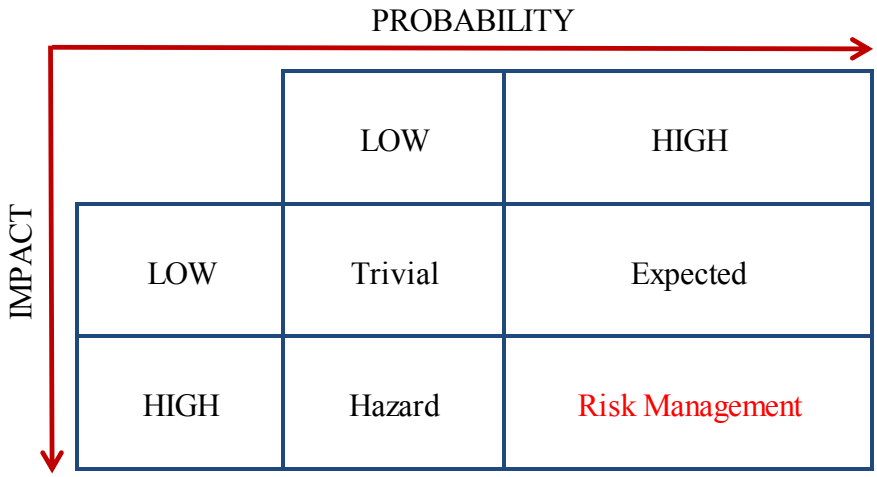


Figure 2.1: Risk event categorizing (Smith et al., 2006)

All risk definitions stated before, explain that lack of some aspect such as information and knowledge can cause a threat to the project. On the other hand, all researchers argue that, risk is usually associated to those ones, which have an adverse effect on a project objective, not the opportunities. Thus, this research has focused on threats instead of opportunities. And in continue, the risk management in the field of construction industry is presented.

2.3 Risks in Construction Projects

Risk management is a crucial process because of the characteristics of construction industry. In projects, which encounter high level of threats, risk management is the key role widely used. These types of risk investments are specified with main process, which will be explained further (identifying, analyzing and responding).

Irrespective of project scope and size, there are different types of threats, which can be determined in the construction industry. However, there are most common risks on each construction project, such as design variations and scope along with time for project accomplishment. On the other hand, early project accomplishment, may have a major problem like delays in the schedule. In other words, too fast finishing may shorten the finishing time but it also may be a consequence of inadequate planning which leads to a low quality of final result and enhances the overall cost (Gould and Joyce, 2002). Zhang and Xing (2010) emphasized that keeping a balance in cost, time and quality is a fundamental subject in every construction project.

Furthermore, risk is a systematic way of identifying, assessing and responding to reach the target of project in construction project management (Telford, 2005; PMBOK, 2008). The benefits of the risk management process are divided into three subjects:

- Identifying and analyzing risks
- Improvement of construction project management processes
- Effective use of resources.

Many authors have pointed out the benefits of risk management in construction industry. Smith et al. (2006) Claimed that risk management plays a key role in better perspective of possible effect as a result of unmanaged threats as well as how to prevent and keep away from them. Another advantage is that it can improve the level of management in the whole project and also has more effective troubleshooting procedure that could be upheld on more authentic foundation (Thomas, 2009). As Zou et al. (2007) pointed out, risk management in construction projects has been considered as a very fundamental process in order to perform main project objectives; for instance, safety, environmental sustainability as well as cost, quality and time. According to a report from European Agency for Safety and Health at Work (2004), construction industry has a massive portion in risk of accidents and more than 1300 people were being killed every year in European Union. Furthermore in comparison with other industries, workers are injured two times more than other occupations. It is good to know that the cost of these incidents is massive to the employer and the society.

The following sections present the risk management processes from different definitions and vision of risk management process, described by many researchers. Different steps are defined in this regard with some comments in each step. Thus, some of known steps are presented in the following section and finally, one of them is chosen for further risk analysis.

2.4 Risk Management Process

In accordance with literature of risk management, there is no common definition on risk management, risk assessment or risk process as each researcher has his/her own view for defining risk management process (Flanagan & Norman 1993; IEC62198,

2001; Smith et al., 2006; Cooper et al., 2005; Baker et al., 1999). Nevertheless, for better understanding of risk management process, some of previous frameworks are presented in this chapter. According to PMBOK (2008), risk management process consists following four essential phases in order to decrease the probability and impact of negative threats on projects and increase the opportunities of positive threats. These phases are:

- Identification
- Assessment and analysis
- Response planning
- Controlling

From a number of definitions, Cooper et al. (2005) expressed a comprehensive concept of risk management process as the systematic approach of management policies and procedures to performing four main steps which consist of identifying, analyzing, assessing, treating, monitoring and communicating risks. As Smith et al. (2006) described, the process of risk management is the fundamental way in order to better perception and controlling risk on project objective. In this sense, they considered basic phases, which are presented in Figure 2.2.

Figure 2.2: Risk management process by Smith et al. (2006)

According to Perry and Hayes (1985), risk management system is divided into 3 main phases (Figure 2.3).

Figure 2.3: Risk management process by Perry and Hayes (1985)

Risk assessment (qualitative or quantitative) should be performed throughout the entire project for all identified threats and also an adequate response must be prepared. This type of process is linear by nature and excellent starting point for successful risk management (Ceric, 2003).

In this research, the model of risk management, which was provided, by Perry and Hayes (1985) will be used for further analysis in the following section. Nevertheless, the definitions of risk identification, assessment and response are fully described from previous studies and comprehensive information about risk management process will be presented.

2.4.1 Risk Management Identification

The first process of risk management is usually relying on the organizations and implemented in different manners. In other words; risk identification mostly relies on project team's experience (Winch, 2002). During risk identification process in every construction project, considering the different classifications of risks, differentiating sources of risk and distinction between risk effect and its sources is very essential on project objectives (Flanagan & Norman, 1993).

As described in PMBOK (2008), this crucial step determines that which types of threats or risks may have an adverse effect on the project and recognize them and recording their characteristics. In this regard, participants may include project managers, stakeholders, project team members, risk management team and experts in this field. The following risk management will then be more effective, when the causes of risk have been identified before they occurred. From the literature review of Winch (2002), it can be realized that it is easier to take control and action of those risks and threats that have been identified, in order to minimize losses. In addition to controlling potential risks to minimizing losses, it can turn them over into the opportunities such as economic and environmental profitability. There are numerous tools and methods that are applied to identify risk effects. Hence, all risk identification techniques which could be found in the previous studies and literatures, have been summarized in Table 2.1

Table 2.1 Risk identification techniques by Flanagan & Norman (1993), Smith et al. (2006), and PMBOK (2008)

Information gathering methods	Brainstorming
	Questionnaires
	Interviews
	Delphi techniques
	Risk Breakdown Structure (RBS)
	SWOT techniques
Documentation	Checklists
	Databases and historical data
Research	Assumption analysis

2.4.1.1 Brainstorming

The purpose of this method is to achieve a comprehensive list of risks and threats (PMBOK, 2008). Similar to Risk Breakdown Structures (RBS), categorized risk can be used as a framework and then should be identified by their type.

In addition, this technique is an open discussion, which all participants discuss their ideas on specific risks in the project to obtain how uncertainty turns into the risk (Smith et al., 2006). The advantage of this method is that it can be used on either simple or complex project (WSDOT, 2010).

2.4.1.2 Questionnaire survey

According to Godfrey et al. (1996), this method has many advantages among other types of data collection. These benefits include:

- Fastest and most efficient way of data gathering and learning all members' opinions.
- Allowing analyzing and comparing all opinions regarding to every project.
- Questions can be structured or even unstructured.
- Easy to use technique.

But among all these benefits, there is one disadvantage, which does not encounter creative thinking. Robson (2002) emphasized that among the whole types of data collection, questionnaire is a suitable one. However, many researchers claim that the advantages of this method are outweighing the drawbacks. A questionnaire survey was selected as the main method of data gathering to analyze how risk management was done in this case study.

2.4.1.3 Interview

In accordance with PMBOK (2008), by interviewing experienced project participants and stakeholders, each risk can be identified. In this regard, interviewees identify risks according to their experience and historical data that could be useful. Thus, participants should answer the prepared questions and discuss the issues involved.

As a matter of fact, the main purpose is to register answers and later on use them for analysis. There is no restriction for questions. They can be unstructured same as questionnaire survey.

However, this method is very time consuming since after each interview, its results should be arranged according to an organized system and then analyzed for further risk process.

2.4.1.4 Delphi

According to PMBOK (2008), Delphi method is based on the agreement of experts on the main project risk. In this method, project manager conducts a questionnaire survey among all project team members and then submits all the answers to the risk manager for further comments. The advantages of this method are:

- Contributes to decrease bias in all data.
- Keeps project team members independent.

But there is a still disadvantage just like the other methods. Same as interviews, this method is very time-consuming since huge numbers of duplications require agreement.

2.4.1.5 Checklist

Similar to questionnaire survey, this method is so quick and easy to use; but it can only deal with the factors indicated on the list. In addition, all projects are not the same; thus a standard list will often not reach to the specific risks (WSDOT, 2010). PMBOK (2008) explained, "Risk identification checklists are developed based on historical information and knowledge that has been accumulated from previous similar projects and from other sources of information".

2.4.1.6 Risk Breakdown Structure (RBS)

Risk Breakdown Structure (RBS) list consists risk type, category and sub-category illustrating that, which risks may occur on the project. Nevertheless, there are different kinds of RBSs prepared to remind participant in risk identification exercise of many sources. At the end, Figure 2.4 is a sample for better understanding of RBS (Smith et al., 2006; Ayyub, 2003; Rajabi, 2011).

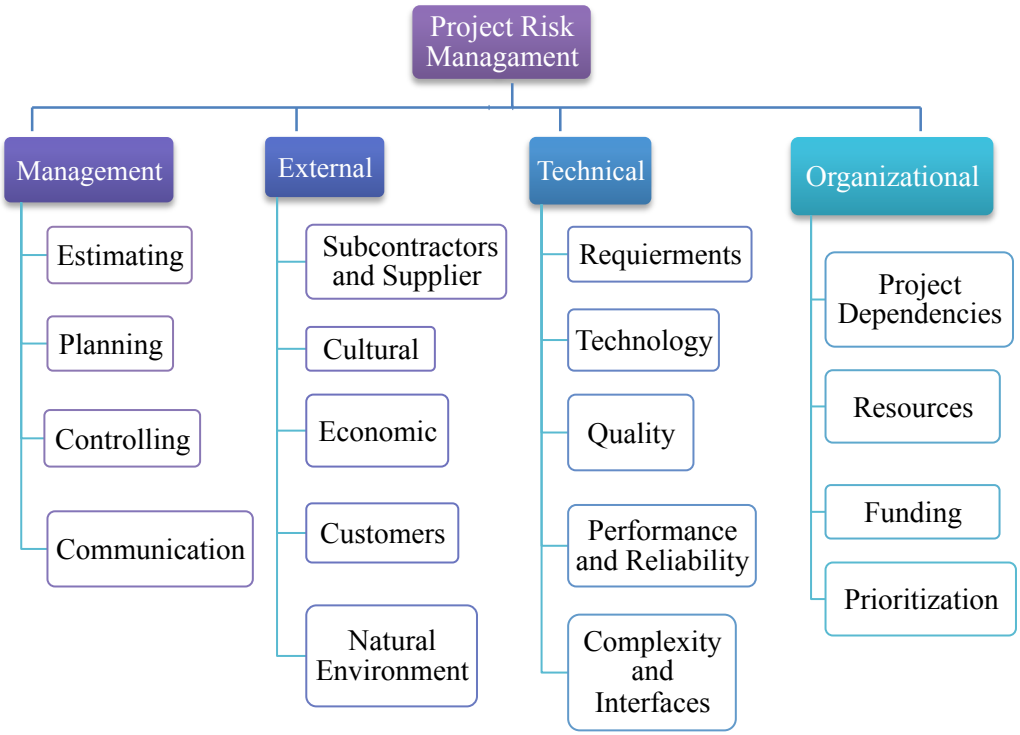


Figure 2.4: Risk Break Down Structure by (Smith et al., 2006; Ayyub, 2003; Rajabi, 2011)

2.4.2 Risk Analysis

After risk identification, risk analysis is the second crucial step in each construction risk management process where all collected information about possible risks are evaluated and analyzed. In this regard, each identified risk should be evaluated in term of the probability of likelihood and consequence.

Generally, the analysis of identified risks is divided into two significant methods; qualitative and quantitative. Both methods can be carried out simultaneously (Winch, 2002; PMBOK, 2008). So it is very fundamental to understand the main difference between them.

2.4.2.1 Qualitative Method

As PMBOK (2008) stated, by unifying and assessing the likelihood of occurrence and consequence, this method prioritizes identified threats and their effect on a project for further analysis. When the threats can be occurred from low to high level on a descriptive scale, qualitative method is the most convenient method of risk assessment (Winch 2002). According to WSDOT (2010), qualitative method is generally defined as a process which measurements and numbers are not involved. In this study, qualities and subjective elements are assessed which are responsible for prioritization and categorization of risks with considering their probability and impact on project objectives. This method is often used as an initial review of project risks as well as if quick assessment is required.

Qualitative methods are widely used in the construction industry in order to analyze identified risks (WSDOT, 2010; Winch, 2002). This method is based on the prioritizing risks according to their effects on a project by using both probability and

impact matrix (PIM) (PMBOK, 2008; Banaitiene and Banaitis, 2012; WSDOT, 2010; Winch, 2002).

Risk Probability and Impact:

PMBOK (2008) and Cooper et al. (2005) emphasized that this technique investigates the likelihood of each risk. In addition, some project objectives like cost, time and quality should be investigated in the potential effect of risk impact. In this regard, each identified risk must be evaluated for both probability and impact. By interviews, checklist and specially questionnaires, each risk can be assessed and analyzed and then the level of risk probability and its impact on the project can be evaluate.

Risk impact and probability are described in terms of very low, low, moderate, high, very high with assigned numerical probabilities scales (1, 2, 3, 4, and 5). In this condition, there are two important definitions: risk probability and risk consequence. Risk probability is the likelihood that a risk will happen. On the other side, risk consequence is the effect of the risk event on the project.

According to HSE (2009) and NPS (2008) impact score can be environmental, financial loss or injury to service users. Scale condition sample for both probability and impact on project objectives is illustrated in Tables 2.2 and 2.3 (PMBOK, 2008).

Table 2.2: Defined conditions for probability scales (HSE, 2009; NPS, 2008)

Probability Category	Probability	Description
Very High	5	Risk event expected to occur.
High	4	Risk event more likely than not to occur.
Moderate	3	Risk event may or may not occur.
Low	2	Risk event less likely than not to occur.
Very Low	1	Risk event not expected to occur.

Table 2.3: Defined conditions for impact scales on major project objectives (PMBOK, 2008)

Project Objectives	Numerical Scales				
	Very low/1	Low/2	Moderate/3	High/4	Very high/5
Cost	Insignificant cost increase	< 10% cost increase	10-20% cost increase	20-40% cost increase	> 40% cost increase
Time	Insignificant time increase	< 5% time increase	5-10% time increase	10-20% time increase	>20 % time increase
Scope	Scope decrease barely noticeable	Minor areas of scope affected	Major areas of scope affected	Scope reduction unacceptable to sponsor	Project end item is effectively useless
Quality	Quality degradation barley noticeable	Only very demanding applications are affected	Quality reduction requires to sponsor approval	Quality reduction unacceptable to sponsor	Project end item is effectively useless

Probability and Impact Matrix:

PMBOK (2008) emphasized that based on risk probability and impact; each risk should be prioritized for meeting the project purposes. Assessment of each risk's priority is generally conducted by using probability and impact matrix. Furthermore, priority scores are assigned with different colors to show the significance of each threat. In order to determine priorities of each risk, impact must be multiplied by the probability of occurrence (Eq. 2.1) (Westland, 2006).

$$Probability \times Impact = Risk\ Rating\ Matrix \qquad \text{Eq. 2.1}$$

Probability and impact matrix for each identified risk can then be tabulated in a table like Table 2.4.

Table 2.4: Probability and impact matrix on an objective (cost, time, quality)

Probability	*Threats*					*Opportunities*				
5	5	10	15	20	25	25	20	15	10	5
4	4	8	12	16	20	20	16	12	8	4
3	3	6	9	12	15	15	12	9	6	3
2	2	4	6	8	10	10	8	6	4	2
1	1	2	3	4	5	5	4	3	2	1
	1	**2**	**3**	**4**	**5**	**5**	**4**	**3**	**2**	**1**

Impact

As it is observable in Table 2.4, each threat is related to its probability of occurring and impact on an objective. Furthermore, both threats and opportunities can be analyzed at the same probability and impact matrix table. This method specifies the combination of likelihood and consequence that leads to rating the identified risk as very low, low, moderate, high and very high priority and the level of each risk is shown by a different color respectively (green, yellow, orange, red and dark red) (PMBOK, 2008).

2.4.2.2 Quantitative Method

As opposed to qualitative method, quantitative method is based on numerical analysis of identified risks and their effects on whole project objectives. This method is appropriate for medium and large project not the small one since it need a lot of work for the assessment and sometimes smaller project does not need that much time for performing the analysis (PMBOK, 2008). The purpose of this method is to

ascertain the likelihood of occurrence and consequence of identified threats (Winch, 2002).

There are different kinds of tools that can be performed in order to quantitative analysis. Some of the most common techniques are following as:

- Scenario technique - Monte Carlo Simulation;
- Diagraming technique - Decision trees;
- Modeling technique - Sensitivity analysis.

Scenario technique - Monte Carlo Simulation

The Monte Carlo method is based on statistics, which are used in a simulation to assess the risks. The simulation is used for forecasting, estimations and risk analysis by generating different scenarios (Heldman, 2005). The most common way of performing the Monte Carlo simulation is to use the program Risk Simulator software, where more efficient simulations can be performed. This analysis can be also done in Microsoft Excel where a special function is used to pick the data randomly, but the results can be very limited (Mun, 2006).

In order to create accurate Monte Carlo analysis the project must provide the model with data. Most simulations use existing data from earlier projects with risks that are similar to the one that needs to be analyzed. This means that it is important for a company to build up a database over time with data that can be used in risk analysis.

Diagraming technique - Decision trees

Decision trees can be very useful if the scenario is complex. One of the main benefits with decisions trees is that they contain a diagramming technique, which can be useful in situation when you need to assess probabilities of particular events that are

reliant on previous events (Potts, 2008).

Decision trees are most commonly used for risks impacting either time or cost, and can be used to calculate the expected value (EV) as well as to evaluate different alternatives before choosing (Heldman, 2005; Potts, 2008). A simple decision tree is shown in Figure 2.5.

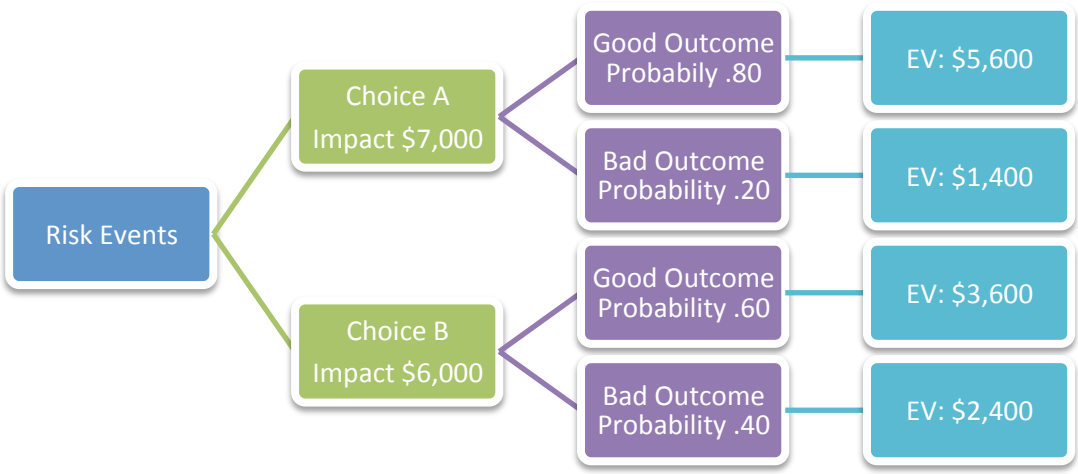


Figure 2.5: Example of a decision tree (Potts, 2008)

Modeling technique - Sensitivity analysis

The purpose of a sensitivity analysis is to establish the risk events which have the greatest impact or value. Those events are later weighed against the objectives of the project. The higher the level of uncertainty a specific risk has, the more sensitive it is concerning the objectives. In other words, the risk events, which are the most critical to the project, are the most sensitive and appropriate action needs to be taken (Heldman, 2005).

The method requires a model of project in order to be analyzed with computer software. According to Smith et al. (2006), the project will benefit if the method is carried out in the project's initial phases in order to focus on critical areas during the project.

The result from the analysis can be presented in Figure 2.6, that illustrate the areas in the project, which are the most critical, and sensitive. Moreover, one disadvantage with this analysis is that the variables are considered separately, which means that there is no connection between them (Perry, 1985 and Smith *et al.* 2006).

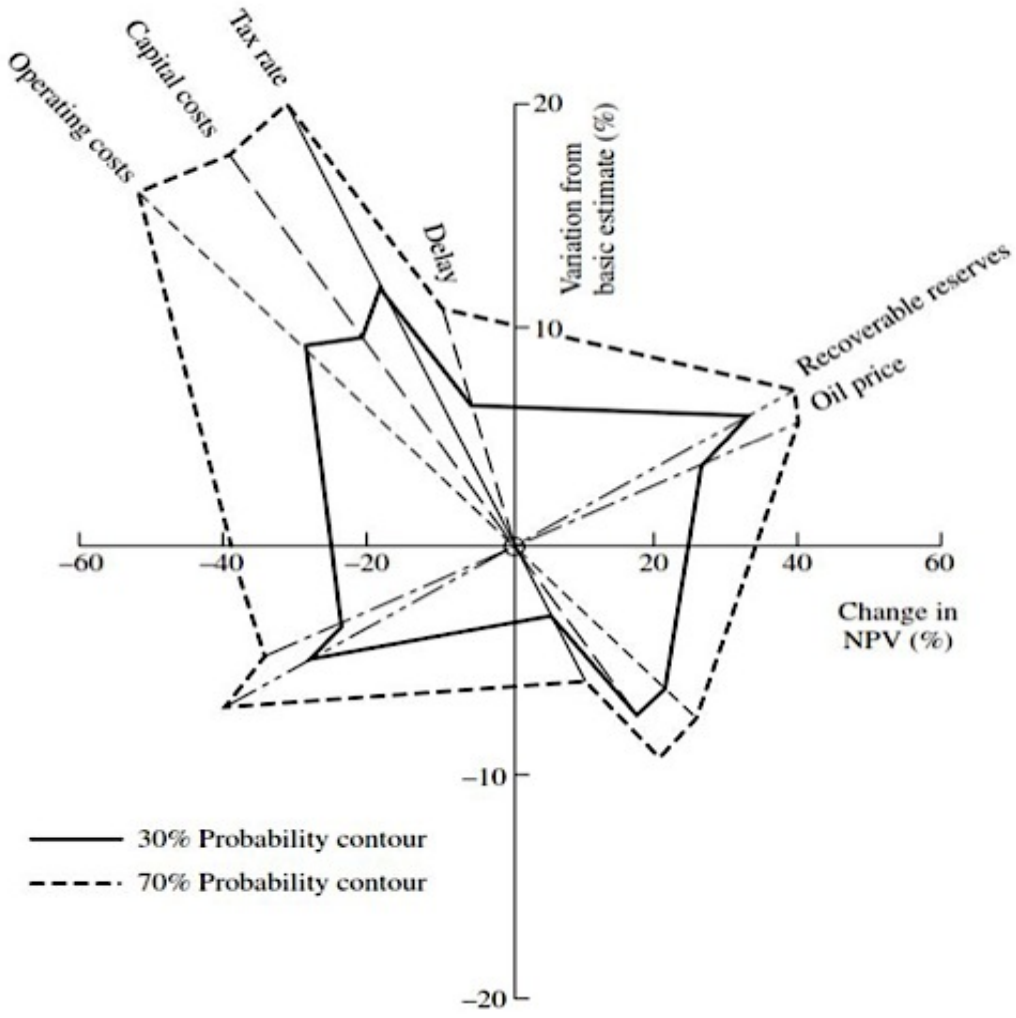


Figure 2.6: An example of sensitivity analysis (Smith et al., 2006)

In overall, it may be problematic to select the suitable method for risk assessment for each project. But these days, most construction companies are interested to use qualitative methods as apposed to quantitative methods since there are more benefits ahead of quantitative method (Banaitiene and Banaitis, 2012). (WSDOT, 2010), described that, qualitative method is very user friendly, quick and also cost-effective to characterize and identify on project objectives. In addition, this method is an appropriate technique in order to describe the threats rather than quantitative technique (Banaitiene and Banaitis, 2012). As a result, qualitative method is chosen in this research.

Next section presents the strategies and actions in order to respond and control all identified risks on the project.

2.4.3 Risk Response and Control

The third step of risk management process is to illustrate the actions, which must be chosen towards the identified risks. Therefore the response strategies should be taken regarding to the type of risks and threats (Winch, 2002).

PMBOK (2008) has defined risk response as "the process of developing options and determining actions to enhance opportunities and reduce threats to the project objectives."

It is also stated that risk control is the execution of risk response, monitoring and identified risk, exploring new threats and analyzing them all over the plan (PMBOK, 2008). In this regard, there are some inputs, which are very important in order to respond the identified risks.

Generally, risk controlling means verifying reports and performing meeting in order to monitoring. Saari (2004) proposed a simple technique for monitoring risk management process Figure 2.5. In this regard she used a status definition for every recognized risk. The proposed model by Saari (2004) can be summarized into four sequential steps. These steps are shown in Figure 2.5.

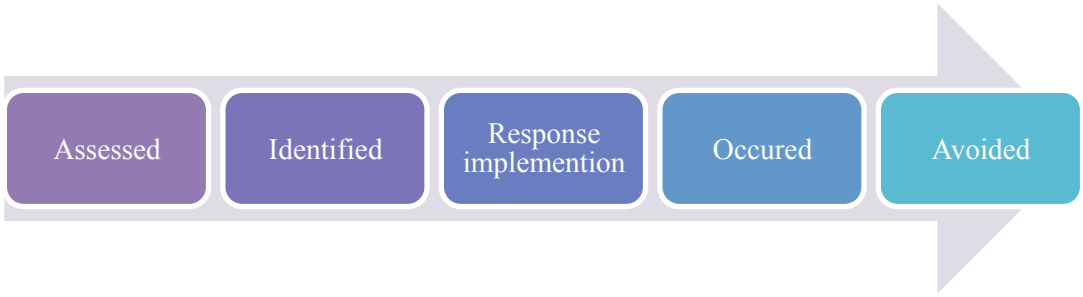


Figure 2.7: Risk control sample (Saari, 2004)

According to PMBOK (2008), the actions and strategies for performing risk response planning are divided into four categories:

- **Avoidance**: Change the plan to ignore the threat from negative impact.
- **Transference**: Does not eliminate risks. It can deal with financial risk exposure like; insurance warranties and etc.
- **Acceptance**: Does not change the plan. It must establish a contingency allowance, which should be determined by the impact and acceptable level of risk exposure.
- **Mitigation**: Find the way to decrease the impact and probability of risk event.

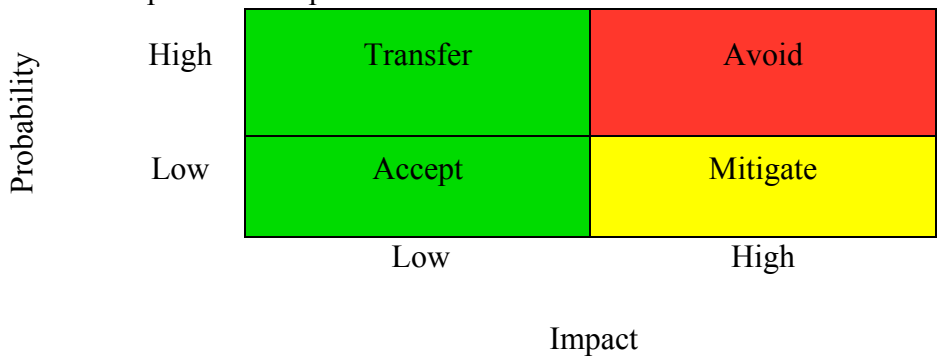
Baker et al. (1999) claimed that every identified threat should be categorized according to its risk score as following items:

- Unacceptable: Risk avoidance

- Undesirable: Risk avoidance, risk transfer, risk mitigation
- Acceptable: Risk retention
- Negligible: No necessary to respond

Planning risk response action can be influenced by the level of the risk with simple response matrix. WSDOT (2010), PMBOK (2008), and Westland (2006) presented the strategies for each level of risk, which should be considered in order to response planning (Table 2.5). Hence, high impact and high probability risks require aggressive responses whereas there may not require any proactive management for those in green zone.

Table 2.5: Simple Risk Response Matrix



Overall, it is very crucial to figure out that, what type of risk must be responded and what type of response action is required and also who is in charge of managing and controlling them. These are questions, which are very fundamental to risk management plan. Therefore, the chosen method will be described and also data and analysis will present and discuss in the following chapter.

Chapter 3

METHODOLOGY

3.1 Introduction

These days, in most developing countries, requirement for starting infrastructures is extremely high. Therefore, forecasting and identifying potential risks are vey fundamental in order to decrease huge amount of loss and injuries in construction project. This research chose Iranian construction projects as a case study to develop the accomplishment of risk management through the appropriate method in order to evaluate people's perception of risk management.

The aim of this chapter is to propose the method of analysis, which is applied in Iranian construction projects.

3.2 Research Method

The selection of research method is depending on the research problem (Morgan and Smircich 1980). On the other hand, qualitative method was found to be widely used these days due to its advantages (Banaitiene and Banaitis, 2012; WSDOT, 2010).

Previous researches have also used qualitative methods and theoretical framework to compare their results. This collation illustrates that other studies selected the same research model for studies within construction projects and the selected research model is well-established one. Thus, qualitative analysis by using probability and impact matrix is chosen for this study as a research method in order to identify,

assess, control and prioritizing threats and uncertainty in construction projects of Iran. For the purpose of this study, questionnaire survey was selected and designed according to the knowledge of Iranian companies to prepare a comprehensive explanation of people's experience in the implementation of risk management on construction projects (Noor, 2008; Tadayon et al., 2012). Therefore questionnaire survey and interviews are selected as main technique to gathering information. In the following, the process of these techniques is explained.

3.3 The Process of Questionnaire Survey and Interviews

The questionnaire started with risk identification in which, professional project managers and their team members identified all types of risks. Second step was risk assessment and analysis where all identified risks were asked regarding to probability and impact score from 1 to 5 according to their likelihood of occurrence and consequences to the overall project. Furthermore, risk score was achieved by multiplying score of both risk impact and risk probability. The final step was risk response and control, which determined different actions (e.g., avoid, accept, mitigate or transfer) in order to reduce threats to the project goal. During risk management process, all risks were prioritized and classified according to their risk score. The data were further put into the application of probability and impact matrix (PIM) and mapping them out in order to find out the priority level of each identified risks (from very low zone to very high zone). As a result, average risk score and percentage of each risk type are presented in different tables, matrices and graphs in the following chapter (see Appendix A). On the other hand, interview questions were prepared in order to find out that how many respondents have knowledge about concept of risk management and also which technique is most commonly used to respond and control threats (see Appendix B).

3.4 Risk Assessment: Qualitative Method with Probability and Impact

As mentioned earlier, the scale used for assessing consequence and probability was a linear one, which is called Likert scale. As Table 2.2 and Table 2.3 illustrated, five measures were adopted in this evaluation with each measure having its own definitions.

There are different methods for defining scale condition for probability and impact which some were presented in the previous Chapter. Defined scales for both probability and impact, which were considered in this research, are presented in Table 3.1 and Table 3.2 respectively.

Table 3.1: Defined conditions for probability scale (NPS 2008, HSE 2009, PMBOK, 2008)

Probability Category	Probability Score	Description
Almost Certain	5	Risk event expected to occur / At least monthly / 81-99%
Likely	4	Risk event more likely than not to occur / Bimonthly / 51-80%
Possible	3	Risk event may or may not occur / Every 1-2 years / 21-50%
Unlikely	2	Risk event less likely than not to occur / Every 2-5 years
Rare	1	Risk event not expected to occur / Every 5 years or more / 0-5%

Table 3.2: Defined conditions for impact scales (NPS 2008, HSE 2009, PMBOK, 2008)

Risk Rating	Risk Score	Criteria (Person / Property / Reputation / Financial)
Catastrophic	5	Multiple deaths or sever permanent disablement / Un-repairable (replace) / Very high / More than $150,000
Major	4	Death or extensive injuries / Extensive external repair / High impact / $50,000-$150,000
Moderate	3	Medical treatment required / External repair / Moderate impact / $10,000-$50,000
Minor	2	First aid treatment required / Internal repair / Low impact / $1,000-$10,000
Insignificant	1	No injury / No damage / Very low impact / Less than $1,000

In this research, all respondents evaluated the impact of identified risks on project objectives (cost, time, quality) as a single factor or value in risk impact.

According to Table 3.1 and Table 3.2, by multiplying the probability of occurrence by the impact, risk matrix can be tabulated which is presented in Table 3.3

Table 3.3: Application of Probability and Impact Matrix

Probability	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Catastrophic (5)
Almost Certain (5)	5	10	15	20	25
Likely (4)	4	8	12	16	20
Possible (3)	3	6	9	12	15
Unlikely (2)	2	4	6	8	10
Rare (1)	1	2	3	4	5

Impact

As can be observed in Table 3.3, the risk matrix illustrates the risk priority, which yields from both probability and impact. All levels of identified risks were shown by different colors. Those risk located on top right corner (dark red and red zone) have most negative influence on whole project performance whilst those located on bottom left corner (yellow and green zone) are considered to impose very low and low impact on the project. In the middle of the matrix, there are some risks, which are categorized to have moderate impact on the project. With this qualitative risk analysis, last process of risk management could be performed which is risk response planning.

As Winch (2002) and PMBOK (2008) stated, the third step of risk management is the process to determine the actions towards the identified risks in order to decrease

threats to the project.

3.5 Risk Response Planning Framework According to Risk Priority

There are a number of methods for risk response such as avoidance, mitigation, transference, and acceptance depending on type of risk impact on the project. As emerged from questionnaire survey, most of the Iranian construction companies performed risk response in unstructured ways. They dealt with risk with use of checklist to mitigate crucial risk and also some of them chose transfer strategy to another parties or experts in such specific area. So they give this permission to other parties for their management.

In this questionnaire survey, all respondents were asked to determine actions in order to reduce threats (Table 3.4).

Table 3.4: Framework for risk response planning

Risk Level	Criteria for Priority Level of Risk	Actions and Strategies for Management
Green	Very Low Priority	Acceptable (not require proactive response)
Yellow	Low Priority	Monitor
Orange	Moderate Priority	Management control Required
Red	High Priority	Urgent management Attention
Dark Red	Very High Priority	Unacceptable (aggressive response strategies needed)

This study considered only the respondents with more than 15 years work experience in construction project management. So, based on their experiences, it concluded that qualification of respondents provided an authentic data source, which is fundamental to comply with research goals.

Next chapter will present data collection and analysis and explains how the chosen methodology was adopted to this research.

Chapter 4

DATA COLLECTION AND ANALYSIS

4.1 Introduction

In this chapter, the collected data form questionnaire survey in the case study is presented. Based on discussions of Robson (2002) and Noor (2008), questionnaire survey is an appropriate technique of data collection for illustrative purposes. Since research objective was to find the probability and impact of each identified risk as well as how risk management worked in the construction projects, questionnaire survey was selected as the main technique of data collection.

The aim of this chapter is to illustrate the summarized results of identified risks from the viewpoint of each respondent. Data analysis and discussions will be presented in the next chapter.

4.2 Questionnaire Survey

Iran is a developing country and thus, interest for starting construction project is enhancing particularly. Subsequently this industry will encounter with different types of risks. But unfortunately, most Iranian companies paid less attention to managing risk in this specific area. Only few companies and contactors can be seen who have an adequate knowledge in risk management. Therefore for better understanding of how Iranian contractors perform risk management, questionnaire survey was prepared and distributed to 20 members of top construction companies, which confirmed by main Iranian Central Buiding and Construction Engineering

Organization. As the result, 15 respondents replied to the survey out of which, 12 were selected for further analysis since 3 of the project managers were in charge for 3 projects each. Therefore, the total response rate was 60% in this questionnaire survey (Table 4.1). The reliability of this questionnaire was done by Cronbach's Alpha with score of 0.834, which can be found in Appendix I.

Table 4.1: Questionnaire description and respondent profile

Total Number of Questionnaires	20
Total Number of Valid Questionnaires	12
Total Response Rate (%)	60
Average age of the respondent (Years)	50
Average Experience (Years)	15

4.3 Analysis and Results

4.3.1 Risk Identification

As mentioned earlier in Chapter 2, there are different methods for risk identification. Among these methods, some are more commonly used in construction projects; for instance, checklist, manuals and historical data are the suitable ones for documentation method and on the other side, experience and negotiation are also mostly performed in order to collect information. The method for identifying risks was different among the project team members. The majority of respondents performed this step by discussion and cooperation. Moreover, risk type was chosen with Risk Breakdown Structure (RBS) for each identified risk. In other words, experience is considered as one of the main sources of identifying potential risks. One of the respondents which was one of the top project managers explained that "By every experience, you will get more knowledge and knowledge is crucial in future construction projects". As a follow up to the first step of risk management, all

respondents were demanded to identify the most important risks, which have commonly occurred in Iran. Therefore, all identified risks were tabulated according to the sample of questionnaire and no priority considered at this step. The results are presented in Table 4.2.

Table 4.2: Identified risks with their Risk Breakdown Structures

Identified Risk	Risk Type
Design variation and changes by employer	Management, Technical
Public objections	External
Excessive agreement procedure administrative government department	External
Inadequate program scheduling	Management, Organizational
Administrative process takes longer than anticipated	External
Inconsistency in the construction documents	Management, Organizational
Inaccurate cost estimate	Management, Organizational
Design errors and omissions	Management, Technical
Inadequate time scheduling	Management, Organizational
Tight project schedule	Management
Non executive design	Management
Unavailability of sufficient professionals and managers	Technical, Organizational
Unavailability of sufficient amount of skilled labors and designers	Technical, Organizational
Inexperienced workforce and staff turnover	Technical, Organizational
Project team conflicts	Management, Organizational
Lack of access to appropriate materials and modern technology	External, Technical
Delayed materials deliveries	Management, Organizational
Price inflation of construction materials	Management, Organizational, External
Lack of coordination between project participants	Management, Organizational
Lack of coordination and cooperation between supervisory team and contractors	Management, Organizational
Unpredictable incidents	External, Organizational
Lack of protections on construction site	Organizational
Ignoring the troublesome conditions and geographical locations of the project	External, Organizational

4.3.2 Risk Analysis

In this step, identified risks were analyzed and assessed with qualitative method due to its advantages in comparison to quantitative method. In this case, questionnaire survey revealed that, the majority of respondents were using different methods in order to prioritize identified threats. Most of them stated that in order to facilitate discussion, they use their experience and have no knowledge about structured risk management methods except three of them. Furthermore, they declared that for many years in Iran, risk has been managed by different methods within their companies and any helpful technique such as qualitative or even quantitative seemed not to be required. This study tried to deal with this issue with the structured risk management method. Hence, qualitative method with probability and impact matrix (PIM) was selected.

Nevertheless, all identified risks were prioritized and average score risk and response rate for each of them were tabulated in Table 4.3 (the process of calculation can be found in Appendix F). As a result, average risk scores, percentages or proportion of each identified risk as well as actual percentage of all identified risk was achieved and are shown in Figures 4.6, 4.7 and 4.8 respectively. Matrix table for top five crucial risks are presented in Figures 4.1 to 4.5 that can be found under application of PIM method. Then, all identified risks are illustrated in one main matrix table in Figure 4.9 (A sample of questionnaire with probability and impact matrix can be found in Appendix A).

4.3.3 Risk Response

As Winch (2002) and PMBOK (2008) stated, the third step of risk management is the process of determining the actions towards the identified risks in order to decrease threats on the project.

Literature shows there are numerous ways depending on type of risk (e.g. avoidance, mitigation, transference, and acceptance). As emerged from questionnaire survey, most of the Iranian construction companies performed risk response in unstructured ways. They deal with risk with use of checklist to mitigate crucial risk and also some of them choose transfer strategy to another parties or experts in such specific area. So they give this permission to other parties for their management.

In this survey, all respondents were asked to determine actions in order to reduce threats (Table 4.4).

Table 4.3: Prioritizing identified risks according to their average scores and percentages

Risk Number	Risk Type / Identified Risk	Average Score Risk	Total Average Score of Risks	Risk Percentage (%)
1	Price inflation of construction materials	14.1	132.1	10.67
2	Inadequate time scheduling	10		7.57
3	Inadequate program scheduling	9.8		7.41
4	Design Variation and Changes by employer	9.4		7.11
5	Inaccurate cost estimate	8.2		6.20
6	Design errors and omissions	7.9		5.98
7	Inexperienced workforce and staff turnover			
8	Inconsistency in the construction documents			
9	Delayed materials deliveries			
10	Unavailability of sufficient amount of skilled labors and designers	7.4		5.60
11	Unavailability of sufficient professionals and managers	7.1		5.37
12	Lack of protections on construction site	7		5.29
13	Tight project schedule	6.8		5.14
14	Non executive design	6.7		5.07
15	Lack of coordination between project participants	5.8		4.39
16	Administrative process takes longer than anticipated			
17	Lack of access to appropriate materials and modern technology	5.5		4.16
18	Excessive agreement procedure administrative government department	5.4		4.08
19	Project team conflicts	4.8		3.63
20	Lack of coordination and cooperation between Supervisory team and contractors	4.4		3.33
21	Ignoring the troublesome conditions and geographical locations of the project	4.3		3.25
22	Unpredictable Incidents	4.1		3.10
23	Public Objections	3.4		2.57

4.4 Application of Probability and Impact Matrix (PIM) Technique

As previously stated in Chapter 3, all respondents were requested to assess both probability and impact scores for each identified risk in the questionnaire. In addition, Likert scale was adopted to obtain the application of PIM.

The primary objective is to demonstrate an example of the risk management process technique (Sample of matrix table and respondent's scores is shown in Appendix H and Appendix G). As it is observed in Table 4.3, there are 23 risks identified by 12 respondents. Thus, matrix tables for top five risks are illustrated in Figure 4.1, 4.2, 4.3, 4.4, and 4.5. At the end, all risks with their average risk scores are mapped out in risk mapping matrix.

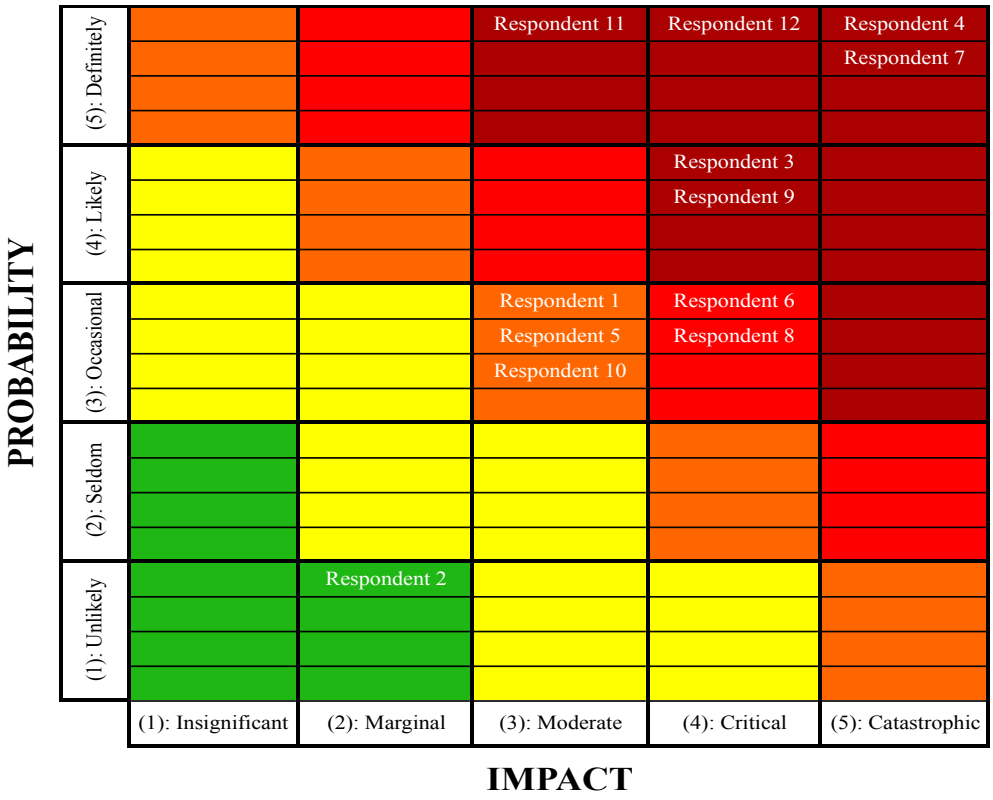


Figure 4.1: Matrix table of "Price inflation" by all respondents

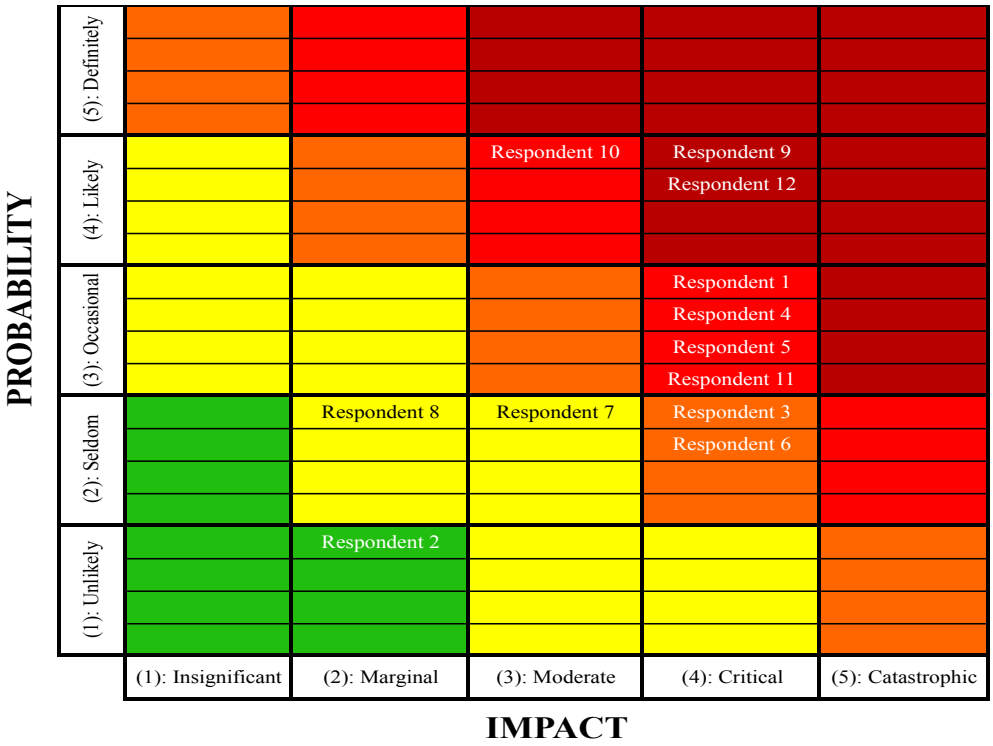


Figure 4.2: Matrix table of "Inadequate time scheduling" by all respondents

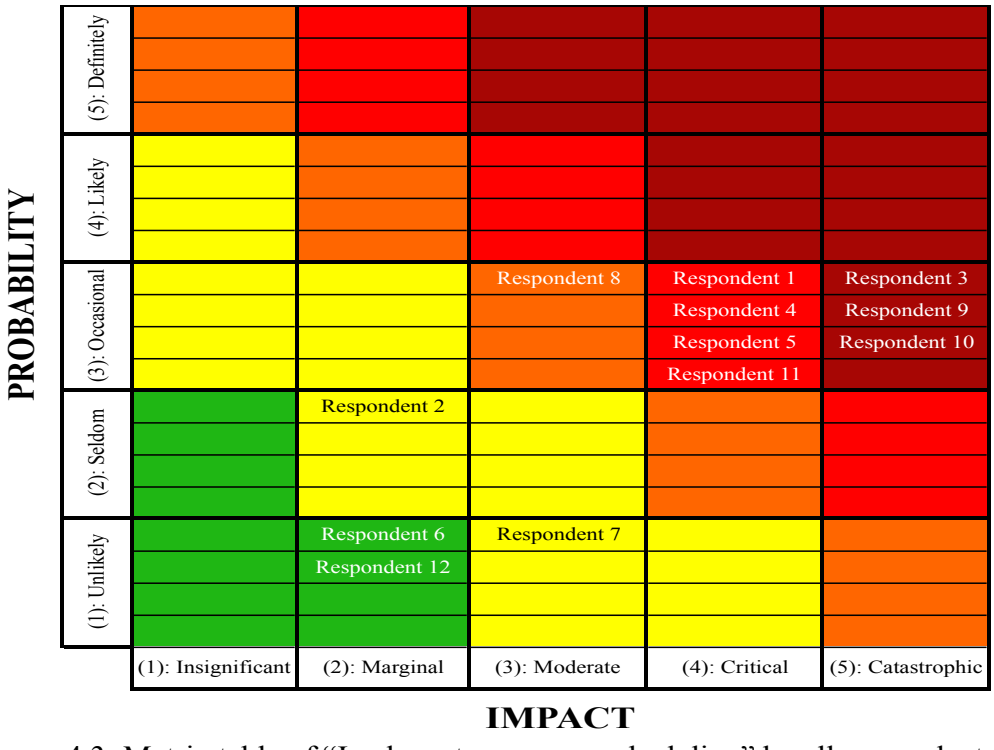


Figure 4.3: Matrix table of "Inadequate program scheduling" by all respondents

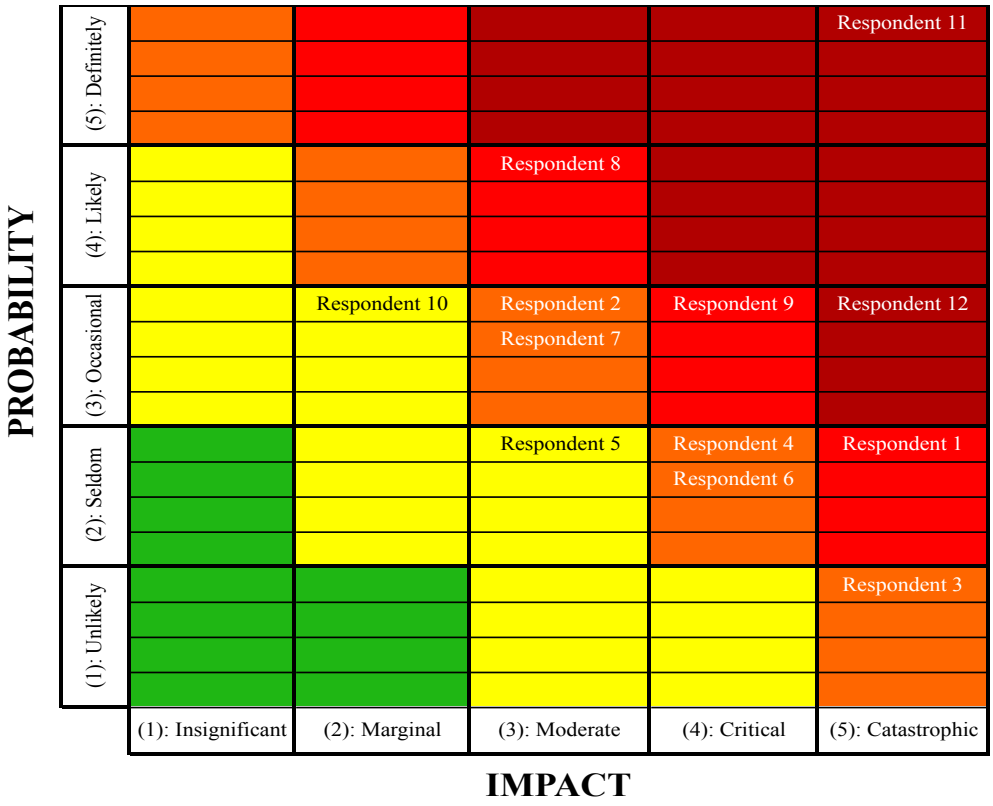


Figure 4.4: Matrix table of "Design variation" by all respondents

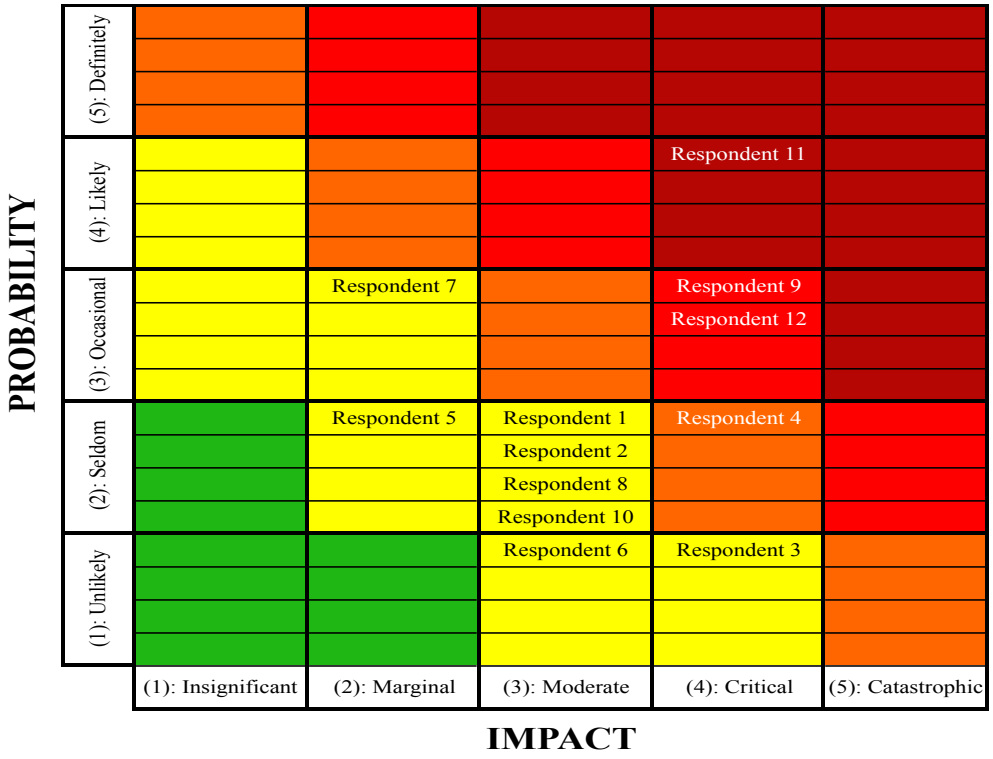


Figure 4.5: Matrix table of "Inaccurate cost estimating" by all respondents

As a follow up to risk assessment, it is the time for risk response planning, which was fully described in previous chapters. There are different action levels depending on the level of risk and the organizations, which are responsible for its management and this study is no exception. The required actions and responses, which proposed by respondent, are tabulated in Table 4.4.

Table 4.4: Risk response planning for priority level of each risk

Risk Level	Recommended Response	Description	Accountable Organization
Very Low	Acceptance	- Not required proactive response. - Limited actions required.	Department team
Low	Acceptance / Transference	- Limited actions required. - Review and re-evaluation should be undertaken.	Department team
Moderate	Transference / Mitigation	- Require continues monitoring and recorded action plans. - Risk assessment should be reviewed and the supervisor must prepare a safe work method. - In some cases, transfer to other parties for its management.	Directorate
High	Mitigation	- Risk assessment should be reviewed and the supervisor must prepare a safe work method. - Requires aggressive response strategy and immediate action. - Requires risk analysis board and management decisions.	Directorate
Very High	Mitigation / Avoidance	- Requires aggressive response strategy and immediate action. - In some cases, changing aspects of the overall project in order to eliminate threat.	Senior Management Team

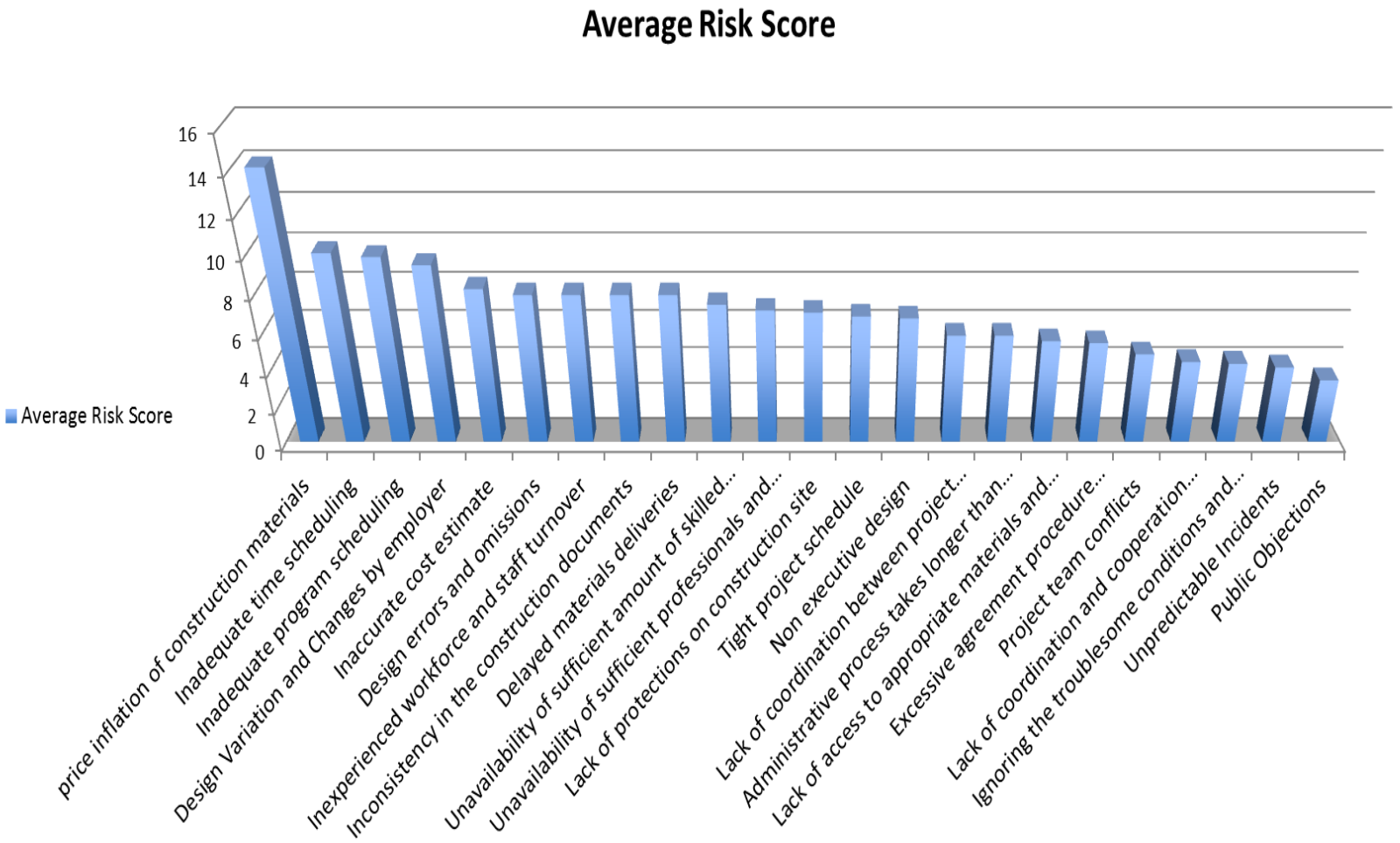


Figure 4.6: “Average risk score” for each potential risk

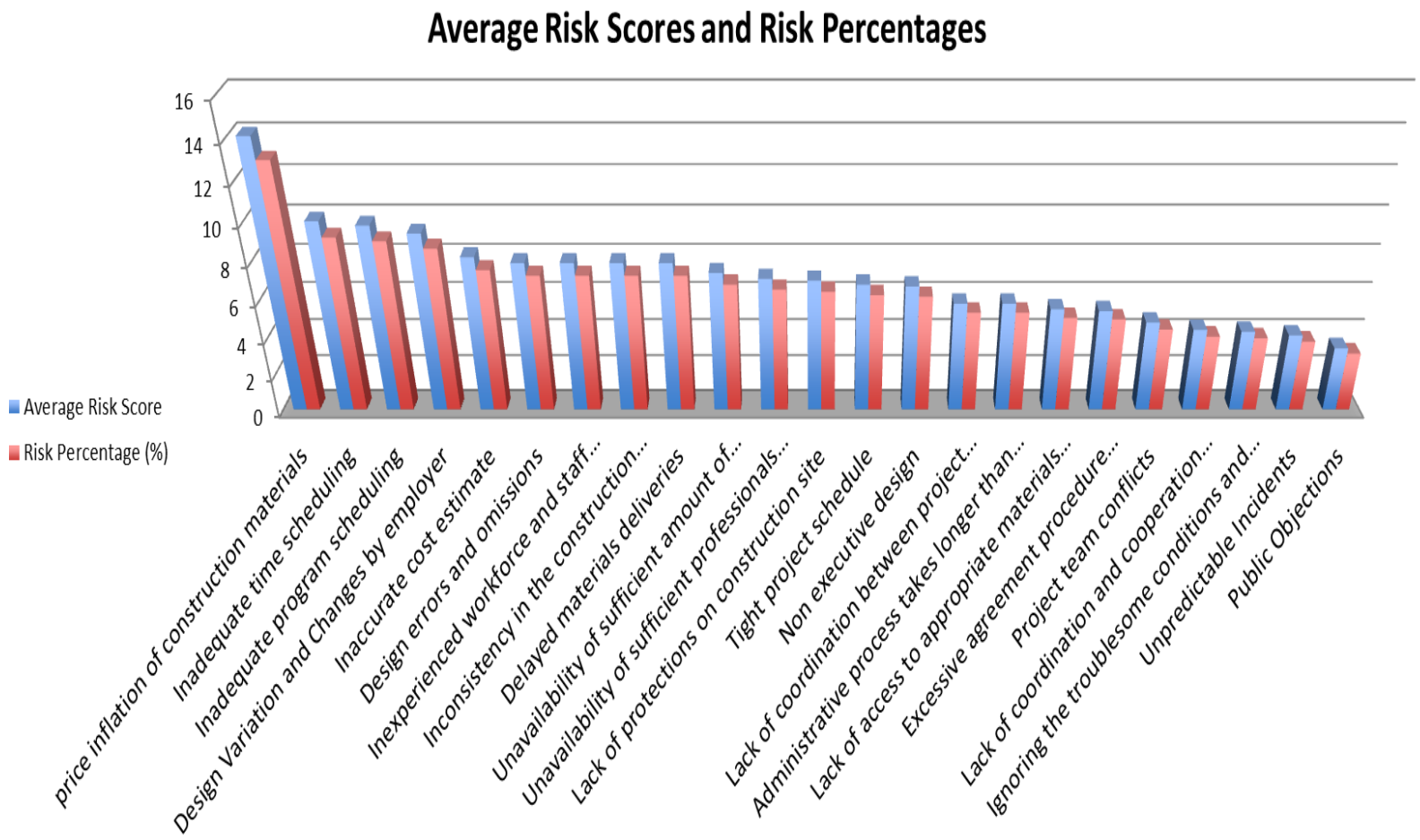


Figure 4.7: Comparison between “average risk scores” and “percentages” of each risk

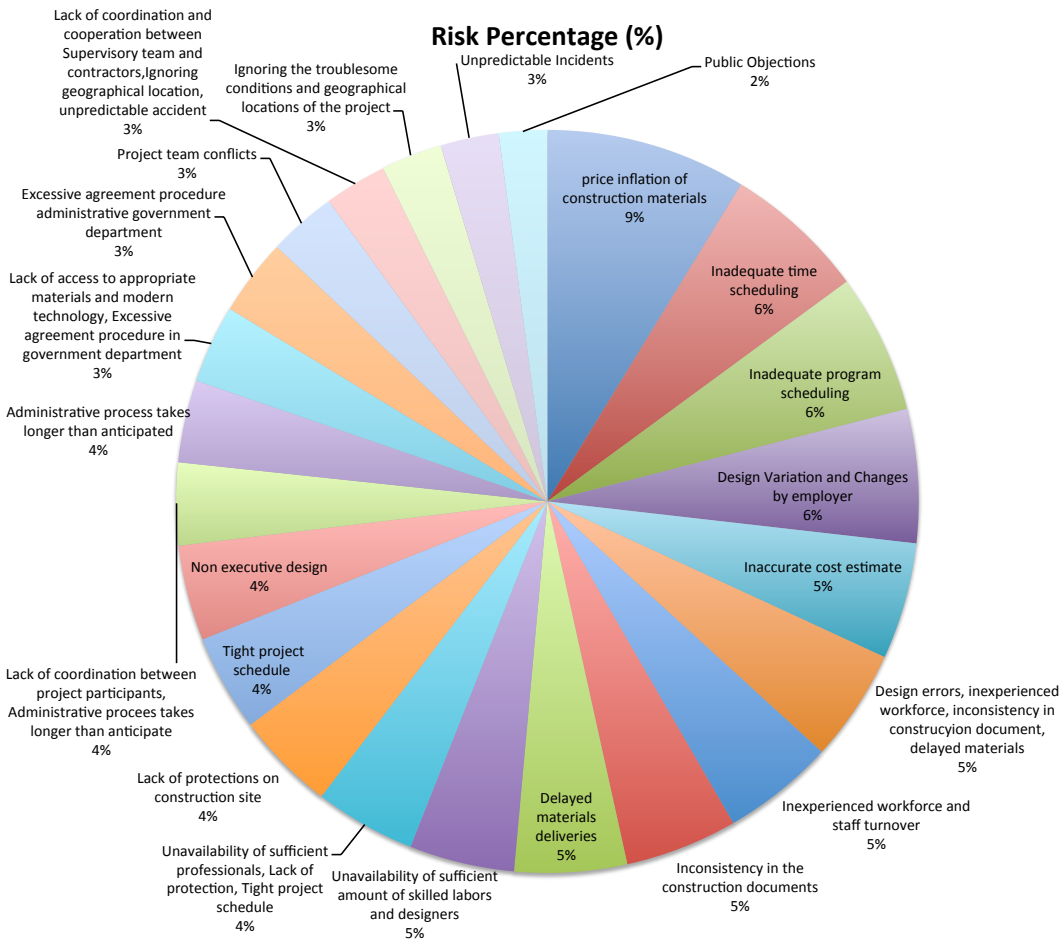


Figure 4.8: The actual risk percentages for each potential risk

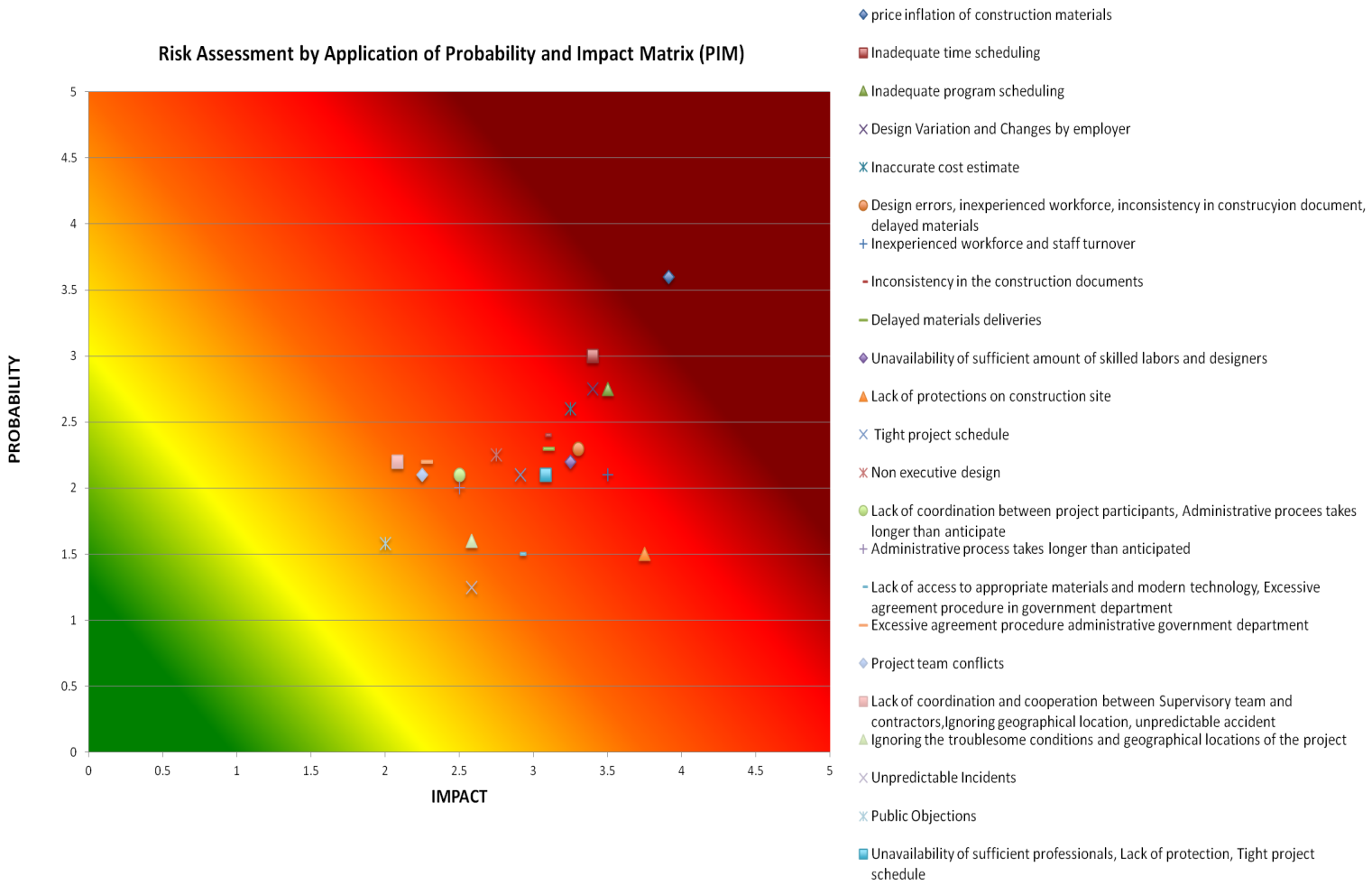


Figure 4.9: Mapping identified risk by Probability and Impact

As it is observable in Figure 4.9, all identified risks were prioritized and categorized with the application of PIM and as the result, each one them located in different zones and level of priority.

In accordance with application of PIM, the distribution of each identified risks depends on probability and impact risk score into matrix. Thus, this research shows that “Price inflation in construction materials” has the highest negative impact on the construction project since it is located in dark red zone, which is defined previously as critical zone. In contrast, the second, third and fourth risks are in territory of red zone and dark red zone which also most be considered as high impact on project goal and take aggressive and proper response in order to mitigate their probabilities or impacts on the project.

In overall, it can be conclude that those risks which are located on the center of the each matrix’s zones, can be much more important to consider in comparison to others, because of the chance of probability and impact for those risks are approximately equivalent (Table 3.3).

Chapter 5

RESULTS AND DISCUSSIONS

5.1 Introduction

This chapter will discuss about data analysis and the results of the analysis. Therefore, findings from interviews and questionnaire survey will be discussed in detail and the main causes of threats and recommended methods to mitigate and control the adverse effect of risks will be presented.

5.2 Results

Risk management is a way to identify threats and perform a structured method in order to managing threats when project is exposed to them. Each organization has its own strategies and methods to find the way to solve the adverse impacts of risks on the project and most of them are not even familiar with the expression of managing risk.

5.2.1 Outcomes of Questionnaire Survey and Interviews

As emerged from the interviews and questionnaire survey, some participants were not familiar with structured way and common techniques (qualitative or quantitative). In the following section, the question of how process of risk management (identification, assessment and response) was used in practice is explained.

5.2.1.1 Risk Identification

As previously stated, in risk identification, most participants and organizations used their past experience with discussion and corporation technique as well as manuals

and checklist in order to identify risks. This finding is similar to the studies conducted by Lynos and Skitmore (2004) and Klemetti (2006), which emphasized that discussion and brainstorming are most common tools in risk identification. In this situation, each company setup meetings with project team to discuss about potential risks in order to identify them on the project. Each company identified potential risk with prepared meeting and discussion about potential risks on the project and then try to make a list to categorized them regarding to their type.

5.2.1.2 Risk Assessment

In Chapter 3, most common risk assessment methods were described and later in Chapter 4, it was explained that respondents were not familiar with structured way to assess potential threats. As Lynos and Skitmore (2004) stated, experience and intuition are the most common ways, which are used in risk assessment, while some structured techniques like probability and impact matrix or Monte Carlo are used rarely. One of the respondents said, “Limited budget is one of the reasons for not using structured method”.

Another respondent explained that most residential projects have limited profit margins; this prevents major changes or implementations of new solutions. In addition, the general lack of knowledge within the area of risk management can result from limited resources such as time or money.

This statement is in agreement with Lynos and Skitmore (2004) which stated that one of the most important factors, which prevents from executing risk management, is lack of time.

As stated before, qualitative approach was used in a form of questionnaire survey to see how this method can help risk analysis process in practice. In this condition, identified risks with highest risk score were tabulated in matrix table. As stated in Chapter 4, price inflations of construction materials had the highest influence on whole project since it can affect time, cost and also quality. on the other hand, Iran has been sanctioned by most of the developed countries (e.g. America and most European countries). As a result, they do not allow specific construction equipment and materials as well as construction machines to be imported to Iran. Therefore, all industries are under pressure of price inflation and construction is one of the most fundamental ones. Hence, this risk stood at highest priority level, which every respondent was worried about. In contrast, different results might have been obtained in previous researches depending on their case and considering that each case does not have the same risk and threats. For instance, the results of the research conducted by Gajewska and Ropel (2011) revealed that "cheap solutions and not finding the right contractor" have the highest priority where tight project schedule was obtained by Zou et al. (2006) as a risk with highest influence on construction projects.

As mentioned before, these discrepancies depend on the case and the research method. In this research, questionnaire survey was prepared and respondents were requested to find potential risks by themselves whilst Zou et al. (2006) prepared a questionnaire with a list of potential threats to all respondents. In addition, same as Zou et al. (2006), this research is processed by using PIM.

As described in PMBOK (2008), those risks with greatest impact on project should be applied by proper response planning in order to minimize negative impacts of risks on projects.

5.2.1.3 Risk Response Planning

In methodology and data analysis, most common actions and strategies were explained which must be performed against identified risks. As achieved from the questionnaire survey and interviews, most respondents did not have adequate knowledge about types of actions in order to respond risks. Only few of them stated that they most often transfer the responsibility to other parties like insurance or other experts in that field to mitigate issues. This action can be interpreted as transference strategy, which is one of the main types of response. On the other hand, one of respondents stated that, “Discussion and checklists are the main tools to support the actions”. It is obvious that this step of risk management process also suffers from lack of knowledge.

Furthermore according to the results, most of the respondents concurred that many of the risks are manageable and mitigation strategy is most commonly used in this stage of risk management. This is also corresponding with Lyons and Skitmore (2004) who described that, risk mitigation is most often selected as an action against identified risk.

5.3 Summary

Respondents believed that the identified risks were due to a number of factors where risks with high impact and high probability are required further analysis and aggressive risk response. These factors are:

- Sanction;
- Poor quality of work;
- Inexperienced managers and inadequate number of experts;
- Delays and associated losses.

This research generally shows that Iranian construction companies manage their risks in their daily operations with a system that they even do not know is actually the framework of risk management. Furthermore, methods and strategies for risk management are presented as a list:

- Past experience and negotiation (discussion, brainstorming) in order to find the potential risks.
- Past experience and intuition are performed in risk assessment process.
- Transference and mitigation are commonly used actions to control and prepare risk response planning.

Finally, most important obstacles and drivers, which must be considered in this study, are presented in Figure 5.1.

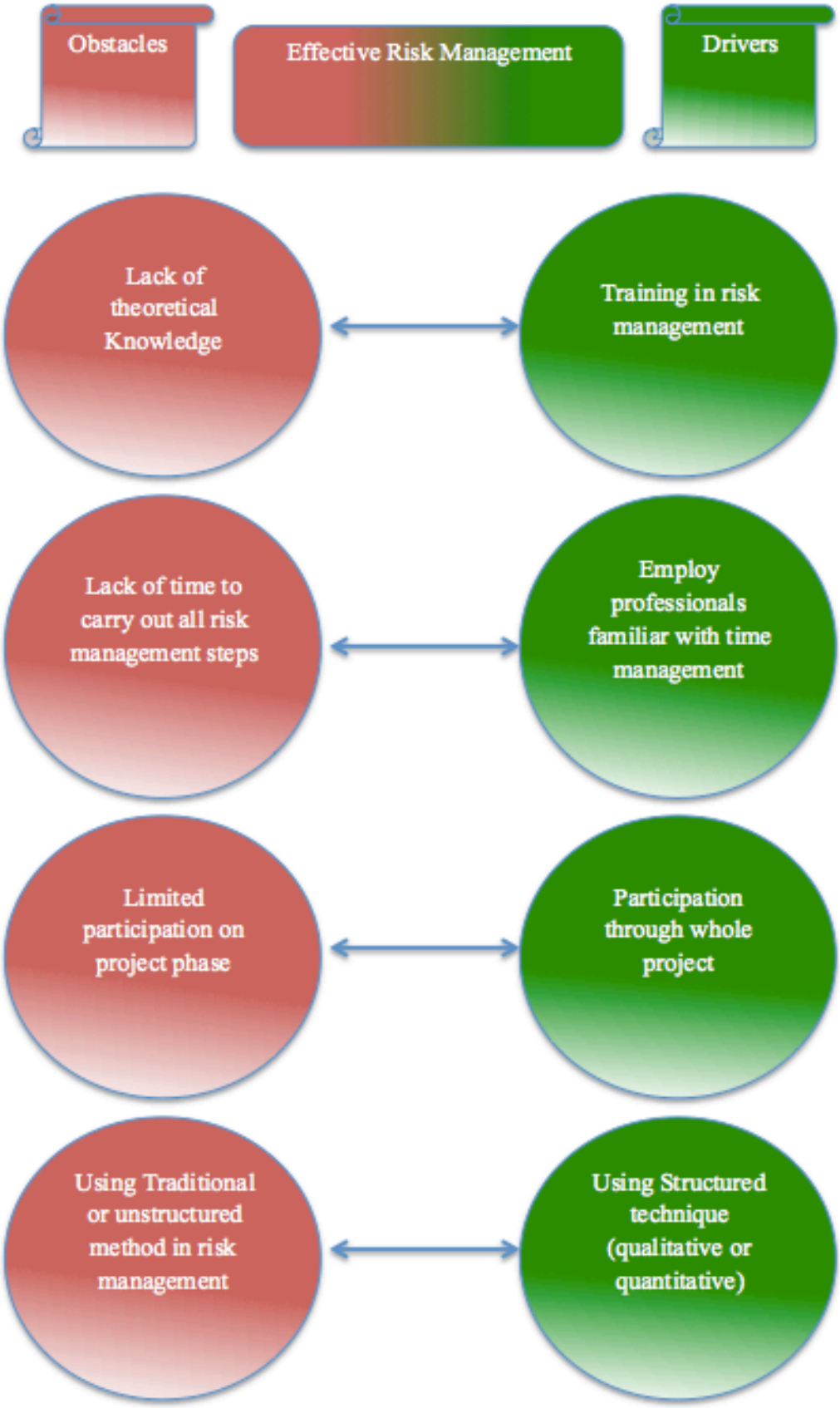


Figure 5.1: Obstacles and drives for effective risk management

Chapter 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This chapter aims to describe overall achievements, which emerge from this study and provides answers for the first part of the research as well as recommendations for further researches. In other words, this chapter is divided into main following sections:

- Conclusions
- Responding to the research questions
- Recommendations for further studies

6.2 Discussion and Achievements

This study was performed through interviews and questionnaire survey, which were designed with regard to the knowledge of Iranian construction companies. As mentioned before, the main purpose of this survey is to determine the level of Iranian Construction Company's knowledge and also their methods in order to risk management in construction industry.

It was clearly figured out that most of the threats in Iranian construction are divided into three groups: financial, organizational and management. In other words, three angles of time, cost and quality are the main factors, which every construction risk is related to.

In comparison to developed countries, risk management has been used with unstructured approach or informal way in Iranian companies. Only a minority of them used structured method in the field of construction risk management. This gap is because of the absence of participant's expertise and also their knowledge.

In most cases all respondents admitted that they would wait until a threat happens throughout construction stage and when it is occurred, they would deal with the risk according to their experience, skills and discussion (brainstorming). This research find out that, each company should start to educate their employers in order to benefit from managing risks in construction site and should focus more on this issue since risk management in all projects mostly relies on every participant and individual.

On the other hand, it is fundamental to know which risk assessment method should be selected depending on project complexity and also time constrains. As emerged from the literature and methodology, these days qualitative risk analysis is most frequently used in construction industry rather than quantitative assessment. Hence, using specific matrix tables can compare the level of each identified risk, which obtained by multiplying risk probability by risk impact, and then regarding to their limits, response strategies must be applied to mitigate problem.

In addition, in order to identify the level of each risk, it is crucial to take into account following factors:

- Project size and complexity
- Extreme time limits

- Adequately knowledgeable and experienced project manager and his team members
- Structured methods of risk management process

This research has proved that PIM is the fastest way and most appropriate method in order to adopting the process of risk management in practice. Thus, it is obvious that previous results from PIM technique can vary among other studies since each case study is unique and has its own scope.

Moreover, this research has helped the author to increase his knowledge and understand the concepts of risk and how to manage risks in the construction industry. This project has enabled the author to acquire skills and knowledge, which are essential to improve the construction risk management in real situations and future professional careers.

At the end of this thesis, recommendations for further studies are presented in the next section.

6.3 Response to Research Questions

As achieved from questionnaire survey and research results, the answers of the research questions are stated in below respectively:

i. What are the main reasons for the deficiency of risk management?
ii. What kinds of methods are most commonly used in risk management?
iii. What are the main obstacles and drivers for risk management?

i. Based on the results of this specific study, the first and main problem is lack of training and knowledge as well as motivation in this field of study and that is the point that why some participants are perceived that managing risk by

systematic approach is time-consuming. On the other side, participants were mostly not familiar with formal and structured way in order to controlling threats on a project. This subject is in contrast with Lynos and Skitmore (2004) study where was pointed out that those members who responsible for handling risk during project phases do not use all exiting formal methods.

Other factors, which interfere with shortcomings of risk management, are as follows:

- Sanctioning which directly effect on price inflation
- Lack of time
- Lack of dedicated resources
- Lack of adequate experience and background knowledge

ii. As stated in Chapter 5, past experience, discussions, negotiation, and manual checklist are the most common ways in order to identify threats and it was emphasized that experience is frequently used as the tool for assessment. However, as Lynos and Skitmore (2004) described, qualitative methods are most common formal methods used by developed countries. Thus, the result of this research was obtained by this technique.

iii. As found from Chapter 5, the most important obstacles are lack of theoretical knowledge, time and limited participation and also using traditional ways in every process of risk management; and in the opposite side drivers are: training staff and employ experts and professional project managers, participation in each process of risk management and using a structured and formal method respectively.

6.4 Recommendations for Future Works

The recommendations for future studies proposed by author are the following:

- The other aspect of risk management worth doing is to make an analysis on those risks, which directly influence the project cost.
- Besides, qualitative methods like probability and impact matrix by using MS Excel; there are novel programs that speed up the process of risk management analysis, for instance; SPSS, Primavera and Crystal.
- It would have been good to collect data separately from three main factors of project scope; time, cost and quality and compared them to see which are the crucial ones in this specific case study.
- By combination of qualitative and quantitative techniques, the framework of risk management can be significantly progress, if we have an adequate time on the construction project.
- Risk management can be more organized and productive if further studies can find a way to improve the combination of organizational culture and individuals' viewpoint since progress in this issue is necessary.

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APPENDICES

Appendix A: Sample of Questionnaire (English Version)

INFORMATION							
Work Experience:				Position:		Field of Study:	
RISK ANALYSIS							
RISK IDENTIFICATION		QUALITATIVE ANALYSIS				RISK RESPONSE PLANNING	
Risk Type		Probability level of the risk occurrence: 1 (rare) - 5 (frequent)	Level of Impact if risk occurs: 1 (very low) - 5 (very high)	Risk Score	Average Risk Score	Risponse Strategy	Risk Owner
1	Design Variation and Changes by employer						
3	Public Objections						
4	Excessive agreement procedure administrative government department						
5	Inadequate program scheduling						
6	Administrative process takes longer than anticipated						
7	Inconsistency in the construction documents						
8	Inaccurate cost estimate						
9	Design errors and omissions						
10	Inadequate time scheduling						
11	Tight project schedule						
12	Non executive design						
13	Unavailability of sufficient professionals and managers						
14	Unavailability of sufficient amount of skilled labors and designers						
15	Inexperienced workforce and staff turnover						
16	Project team conflicts						
17	Lack of access to appropriate materials and modern technology						
18	Delayed materials deliveries						
19	price inflation of construction materials						
20	Lack of coordination between project participants						
21	Lack of coordination and cooperation between Supervisory team and contractors						
22	Unpredictable Incidents						
23	Lack of protections on construction site						
24	Ignoring the troublesome conditions and geographical locations of the project						

Appendix B: Sample of Interview

Name and Surname:	**Work Experience:**	**Company Name:**
Introduction	*General Information*	1. Which Position do you have in the project? 2. Which phase do you take part in the project? 3. How would you define risks in construction projects? 4. How much are you familiar with the concept of risk management and risk management process?
Risk Management Process	*Identification*	1. In what ways do you identify threats in construction project? (e.g., as an individual or in the organization) 2. What are the main risks that you encounter with them? 3. Which methods or techniques do you use in order to identify potential risks?
	Assessments	1. Supposing that you discovered a number of risks on a project. How would you categorize and prioritize them? 2. Have you ever used risk analysis techniques? (for instance, Probability and Impact Matrix, decision tree, Monto Calro,…) 3. Do you think that performing formal and structured method can enhance overall project performance?
	Response and Control	1. What are the main actions and strategies you usually take against risks? 2. How are risks controlled within your construction projects? 3. How should risk management be organized in construction projects?

Appendix C: Questionnaire Result by Respondent 2 (Persian Version)

مشخصات

رشته تحصیلی: فوق لیسانس عمران - سازه | سمت : مدیر عامل شرکت سفید رود گیلان - ناظر شهرسازی کلاردشت | سابقه کاری (سال) : ۱۸ سال

این فرم با توجه به کدام منطقه آب و هوایی پر میشود؟ کلاردشت -شمال ایران

با تشکر از توجه و همکاری شما در این پروژه دانشجویی , در صورت تمایل موارد دیگری اگر در ذهن دارید ذکر نمایید.

Risk Analysis

	Risk Identification	Qualitative Rating				Risk Response	
	نوع ریسک	احتمال وقوع ریسک از ۱ تا ۵	تاثیر ریسک روی پروژه از ۱ تا ۵	تاثیر * احتمال	رتبه بندی ریسک	چه واکنش و عملکردی بعد از وقوع ریسک پیشنهاد میدهید؟	چه شخصی مسئول مدیریت و کنترلِ ریسک می‌باشد؟
۱	تغییرات دیرهنگام در طراحی توسط کارفرما	۳	۳	۹		تغییر برنامه ریزی	کارفرما و مدیر پروژه
۲	جابجایی و تغییر کارفرما	۱	۲	۲		تغییر برنامه ریزی	کارفرما و مدیر پروژه
۳	اعتراضات و ممانعت محلی و مردمی به پروژه	۱	۱	۱		_	_
۴	ممانعت دولتی با اجرای پروژه	۲	۳	۶		تغییر برنامه ریزی و پیگیری علت	مدیر پروژه
۵	عدم برنامه ریزی مشخص و منسجم در اجرای پروژه	۲	۲	۴		تنظیم برنامه در اسرع وقت	مدیر پروژه
۶	زمانبری مراحل اداری	۱	۲	۲		پیگیری مداوم و هر روزه	گروه اداری پروژه
۷	نقص و کمبود مدارک و اسناد	۱	۱	۱		پیگیری و رفع کمبود	گروه اداری پروژه
۸	اشتباه و یا نقص در برآورد هزینه	۲	۳	۶		تنظیم برآورد جدید و دقیق به محز اطلاع از نقص	گروه اداری پروژه و مدیر پروژه و کارفرما
۹	نقص و نادرستی در طراحی و نقشه های پروژه	۲	۲	۴		پیگیری از طریق مشاور و رفع نقص	مشاور
۱۰	زمانبندی نادرست و نا کافی پروژه	۱	۲	۲		زمانبندی جدید با هماهنگی کارفرما - تنظیم برنامه فرس ماژور	مدیر پروژه - مشاور
۱۱	فشردگی زمانبندی پروژه	۱	۲	۲		در صورت برنامه ریزی درست ریسک محسوب نمیشود	
۱۲	(عدم امکان اجرا طبق طراحی(اجرایی نبودن طراحی	۲	۲	۴		تغییر طراحی توسط مشاور و کارفرما	کارفرما و مشاور
۱۳	در دسترس نبودن مدیران حرفه‌ای و با تجربه	۲	۳	۶		پیگیری تا پیدا کردن مدیر صالح	کارفرما - مشاور
۱۴	...) در دسترس نبودن نیروی متخصص(طراح - مهندس و	۲	۳	۶		فراهم کردن نیرو از خارج از منطقه	مدیریت و سرپرستی پروژه
۱۵	دردسترس نبودن پیمانکاران و نیروی کار ماهر	۲	۲	۴		نظارت و سرپرستی بیشتر و دقیق تر - استخدام از خارج از منطقه	مدیریت و سرپرستی پروژه
۱۶	وقوع مشاجره و اختلاف نظر و درگیری در بین تیم پروژه	۲	۳	۶		تغییر و جابجایی نفرات	مدیریت و سرپرستی پروژه
۱۷	عدم دسترسی به مصالح مناسب و تکنولوژی روز	۲	۲	۴		پیشبینی از قبل و تهیه از خارج از منطقه	سرپرستی پروژه
۱۸	تاخیر در دریافت مصالح	۲	۲	۴		پیشبینی از قبل	سرپرستی پروژه
۱۹	تورم قیمت مصالح	۱	۲	۲		برآورد جدید هزینه	مدیریت و سرپرستی پروژه
۲۰	عدم هماهنگی و همکاری بین کارفرما و مجری	۲	۲	۴		مدیریت بحران	کارفرما - مدیر پروژه
۲۱	عدم هماهنگی و همکاری بین مجری و تیم نظارت یا مشاور	۱	۲	۲		مدیریت بحران	مدیر پروژه
۲۲	عدم هماهنگی و همکاری بین مجری و پیمانکاران جزء	۲	۳	۶		سرپرستی دقیق تر و مدیریت اختلاف	مدیریت و سرپرستی پروژه
۲۳	وقوع حوادث غیر مترقبه	۱	۱	۱		پیگیری و رفع حادثه	سرپرستی پروژه
۲۴	عدم رعایت ایمنی کارگاه	۱	۲	۲		کنترل و نظارت دقیق سرپرستی کارگاه	سرپرستی پروژه
۲۵	در نظر نگرفتن شرایط سخت اقلیمی و جغرافیایی	۲	۳	۶		بکار گیری نفرات و نیروی آشنا به منطقه	مدیریت و سرپرستی پروژه
۳۰							

Appendix D: Answers of Interview Questions

Introduction: General Information

1. All respondents are project managers of their companies.
2. All respondents try to participate in all phases of risk management in the project.
3. They perceived risks as threats, which have an adverse effect on the project goals.
4. Respondent 1, Respondent 5, Respondent 6, Respondent 7 and Respondent 9 are familiar with most parts of risk managements but the rest of the respondents do not have a proper insight and knowledge with structured risk management.

Risk Management Process: Risk Identification

1. All respondents admitted that they identify potential risks with discussions and meetings by team members within culture of organization.
2. Main risks form respondent's view:
    - Respondent 1 stated that Price inflation; inadequate time, cost and program scheduling are the main threats in construction projects.
    - Respondent 2 stated that Program scheduling; Lack of professionals and design variation are the crucial risks.
    - Respondent 3 as same as Respondent 1 are agree with that, Price inflation; inadequate time, cost and program scheduling are the main problem.

- Respondent 4 stated that Price inflation; inconsistency in the construction documents and inaccurate cost estimating.
- Respondent 5 stated that Price inflation is the most important one plus problems in estimating and cost scheduling causes lot of threats.
- Respondent 6 stated that unavailability of sufficient amount of skilled labors and designers and also Price inflation are the crucial ones.
- Respondent 7 stated that Price inflation is the most important ones and Inexperienced workforce and staff turnover are another issues.
- Respondent 8 stated that Price inflation and Lack of protection on construction site are the main threats.
- Respondent 9 also stated that Price inflation; Mistakes in cost and time scheduling and also Time management are most important risks.
- Respondent 10 stated that Mistakes in time, cost and program scheduling are the key crucial risk in construction project.
- Respondent 11 stated that Design variation and changes is most important ones and also inaccurate cost management is another important risks.
- Respondent 12 stated that Price inflation; mistakes in time management and in experienced workforce are most important issues.

Risk Management Process: Risk Assessment

1. All respondent declare that the most widely tool in order to assessment is discussion. The risks were primarily managed within the actor's organization concerning only the scope of worked assigned, then later managed and consulted with the other members of the project team. Within the project, there had been few meetings organized where risk issues were raised. The

purpose was to consult the problems with experts from the field in which the problem was identified. Systemizing and mapping were those only techniques of handling risk used at those meetings after that by set criteria they try to prioritize each identified risks.

2. They admitted that they did not use any formal and structural methods in order to analysis and assess since they though the structured methods is time consuming and not cost effective.
3. Most of the respondent are keen on learning some structural method in order to develop and improve the result of risk analysis but few of them (Respondent 3,5,6) are in believe that traditional way and their past experience can solve most of the risk related issues.

Risk Management process: Risk Response and Control

1. Respondent 8 stated that discussions and checklist are the main tools to support the actions. Respondent 10 said that by every experience, you will get more knowledge and that knowledge is crucial for following projects. As all respondent did not use any structured technique, they mostly deal with risk by shifting its responsibility to other parties like insurance or warranties. This action can be interpreted as Transference strategy, which is one of the common techniques in this condition. Another way is try to mitigate risk's impact on the project.
2. Respondent 1, 2, 4, 5, 7, 9, 10, 12 stated that risk should be monitored by tracking all identified and potential risks. On the other side respondent 3, 6, 8 and 11 are believed that cost, time and quality most be considered in order to

find risks impact on project and by discussion and meeting or transfer to expert judgments try to control threats.

3. In overall most respondents are common in order to take actions. By documentation of contract procedures, documented meetings to consider key risk and use their past experience, they try to deal with the concept of risk management. They admitted that absence of knowledge and training in this field of study is the key important of deficiency of risk management. So by training and improve their knowledge risk management can significantly enhance in their organizations.

Appendix E: Respondents and Companies Profile

	Names of Respondents	Company Name	Work Experience
Respondent 1	Ghadiri H.	Kish Frame	18 Years
Respondent 2	Rabi Pour M.	Sefidrood Gilan	15 Years
Respondent 3	Bakhtiari H.	Patronak	14 Years
Respondent 4	Shahinfar K.	Moshaver Aban	16 Years
Respondent 5	Ensafi A.	Espidez	20 Years
Respondent 6	Moadeli A.	Perlite	15 Years
Respondent 7	Hadian A.	Iran Sazeh	13 Years
Respondent 8	Tarkesh Dooz N.	Mahab Ghods	16 Years
Respondent 9	Khajeh Abadi E.	Moshaver Atek	15 Years
Respondent 10	Pak Nejad A.	Tarhe No Andisahan	12 Years
Respondent 11	Ghareh Abadi K.	Gamasiab	14 Years
Respondent 12	Roodgari M.	Moshaver Haraz Rah	10 Years

Appendix F: Significance Score Risk by (Shen et al. 2001)

The significance risk score for each identified risk can be achieved by Eq. C1, which developed by Shen et al. (2001):

$$r_{ij} = \alpha_{ij} \times \beta_{ij} \quad \text{Eq. C1}$$

Where:

- α_{ij} = Probability of occurrence of risk *i* which is assessed by respondent *j*.
- β_{ij} = Intensity of risk impact *i* which is assessed by respondent *j*.

Shen et al. (2001) stated that the average risk score is known as significant index score risk, which can be calculated by Eq. C2:

$$R_i = \frac{\sum_j^n r_{ij}}{n} = \frac{1}{n} \sum_j^n \alpha_{ij} \times \beta_{ij} \quad \text{Eq. C2}$$

Where:

- n = Total number of valid questionnaires
- R_i = Significant index score for risk *i* (Average risk score for risk *i*)

On the other hand, Eq. C3 is formulated in order to find percentages of each risks than other ones which is observable below:

$$R_{pi} = \frac{R_i}{\sum R_t} \times 100 \quad \text{Eq. C3}$$

Where:

- R_{pi} = Percentage for risk *i*
- $\sum R_t$ = Total significant index score

Appendix G: Respondent's Risk Scores for all Identified Risks

Price inflation	Probability	Impact
Respondent 1	3	3
Respondent 2	1	2
Respondent 3	4	4
Respondent 4	5	5
Respondent 5	3	3
Respondent 6	3	4
Respondent 7	5	5
Respondent 8	3	4
Respondent 9	4	4
Respondent 10	3	3
Respondent 11	5	3
Respondent 12	5	4

Inadequate time scheduling	Probability	Impact
Respondent 1	3	4
Respondent 2	1	2
Respondent 3	2	4
Respondent 4	3	4
Respondent 5	3	4
Respondent 6	2	4
Respondent 7	2	3
Respondent 8	2	2
Respondent 9	4	4
Respondent 10	4	3
Respondent 11	3	4
Respondent 12	4	4

Inadequate program scheduling	Probability	Impact
Respondent 1	3	4
Respondent 2	2	2
Respondent 3	3	5
Respondent 4	3	4
Respondent 5	3	4
Respondent 6	1	2
Respondent 7	1	3
Respondent 8	3	3
Respondent 9	3	5
Respondent 10	3	5
Respondent 11	3	4
Respondent 12	1	2

design variation	Probability	Impact
Respondent 1	2	5
Respondent 2	3	3
Respondent 3	1	5
Respondent 4	2	4
Respondent 5	2	3
Respondent 6	2	4
Respondent 7	3	3
Respondent 8	4	3
Respondent 9	3	4
Respondent 10	3	2
Respondent 11	5	5
Respondent 12	3	5

Inaccurate cost estimating	Probability	Impact
Respondent 1	2	3
Respondent 2	2	3
Respondent 3	1	4
Respondent 4	2	4
Respondent 5	2	2
Respondent 6	1	3
Respondent 7	3	2
Respondent 8	2	3
Respondent 9	3	4
Respondent 10	2	3
Respondent 11	4	4
Respondent 12	3	4

Design errors and omissions	probability	Impact
Respondent 1	2	4
Respondent 2	2	2
Respondent 3	2	4
Respondent 4	2	4
Respondent 5	2	3
Respondent 6	2	2
Respondent 7	3	3
Respondent 8	2	3
Respondent 9	1	3
Respondent 10	2	3
Respondent 11	4	5
Respondent 12	3	3

inexperienced workforce and staff turnover	probability	impact
Respondent 1	3	4
Respondent 2	2	2
Respondent 3	1	4
Respondent 4	1	4
Respondent 5	2	4
Respondent 6	2	2
Respondent 7	3	4
Respondent 8	2	3
Respondent 9	2	3
Respondent 10	2	4
Respondent 11	3	4
Respondent 12	3	5

inconsistency in the construction documents	probability	impact
Respondent 1	1	4
Respondent 2	2	2
Respondent 3	2	2
Respondent 4	3	3
Respondent 5	3	3
Respondent 6	3	3
Respondent 7	2	3
Respondent 8	1	1
Respondent 9	2	4
Respondent 10	1	2
Respondent 11	3	4
Respondent 12	1	3

delayed materials deliveries	probability	impact
Respondent 1	3	3
Respondent 2	2	2
Respondent 3	3	4
Respondent 4	1	3
Respondent 5	2	2
Respondent 6	3	3
Respondent 7	3	4
Respondent 8	2	2
Respondent 9	2	2
Respondent 10	2	3
Respondent 11	1	1
Respondent 12	2	5

unavailability of sufficient amount of skilled labors and designers	probability	impact
Respondent 1	3	4
Respondent 2	2	3
Respondent 3	2	2
Respondent 4	1	4
Respondent 5	2	3
Respondent 6	2	4
Respondent 7	2	2
Respondent 8	2	4
Respondent 9	2	3
Respondent 10	2	4
Respondent 11	4	4
Respondent 12	3	3

unavailability of sufficient professionals and managers	probability	impact
Respondent 1	2	5
Respondent 2	2	3
Respondent 3	2	3
Respondent 4	2	3
Respondent 5	2	3
Respondent 6	2	4
Respondent 7	2	4
Respondent 8	1	3
Respondent 9	2	3
Respondent 10	2	3
Respondent 11	2	4
Respondent 12	3	3

Lack of protection on construction site	probability	impact
Respondent 1	2	3
Respondent 2	1	2
Respondent 3	2	4
Respondent 4	1	3
Respondent 5	1	2
Respondent 6	1	3
Respondent 7	2	4
Respondent 8	3	3
Respondent 9	2	3
Respondent 10	2	3
Respondent 11	4	4
Respondent 12	3	3

tigh project schedule	probability	impact
Respondent 1	2	3
Respondent 2	1	2
Respondent 3	1	3
Respondent 4	2	2
Respondent 5	3	3
Respondent 6	2	3
Respondent 7	3	3
Respondent 8	2	4
Respondent 9	2	3
Respondent 10	1	3
Respondent 11	3	4
Respondent 12	3	3

non executive design	probability	impact
Respondent 1	1	4
Respondent 2	2	2
Respondent 3	2	5
Respondent 4	2	2
Respondent 5	1	2
Respondent 6	1	2
Respondent 7	1	5
Respondent 8	3	2
Respondent 9	1	4
Respondent 10	2	3
Respondent 11	2	3
Respondent 12	3	3

Lack of coordination between project participants	probability	impact
Respondent 1	2	5
Respondent 2	2	2
Respondent 3	2	3
Respondent 4	2	2
Respondent 5	2	3
Respondent 6	2	2
Respondent 7	2	3
Respondent 8	2	2
Respondent 9	2	3
Respondent 10	3	3
Respondent 11	1	2
Respondent 12	1	5

Administrative process takes longer than anticipated	probability	impact
Respondent 1	2	4
Respondent 2	1	2
Respondent 3	2	3
Respondent 4	2	2
Respondent 5	2	2
Respondent 6	1	1
Respondent 7	2	2
Respondent 8	2	4
Respondent 9	1	1
Respondent 10	2	3
Respondent 11	3	4
Respondent 12	4	4

lack of access to appropriate materials and modern technology	probability	impact
Respondent 1	3	3
Respondent 2	2	2
Respondent 3	3	3
Respondent 4	2	5
Respondent 5	1	2
Respondent 6	1	1
Respondent 7	2	4
Respondent 8	1	1
Respondent 9	2	2
Respondent 10	3	3
Respondent 11	2	4
Respondent 12	3	3

excessive agreement procedure administrative government department	probability	impact
Respondent 1	1	4
Respondent 2	2	3
Respondent 3	2	4
Respondent 4	2	2
Respondent 5	1	4
Respondent 6	1	3
Respondent 7	2	5
Respondent 8	2	2
Respondent 9	1	3
Respondent 10	2	4
Respondent 11	1	1
Respondent 12	1	3

project team conflict	probability	impact
Respondent 1	1	5
Respondent 2	2	3
Respondent 3	1	2
Respondent 4	2	2
Respondent 5	1	2
Respondent 6	1	1
Respondent 7	3	3
Respondent 8	1	2
Respondent 9	3	3
Respondent 10	1	2
Respondent 11	1	2
Respondent 12	2	2

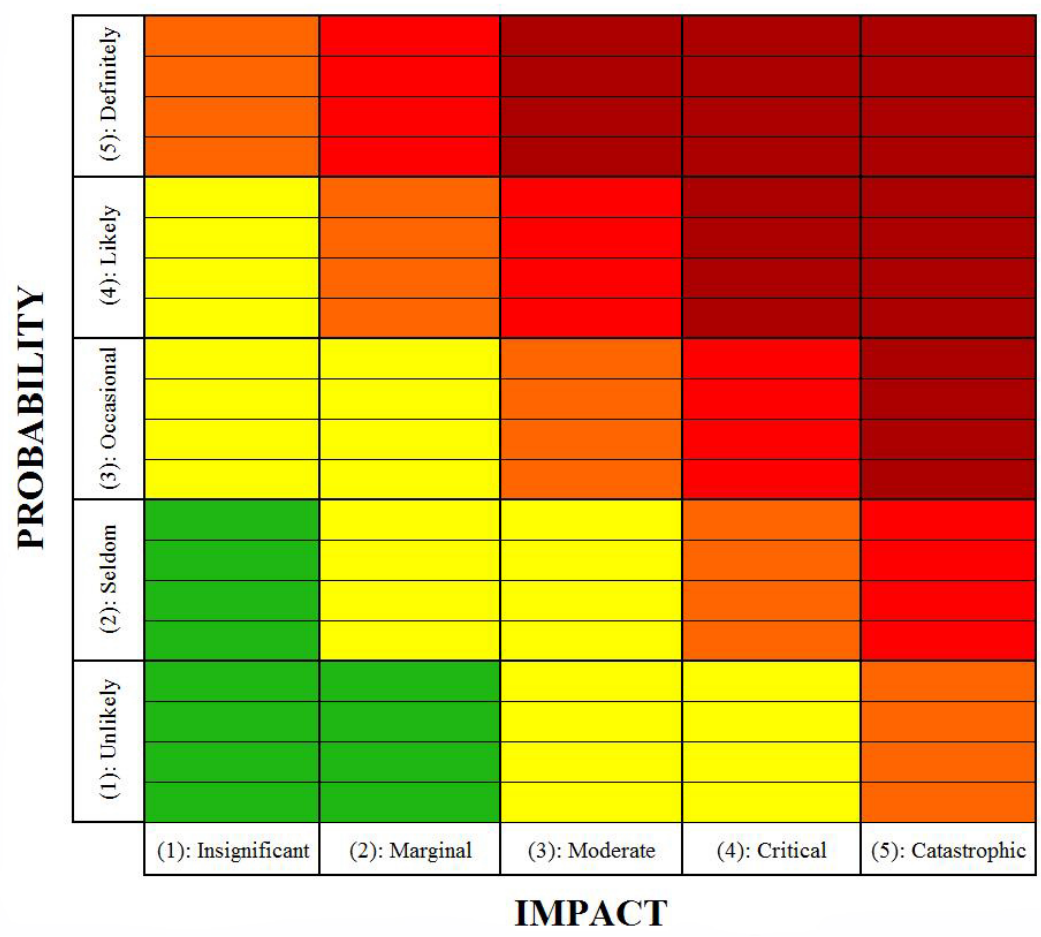
lack of coordination and cooperation between supervisory team and contractor	probability	impact
Respondent 1	2	2
Respondent 2	2	3
Respondent 3	1	2
Respondent 4	1	3
Respondent 5	2	3
Respondent 6	2	2
Respondent 7	3	4
Respondent 8	1	4
Respondent 9	2	2
Respondent 10	1	2
Respondent 11	1	2
Respondent 12	1	3

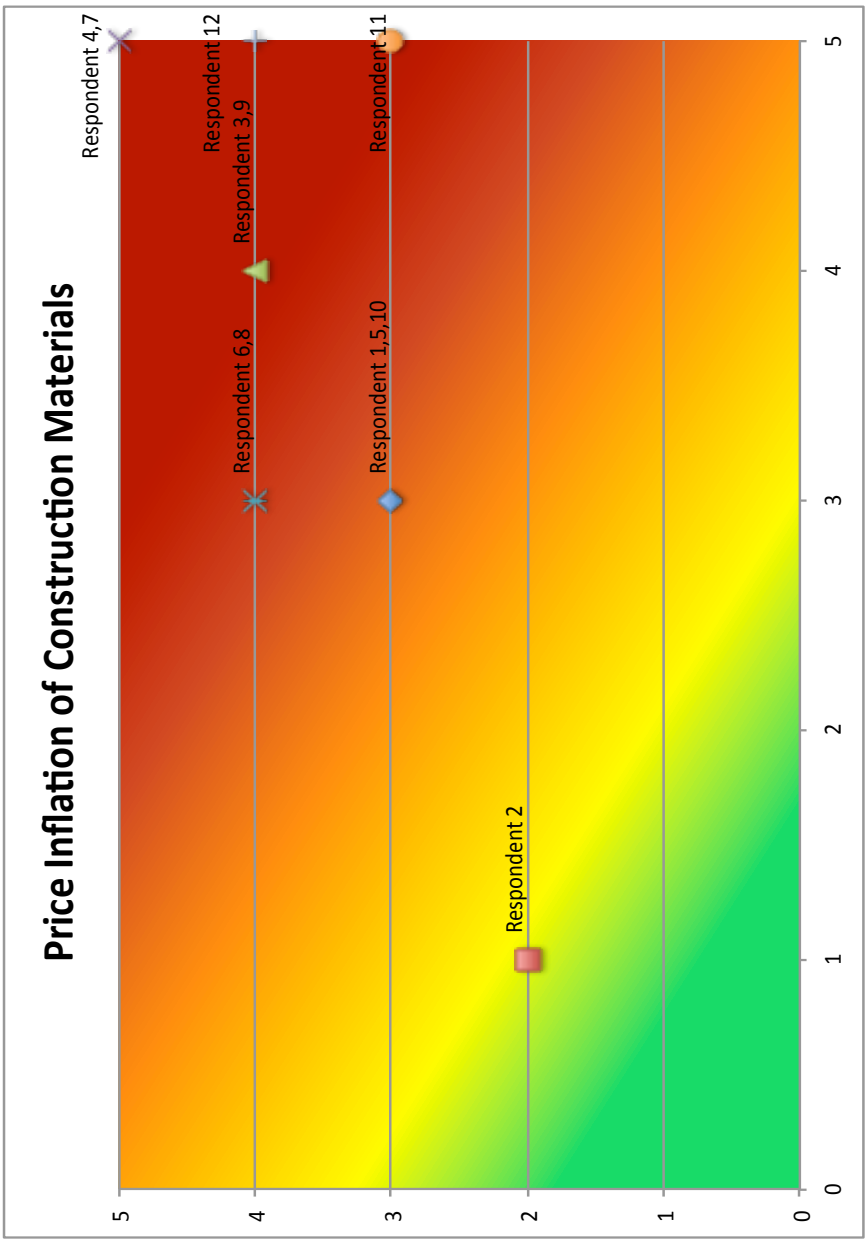
Ignoring the troublesome conditions and geographcal locations of the project	probability	impact
Respondent 1	2	5
Respondent 2	2	3
Respondent 3	1	3
Respondent 4	2	2
Respondent 5	1	3
Respondent 6	1	3
Respondent 7	1	3
Respondent 8	1	4
Respondent 9	2	3
Respondent 10	1	3
Respondent 11	1	3
Respondent 12	1	2

Unpredictable accidents	probability	impact
Respondent 1	1	1
Respondent 2	1	1
Respondent 3	1	2
Respondent 4	2	2
Respondent 5	2	3
Respondent 6	1	2
Respondent 7	2	3
Respondent 8	2	2
Respondent 9	2	3
Respondent 10	2	2
Respondent 11	1	1
Respondent 12	1	3

Public objections	probability	impact
Respondent 1	2	3
Respondent 2	1	1
Respondent 3	1	5
Respondent 4	1	3
Respondent 5	1	3
Respondent 6	1	1
Respondent 7	1	3
Respondent 8	1	3
Respondent 9	2	2
Respondent 10	2	2
Respondent 11	1	1
Respondent 12	1	3

Appendix H: Sample of Matrix Table




Price Inflation of Construction Materials
Respondent 4,7
Respondent 12
Respondent 3,9
Respondent 11
Respondent 6,8
Respondent 1,5,10
Respondent 2
0
1
2
3
4
5

Appendix I: Questionnaire Reliability (SPSS, Cronbach's Alpha)

```
RELIABILITY
 /VARIABLES=Respondent1 Respondent2 Respondent3 Respondent4 Respondent5 Respondent7 Respondent
 /SCALE('ALL VARIABLES') ALL
 /MODEL=ALPHA
 /STATISTICS=DESCRIPTIVE SCALE CORR
 /SUMMARY=TOTAL.
```

Reliability

Notes

Output Created		**09-FEB-2014 12:57:55**
Comments		
Input	**Data**	/Users/Sina/Desktop/Reliability. SPSS.sav
	Active Dataset	**DataSet1**
	Filter	**<none>**
	Weight	**<none>**
	Split File	**<none>**
	N of Rows in Working Data File	**23**
	Matrix Input	
Missing Value Handling	**Definition of Missing**	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the procedure.
Syntax		RELIABILITY /VARIABLES=Respondent1 Respondent2 Respondent3 Respondent4 Respondent5 Respondent7 Respondent8 Respondent9 Respondent10 Respondent11 Respondent12 /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /STATISTICS=DESCRIPTIVE SCALE CORR /SUMMARY=TOTAL.
Resources	**Processor Time**	**00:00:00.01**
	Elapsed Time	**00:00:00.00**

[DataSet1] /Users/Sina/Desktop/Reliability. SPSS.sav

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	23	100.0
	Excluded[a]	0	.0
	Total	23	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.834	.831	11

Item Statistics

	Mean	Std. Deviation	N
Respondent1	7.6957	3.15414	23
Respondent2	4.1304	2.02943	23
Respondent3	6.5217	3.90652	23
Respondent4	6.5217	4.95314	23
Respondent5	5.6522	2.96355	23
Respondent7	7.8696	4.95713	23
Respondent8	5.8696	2.95887	23
Respondent9	6.9130	4.31607	23
Respondent10	6.3478	3.21373	23
Respondent11	9.3478	6.94530	23
Respondent12	8.7391	5.45408	23

Inter-Item Correlation Matrix

	Respondent1	Respondent2	Respondent3	Respondent4	Respondent5	Respondent7
Respondent1	1.000	.184	.334	.290	.387	.073
Respondent2	.184	1.000	-.227	-.138	-.166	.042
Respondent3	.334	-.227	1.000	.631	.201	.375
Respondent4	.290	-.138	.631	1.000	.465	.523
Respondent5	.387	-.166	.201	.465	1.000	.059
Respondent7	.073	.042	.375	.523	.059	1.000
Respondent8	.186	.011	.317	.445	.373	.296
Respondent9	.399	.058	.367	.700	.545	.314
Respondent10	.648	-.105	.695	.476	.462	.077
Respondent11	.387	.171	.159	.413	.320	.162
Respondent12	.421	-.104	.327	.483	.177	.533

Inter-Item Correlation Matrix

	Respondent8	Respondent9	Respondent10	Respondent11	Respondent12
Respondent1	.186	.399	.648	.387	.421
Respondent2	.011	.058	-.105	.171	-.104
Respondent3	.317	.367	.695	.159	.327
Respondent4	.445	.700	.476	.413	.483
Respondent5	.373	.545	.462	.320	.177
Respondent7	.296	.314	.077	.162	.533
Respondent8	1.000	.391	.187	.745	.457
Respondent9	.391	1.000	.523	.380	.310
Respondent10	.187	.523	1.000	.255	.298
Respondent11	.745	.380	.255	1.000	.666
Respondent12	.457	.310	.298	.666	1.000

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Respondent1	67.9130	740.628	.513	.607	.822
Respondent2	71.4783	837.352	-.024	.464	.847
Respondent3	69.0870	715.447	.516	.788	.820
Respondent4	69.0870	631.356	.734	.772	.797
Respondent5	69.9565	756.407	.450	.553	.826
Respondent7	67.7391	704.383	.417	.654	.830
Respondent8	69.7391	731.747	.613	.733	.816
Respondent9	68.6957	676.585	.639	.657	.808
Respondent10	69.2609	732.747	.549	.793	.819
Respondent11	66.2609	591.929	.587	.842	.821
Respondent12	66.8696	631.846	.646	.782	.807

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
75.6087	838.613	28.95881	11