RISK ASSESSMENT OF INTERNATIONAL CONSTRUCTION PROJECTS USING THE ANALYTIC NETWORK PROCESS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
CIVIL ENGINEERING

JUNE 2007

Approval of the Graduate School of Natural and Applied Sciences

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ABSTRACT

RISK ASSESSMENT OF INTERNATIONAL CONSTRUCTION PROJECTS USING THE ANALYTIC NETWORK PROCESS

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June 2007, 188 Pages

This thesis offers a comprehensive risk assessment methodology that provides a decision support tool, directed for Turkish construction organizations, which can be utilized through the bidding decisions for international construction projects. Within this context the analytic network process technique is implemented to develop a risk assessment model, which is used to derive the relative priorities of the risk factors associated with international construction projects. The findings of the risk assessment model have demonstrated that the most significant sources of risk are vagueness of contract conditions about risk allocation, client, and immaturity of legal system in the host country. Factors such as low % of advance payment, geographical distance, and bribery were found to be relatively insignificant. An international construction project risk rating software application is then developed. The application incorporates the derived priorities from the risk assessment model to calculate a risk rating for a given international construction project.

To increase the credibility of the results a risk rating adjustment methodology was integrated into the application. Its purpose is to count for the potential influencing factors that may increase the risk level of a given project. The influencing factors which were considered are the company's experience, contract type, level of the available project data from the outset, and project delivery system.

The application is also structured to enhance the organizational learning practices. It improves the process of the organizational memory formation with respect to post-project risk data by developing a database of risk information of the rated projects for future references. The reliability of the application was tested with post-projects risk data and was found to be satisfactory.

Keywords: Analytic Network Process, International Construction, Risk Assessment.

ÖZ

ANALİTİK AĞ SÜRECİ İLE ULUSLARARASI İNŞAAT PROJELERİNDE RİSKLERİN DEĞERLENDİRİLMESİ

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Bu tezde, Türk inşaat şirketlerinin uluslararası pazarlarda riskleri değerlendirmek için kullanabilecekleri bir yöntem önerilmekte ve bu yöntemin kullanımını kolaylaştıracak bir karar destek sistemi sunulmaktadır. Bu kapsamda, risk değerlendirme yöntemi olarak Analitik Ağ Süreci tekniği kullanılmış ve risklerin göreceli önem dereceleri bu teknikle hesaplanmıştır. Türk inşaat şirketlerinin deneyimleri ışığında gerçekleştirilen risk değerlendirme sürecinin sonucunda, risk paylaşımına ilişkin sözleşme koşullarının belirsizliği, işveren kaynaklı riskler ve işin gerçekleştirileceği ülkedeki hukuksal sisteme ilişkin problemler en önemli risk kaynakları olarak belirlenmiştir. Avans ödemesinin miktarı, ülkeler arasındaki coğrafi uzaklık ve rüşvet önem derecesi düşük riskler olarak belirginleşmektedir. Analitik Ağ Süreci ile edinilen risk önem dereceleri kullanılarak, uluslararası inşaat projeleri için bir risk derecelendirme yazılımı geliştirilmiştir. Bu yazılım kapsamında, bir projenin risk derecesini etkileyen ancak Analitik Ağ Süreci bazlı risk derecelendirme yöntemiyle hesaplara dahil edilemeyen faktörler düşünülerek bir risk revizyon sistemi oluşturulmuştur.

Risk revizyonunda kullanılacak olan faktörler; şirketin deneyimi, sözleşme tipi, ödeme şekli ve projenin başında maliyet tahminlerinde kullanılmak üzere gerekli olan verilerin bulunup bulunmaması olarak belirlenmiştir.

Geliştirilen karar destek sistemi inşaat şirketlerinde kurumsal öğrenmeyi artıracak şekilde yapılandırılmıştır. Proje bitiminde risklere ilişkin verilerin tekrar gözden geçirilerek bir veritabanında saklanması ile gelecekteki benzer projelerde kullanılmak üzere bir risk belleğinin oluşturulması hedeflenmektedir. Karar destek sisteminin performansı gerçek proje verileri kullanılarak test edilmiş ve tatmin edici sonuçlara ulaşılmıştır.

Anahtar Kelimeler: Analitik Ağ Süreci, Uluslararası İnşaat, Risk Değerlendirmesi

To my parents who believed in me, to my husband who supported me to reach this point, and to my children.

ACKNOWLEDGMENTS

Great deal of gratitude is expressed by the author of this thesis to Prof. Dr. Talat Birgönül and Assoc. Prof. Dr. Irem Dikmen Toker without whom she could not be able to proceed. Their guidance, support, and understanding were provided throughout this study. It has been a privilege to work with them.

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AEC	Architectural, Engineering, and Construction
AHP	Analytic Hierarchy Process
AIRMIC	Association of Insurance and Risk Managers
ALARM	National Forum for Risk management in the Public Sector
ANP	Analytic Network Process
APM	Association for Project Management
ASCE	American Society of Civil Engineers
BERI	Business Environment Risk Intelligence
BSI	British Standard Institute
CCR	Country Credit Ratings
CF	Cost-Plus-Fee
CI	Criticality Index
CR	Consistency Ratio
CRIS	Control risks Information Services
CSA	Canadian Standards Association
CT	Contract Type
DA	Data Availability
DB	Design-Build
DBB	Design-Bid-Build
EIRM	European Institute of Risk Management
EIU	Economist Intelligence Unit
EMV	Expected Monetary Value
FERMA	Federation of European Risk Management Association
GARP	Global Association of Risk Professionals
GATT	General Agreement on Tariffs and Trade
HAZOP	Hazard and Opportunity Studies
HRBS	Hierarchical Risk Breakdown Structure

IACCM	International Association of Contract and Commercial Managers
ICE	Institute of Civil Engineers
ICJV	International Construction Joint Venture
ICPR	International Construction Project Risk
ICPRR	International Construction Project Risk Rating
ICRAM	Model for International Construction Risk Assessment
ICRM	International Construction Project Risk Assessment Model
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
II	Institutional Investor
IJV	International Joint Venture
INCOSE	International Council on Systems Engineering
IRM	Institute of Risk Management
ISO	International Organization for Standardization
IT	Information Technology
JV	Joint Venture
LS	Lump-Sum
MAUT	Multiple Attribute Utility Theory
MC	Monte Carlo
MCDM	Multi Criteria Decision Making
MSP	Macro-Sociopolitical
NAFTA	North American Free Trade Agreement
NPV	Net Present Value
OECD	Organization for Economic Cooperation and Development
OL	Organizational Learning
OM	Organizational Memory
PDS	Project Delivery System
PMBok®	Project Management Body of Knowledge
PMI®	Project Management Institute
PRAM	Project Risk Analysis and Management

RAMP	Risk Analysis and Management for Projects
RBS	Risk Breakdown Structure
RFI	Request for Information
RMA	Risk Management Association
RMWG	Risk Management Working Group
RR	Risk Rating
SEI	Software Engineering Institute
SIG	Specific Interest Group
SMART	Simple Multi Attribute Rating Technique
S&P	Standards & Poor's Rating Group
SRA	Society of Risk Analysis
SWOT	Strengths, Weaknesses, Opportunities, and Threats
UAE	United Arab Emirates
UK	United Kingdom
UP	Unit Price
U.S	United States
USA	United States of America

CHAPTER 1

INTRODUCTION

The construction industry inherent momentous amount of risks; as it is portrayed with a unique characteristic in which most of its products are exceptional in respect of form, size and purpose. In addition, the products of construction differ widely in terms of location, materials, production techniques, and the standards of the finished product with respect to space, quality and durability. Moreover, the construction processes witness the involvement of diverse parties throughout projects lifecycle; each of which carryout different perspective and cultural background. On the other hand, the severe competition endured by the construction organizations and the low margin of profit has always acted as motivators to seek better opportunities not only for organization growth but also its bare survival within the industry. Nevertheless, the tendency towards construction industry is never affected by the individuality of its practices; but it is encouraged by the continuous demand for new facilities that can not be achieved without the existence of gut practitioners prepared to handle the unexpected involved within practicing such line of business. Supplementary, the openness of global markets answers the ultimate need of local construction organizations for new opportunities. Such opportunities are offered by the developing countries who are seeking assistant to sustain their development efforts; together with the emerging markets in Asia, Eastern Europe and former Soviet countries. In addition, different international agreements have created radical changes in the international construction industry such as North American Free Trade Agreement (NAFTA) and the "Uruguay Round" in General Agreement on Tariffs and Trade (GATT). Accordingly, construction organizations are willing to expand their business into international construction markets.

However, it should be perceived that achieving success abroad is no trouble-free; frankly it will not be astonishing that international construction does involve more risk than local construction, since international construction project will encounter risks similar to the risk coupled with domestic construction together with the risk associated with the characteristics of the host country and its markets conditions. Moreover, despite the fact that local construction organizations may face threats from external practitioners; they should not expect the same level of competition in a foreign country.

Because of the previously described nature of the construction industry as well as the growing complexity and difficulty of construction projects, combined with the severity of the construction business environment together with the continuous frustrating project results to stakeholders; it becomes inevitable for construction organizations to analyze the potential sources of risk associated with construction projects in order to improve the effectiveness of such projects. On the other hand, construction organizations are keen to reveal new opportunities abroad; the significance of the circumstances examined when working in international markets creates new sources of risk. Therefore, several studies and researches were conducted to assess risk particularly related to international construction projects. The available studies for international construction projects risk assessment can be categorized into two main categories: (1) Risk assessment models support the market entry decision, and (2) Risk assessment models support the bidding decision (bid/no-bid and bid markup decisions). Regarding these two perspectives; various attempts were made to assess risk in international construction, although there may be different approaches for the assessment of risk, yet the processes are almost identical. Typically, prior to the assessment process it is necessary to identify risks likely to affect the project then develop a conceptual model or risk breakdown structure (RBS) for the identified factors which results from the logical arrangement of the factors. In literature, several lists were proposed for different construction risk factors and diverse breakdown structures are available, some factors are found in more than one list and overlaps recognized between the risk breakdown structures.

Usually, following the identification of the risk factors a multicriteria decision making method (MCDM) is used to assess the level of risk according to the predetermined objectives of the conducted research/study. The analytic hierarchy process (AHP), and simple multi attribute rating technique (SMART) are examples of techniques that may be located in literature related to risk assessment in international construction. On the other hand, there exist several tools for quantifying risk with respect to certain project objective (e.g. Cost, duration) including, but not limiting to: expected monetary value (EMV), statistical sums, simulation, decision trees. However, these tools can not handle the complex nature of risk when considering all the project objectives (Cost, Time, Quality, stakeholder satisfaction…etc).

With regard to MCDM techniques; even with the numerous researches that provide models for international risk assessment there is a frequent shortcoming with the models utilizing AHP or SMART. The assumption of independence between risk factors among certain levels or at the same level reduces the trustworthiness of the proposed models in providing reliable outcomes.

For the previously described reasons, it turns out to be essential to pursue for the critical risk factors that may jeopardize the success of international construction project and articulate how the level of risk can be measured by considering the complex relations between these risk sources.

The aim of this thesis is to develop a model that combines both research standpoints (revealing the critical risk sources and accounting for the multifaceted interaction between them) and performs a comprehensive risk assessment methodology while overcoming the independence assumption between the risk factors. The analytic network process (ANP) technique, the general form of the AHP; permits the definition of any potential relation between the risk factors. Nevertheless, it should be dropped into attention that adequate analysis of the potential sources of risk in international market does not necessitate the success of the project.

Yet, it is projected that systematic risk assessment may facilitate the quantification of the level of risk, assist in building up effective response strategies to diminish its impacts, and aid the determination of dependable risk markups while conducting construction projects abroad (Bu-Qammaz et al., 2006). Moreover, this thesis intended to create a model to assess risk accompanied with international construction from Turkish construction organizations perspective. To achieve this objective, the potential sources of risk on international construction project will be examined, while considering the Turkish experience in the global construction markets.

Correspondingly, the key objectives of this study are recapitulated below:

- To identify the primary sources of risk which affect international construction projects that will be performed by Turkish construction organizations.
- To assess the identified factors by taking into account all the prospective influences between the factors.
- To reveal the potential influencing factors that are expected to have an influence on the level of risk for a given international construction project.
- To provide a reliable risk rating for a given international construction project by developing a software application considering the characteristics of the project, and hence afford a decision support tool for the decision maker that can be utilized within the bidding decisions.
- To present a tool for organizational learning (OL) that enhance the formation of organizational memory (OM) by creating a database for the risk profiles of post-projects, this will allow the utilization of the previous experience of the organization.

In order to be able to achieve the previously stated objectives supportive methodology was prepared, thus the methodology followed in this thesis is avowed below:

- Identification of the risk factors associated with international construction through literature review, discussion sessions, and experience.
- Development of the logical grouping for the identified risk factors according to the potential relations between them, and then creates the risk breakdown structure consequential from the logical grouping of the risk factors.
- Utilization of *SUPERDECISIONS* software to construct the ANP model and find the importance weights (priorities) of the risk factors.
- Employment of the derived importance weights of the risk factors to develop a software application into which a performance rating can be given to each risk factor for a specific construction project that will be conducted by a Turkish contractor in a foreign country. This will provide a risk rating for the project under consideration.
- Modifying the derived risk rating while accounting for the potential influencing factors on the project risk.
- Constructing a database for the risk rating from post-projects data, which were conducted into the international construction markets.

Throughout the following chapters consideration will take place to the major knowledge areas that are related to risk associated with international construction projects together with satiated description of the model and the results of the research.

Chapter 2 will give attention to project risk management; the major topics that will be covered in this chapter will include revealing the available perspectives towards risk associated with the business environments, and the diverse views adopted by the different definitions of the term "risk", also some risk related terms will be discussed, such as uncertainty and risk attitude. Then, the available risk management practices will be examined to depict the essential role of the identification and assessment steps in the integrated risk management process. Moreover, this chapter will include a comparative summary for some of the existing risk management standards and guidelines, which will reveal considerable amount of similarities between the formal processes of conducting risk management.

The international construction project risk assessment model (ICRM) will be described in Chapter 3, this chapter will explain the major steps undertaken to develop the model starting from risk identification through developing the risk breakdown structure then the ANP model and finally findings of the model. This chapter will also include some literature review results regarding international construction risk assessment models, identification of risk associated with international construction, risk analysis and assessment tools, and particulars concerning the ANP technique.

After discussing the ANP model outcomes, the developed software application for international construction project risk rating (ICPRR) will be described. Chapter 4 will provide a descriptive review for the key objectives for developing the ICPRR software application together with the major components from which the ICPRR is structured. This chapter will also include the results obtained from implementing the developed software application on 8 case studies. The findings of the case studies will be discussed to demonstrate the validity of the software.

The major contribution of this thesis study to the knowledge in its area together with the main shortcomings of the proposed methodology will be discussed in Chapter 5. The findings of the research together with the relevant conclusions will be included in Chapter 5, as well.

The appendices will include, a sample of the questionnaire used to fill in the ANP model (Appendix A), sample from the questionnaire of the risk rating adjustment methodology (Appendix B), and an example of the results obtained from the implementation of the ICPRR software to one of 8 international construction projects (Appendix C). However, the name of the project together with the construction organization is not given for the sake of confidentiality.

CHAPTER 2

CONSTRUCTION PROJECT RISK MANAGEMENT

Before proceeding to discuss the proposed risk assessment model it is essential to elucidate what we connote while using the "risk" terminology. Risk is associated with every aspect of our daily life. Further, wherever risk exists, the tendency to adequately mange it will be found. However, when the construction industry is examined it would be seen that formal risk management has only become an integral process in the past few decades. One of the drivers for the recent sudden increased need to manage risk is the rapid development of technology; as a result risk and its management have turned to be wholly specialized subject. With the adequate assistance of risk management two essential advantages will be captured, more confidence can be given to the estimated project costs and profits will be maximized (Baker et al., 1999). For the context of this chapter, the available risk definitions from business perspective will be revealed, and then the offered risk management practices will be examined to depict the essential role of the identification and assessment steps in the risk management process. Moreover, this chapter will include a comparative summary for some of the existing risk management standards and guidelines, which will reveal considerable amount of similarities between the formal processes of conducting risk management.

2.1 What is Risk?

For the first sight it would be thought meaningless to inquire what the meaning of risk is, but after comprehensive exploration into the available literature regarding business risks it was believed to be easier said than done locating united perspective towards risk definition within different professional bodies and standard institutions.

However, investigating the traditional linguistic definition of the term "risk" in the standard dictionaries would confirm that the view towards risk is always negative. "A factor, thing, element, or course involving uncertain danger; a hazard" is one of various definitions for risk that were found in a typical linguistic dictionary (Farlex, 2007). Yet, these are conventional definitions and not specific to certain industry or business.

2.1.1 Definition of Risk

The outcome for the absence of consensus towards the definition of the term "risk" within the professional bodies and standard institutions is reflected in the presence of different phrases to define risk in literature concerning risk and its management. For instance; risk is defined as "the exposure to loss/gain", "the probability of occurrence of loss/gain multiplied by its respective magnitude" (Jaafari, 2001), "the probability that unfavorable outcome will occur", "uncertainty and the result of uncertainty", "lack of predictability about structure, outcomes, or consequences in a planning or decision situation" (Nasir et al., 2003), "the probability of occurrence of some uncertain, unpredictable and even undesirable event(s) that would change the prospects for the profitability on a given investment", and in relation to construction; risk is described as "an exposure to economic loss or gain arising from involvement in the construction process", and "a consideration in the process of a construction project whose variation results in uncertainty in the final cost, duration and quality of the project" (Kartam and Kartam, 2001). Although, these previous expressed definitions of risk do not cover all and every definition available, yet they show that there are three different perspectives towards the term "risk": (1) risk is all negative (threat), (2) risk is defined neutrally (could be threat/opportunity), and (3) risk is explicitly described to include both negative and positive outcomes (threats and opportunities).

On the other hand, regardless of the continuing debate among risk management practitioners about the definition of risk; there exist several attempts from different professional bodies and standard institutions to propose a definition of risk that capture broad acceptance. Although, they adopt different perspectives, they trend to agree on common view (Hillson, 2002).

Hillson (2002) in his quest to answer the question "What is risk?" from business perspective; reveals some definitions from several professional bodies and standard institutions. Surprising result was to find that the institute of risk management (IRM) has no official definition of "risk", despite the usage of phrases such as "chance of bad consequences, or exposure to mischance" in IRM documents which clearly show that IRM until the date of the research has adopted the traditional view that risk is wholly negative. Moreover, he found that some other national standard-setting bodies also apply a negative definition of risk, this would include the Norwegian Standard NS5814:1981, British Standard BS8444-3:1996, and National Standard of Canada CAN/CSA-Q850-97:1997.

Hillson (2002) has further added that, recently a neutral view of risk have extended among professional bodies, such as the United Kingdom (UK) association for project management (APM), where risk is defined in their project risk analysis and management guide (PRAM Guide) as "an uncertain event or set of circumstances which, should it occur, will have an effect on achievement of objectives". While the effect is not specified; it could include both positive and negative effects. Further, the British standard institute (BSI) has adopted this general view in BS6079-3:2000, it says that "risk is uncertainty … that can affect the prospects of achieving … goals". The joint Australian/New Zealand risk management standard AS/NZS 4360:1999 has also provided a general definition that could indicate the composite nature of risk that include both opportunities and threats. In addition to the international electrotechnical commission (IEC) whose project risk management guidelines (IEC62198:2001) once more define risk without explicitly referring to its consequences whether positive or negative.

What is more, other guidelines have started to explicitly bring in upside effects in the definition of risk. An example of which is the risk analysis and management for projects guide (RAMP Guide) produced jointly by the institute of civil engineers (ICE), the Faculty of Actuaries, and Institute of Actuaries who defines risk as "a threat (or opportunity) which could affect adversely (or favorably) achievement of objectives". Likewise, the guide to the project management body of knowledge (PMBok® Guide, 2004) created by the project management institute (PMI®) defines risk as "an uncertain event or condition that, if it occurs, has a positive or negative effect on a project's objectives". Moreover, IRM has published risk management standard (2002) jointly with national forum for risk management in the public sector (ALARM) and association of insurance and risk managers (AIRMIC); the standard has used the terminology for risk set out by the international organization for standardization (ISO) in its recent document ISO/IEC Guide 73; which defines risk as " the combination of the probability of an event and its consequences"; the standard has further explained that "there is the potential for events and consequences that constitute opportunities for benefit (upside) or threats to success (downside)"; thus the standard takes into account both perspectives of risk; this would indicate that even IRM has recently changed its negative perspective towards risk to include opportunities.

Bring to a close; the view towards risk from the standard publications and professional bodies can be pointed up as follow (Hillson and Murray-Webster, 2007a):

- Until the late nineties, the vast majority of official published risk management standards exclusively used a negative definition of risk (risk equals threat); the definitions proposed have seen risk as "an uncertainty that could have a negative/ harmful/ adverse/ unwelcome/ bad effect on one or more objectives".

- From late nineties onwards, two different views have emerged; either a neutral risk definition was presented "an uncertainty that could affect one or more objectives" where the nature of the effect is not specified, or a wider definition including both threats and opportunities was adopted "an uncertainty that could have a positive or negative effect on one or more objectives".
- Since the new millennium the mainstream within the newly published or updated official standards regarding risk management was to explicitly redefine risk to include both threats and opportunities.

Although it is unrealistic to assume that all risk practitioners agree on the new trend in defining risk and the debate is over. Yet, it would be fair to say that the majority of risk management practitioners became aware that risk management should be utilized to minimize the negative effect of threats, as well as to maximize opportunities; so it can optimize the achievement of objectives (Hillson and Murray-Webster, 2007a). Whether they adopt the new perspective for the definition of risk which accounts for both threats and opportunities or just thinking of uncertainty to have two types of effects namely risk and opportunities; risk practitioners agreed on the indispensable need for developing the traditional practices of risk management to include opportunities within their process.

For the purpose of this study; the traditional definition of risk is adopted. The study will give emphasis to the sources of risk that may have negative effect on the predefined project objectives; thus risk is seen as threats. However, even though in-depth analysis of opportunities associated with international construction is out of the scope of this research, yet it is believed that no integral risk management methodology can be approached without taking opportunities into consideration.

2.1.2 Risk versus Uncertainty

Often risk is confused with uncertainty; more or less all the definitions of risk either explicitly or implicitly embrace uncertainty. Uncertainty is related to the probability of occurrence of an event; an event is assumed to be certain if the probability of its occurrence is 100% or totally uncertain if the probability of its occurrence is 0%; where among theses boundaries the uncertainty varies quite widely (Jaafari, 2001).

The existence of uncertainty makes it difficult to predict future events. Therefore, great deal of attention has been given to define, understand, and manage uncertainty. Two diverse aspects of uncertainty should be carefully distinguished to adequately manage it; firstly variability and secondly ambiguity. Where variability describes the situation when a measurable factor can take one of a range of possible values (i.e. the event is defined but its outcome is uncertain because it is variable), while ambiguity is defined as uncertainty of meaning. Ambiguity can be used when a particular event may or may not happen at all, and sometimes whether something else unexpected might take place (i.e. there is incomplete knowledge about the situation under consideration) (Hillson and Murray-Webster, 2007a).

However, not all uncertain events are considered to be risk; if the uncertainty is irrelevant to the desired objectives then it will not be risk. Risk can only be defined with respect to some objectives; we can simply see risk as uncertainty that when it occurs could affect one or more objectives. Moreover, whenever objectives are defined then risk to successfully achieving them should be expected. Additionally, the level of risk differ according to the hierarchy of the organizational objectives; strategic risks are uncertainties that is concerned with strategic objectives (example of strategic objective is increase profit and market share), project risks are uncertainties that could prevent the achievement of project objectives (e.g. on time within budget delivery), similarly technical risk could influence technical objectives and reputation risk may affect reputation (Jaafari, 2001; Hillson, 2005). Figure 2.1 demonstrates the relation between risk and uncertainty for projects.

It was shown earlier that even with different details of the definitions of risk they all concur that risk has two attributes; risk is associated with uncertainty and it has consequences; regarding the predefined objectives (Hillson and Murray-Webster, 2007a). Thus risk is distinguished from uncertainty that the former considers the consequences while the later does not; risk can not be defined without linking it to the objectives.

Taking into consideration the relation between risk and objectives allow for adequate risk management process. It is evident that before identifying risks one needs to know what events might be risky and against what. Moreover, while assessing the significance of risk and preparing adequate risk response objectives should be thoroughly considered. Furthermore, adequately defining objectives is a key to understand risk attitudes, the risk response and the degree to which an organization is willing to take risk depend on the objectives of the organization and the extent to which uncertainty is seen critical (Hillson and Murray-Webster, 2007a). Yet again, considering opportunities together with threats is believed to have great influence on risk attitude. People who see risk from its negative angle and dismiss opportunities from their decisions will have completely different response from those who consider both risk and opportunities.

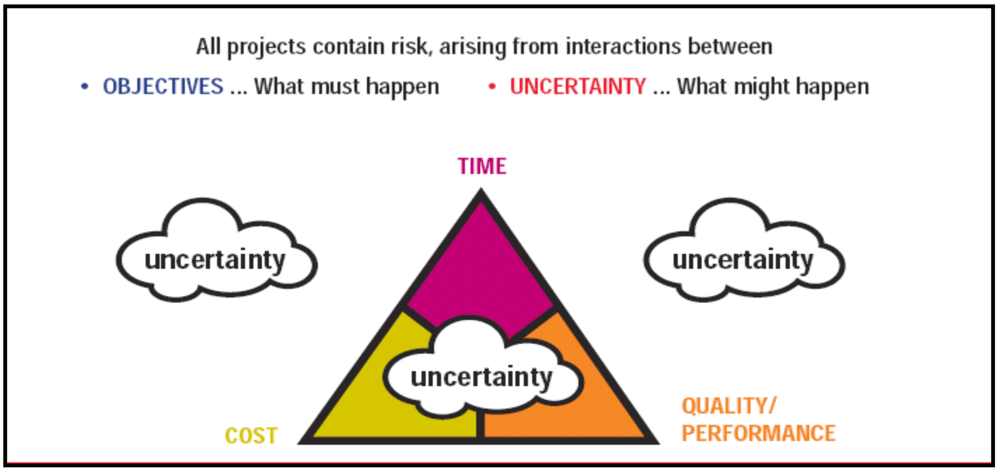


Figure 2.1. Risk Arises from the Effect of Uncertainty on Objectives (Hillson, 2005)

To end with, and for the sake of comprehensiveness it should be pointed out that a number of researchers define risk and uncertainty from different point of view. Although they accept as true that risk and uncertainty are usually used interchangeably. Yet, in their opinion they believe that in risk management, the terms have distinct meanings. In their perspective the term "risk" is used when the outcome can be predicted on the basis of statistical probability. Whereas, "uncertainty" is a future outcome to which probability can be attached only subjectively, if at all. Moreover, both risks and uncertainties are future outcomes which are products of performance variables, and their likelihoods. Yet again, some believes that Risks/uncertainties operate bi-directionally. Therefore, performance may be better than predicted.

2.1.3 Risk Attitude

A well known essay written by Swindoll (1999) is frequently quoted to adequately describe the concept of attitude, it says;

The longer I live, the more I realize the impact of attitude on life. Attitude, to me, is more important than facts. It is more important than the past, than education, than money, than circumstances, than failures, than successes, than what other people think or say or do. It is more important than appearance, giftedness or skills. It will make or break a company or a home. The remarkable thing is we have a choice every day regarding the attitude we will embrace for that day. We cannot change our past… we cannot change the fact that people will act in a certain way. We cannot change the inevitable. The only thing we can do is play on the one string we have, and that is our attitude… I am convinced that life is 10% what happens to me and 90% how I react to it; and so it is with you… we are in charge of our attitudes (cited Hillson and Murray-Webster, 2007b).

2.1.3.1 Defining Attitude

Similar to the word "risk", once more we are faced with a term that has multiple definitions. What is more is the existence of two unrelated meanings while using the term "attitude". First let us list the linguistic definitions to reveal them (Farlex, 2007):

- The orientation of an aircraft's axes relative to a reference line or plane, such as the horizon.
- A complex mental state involving beliefs, feelings, values, and dispositions to act in certain ways.

It is needless to declare that the second definition is the one that is relevant to our research. Similar to risk; attitude can only be defined in relation to a datum point; in the case of the second definition which we are interested in the datum point is the fact or state towards which mental disposition is held. Therefore, in this manner attitude represents the choice one takes with respect to certain situation, since each situation is influenced with different circumstances then the chosen response will also vary according to the considered influences. Moreover, if an effort is given to identify and understand the influences on a given situation, then the ability to manage them is improved. Consequently, the chosen attitude is expected to be the most advantageous (Hillson and Murray-Webster, 2006).

The previous argument reveals that attitudes may be customized to promote the achievement of business objectives. Attitudes are assumed to be manageable when they are subject to change; if attitudes are to be fixed then even if they can be understood they can never be managed. Managing attitude allow to direct them into the most appropriate choice for the given situation (Hillson and Murray-Webster, 2006).

2.1.3.2 Understanding Risk Attitude

Risk attitude can be understood by combining both individual definitions of "risk" and "attitude". So risk attitude can be seen as the "chosen state of mind with regard to those uncertainties that could have a positive or negative effect on objectives" (Hillson and Murray-Webster, 2006). However, according to majority of risk practitioners there is an important factor which should be taken into account; that is perception; jointly risk and attitude are influenced by perception. Hillson and Murray-Webster (2006) have stated that there are three factors that should be considered under perception namely: (1) Rational situational factors (e.g. familiarity, manageability, and proximity), (2) Subconscious heuristics operating at both individual and group level (e.g. availability, groupthink, or risky/cautious shift), and (3) Emotions. They have further explained that the influence of perception on risk affect the degree to which uncertainty is considered to be important. Finally, they have proposed the following definition for risk attitude; risk attitude is the "chosen response to uncertainty that matters, influenced by perception".

As was pointed out earlier there may be different attitudes to be adopted with regard to the same situation, each attitude will lead to different behavior, and according to each behavior consequences will result. Behavior is the solely indicator to the adopted attitude. Moreover, there is a consensus among risk practitioners that there is a range among which risk attitude fluctuate according to the way individuals or groups recognize the uncertainty. Accordingly, different behaviors will results from different individuals/organizations to the same situation resulting from their attitudes. Uncertainty that is regarded as extremely risky by a person or organization may be regarded as acceptable by others (Hillson and Murray-Webster, 2006). Figure 2.2 illustrates this fact.

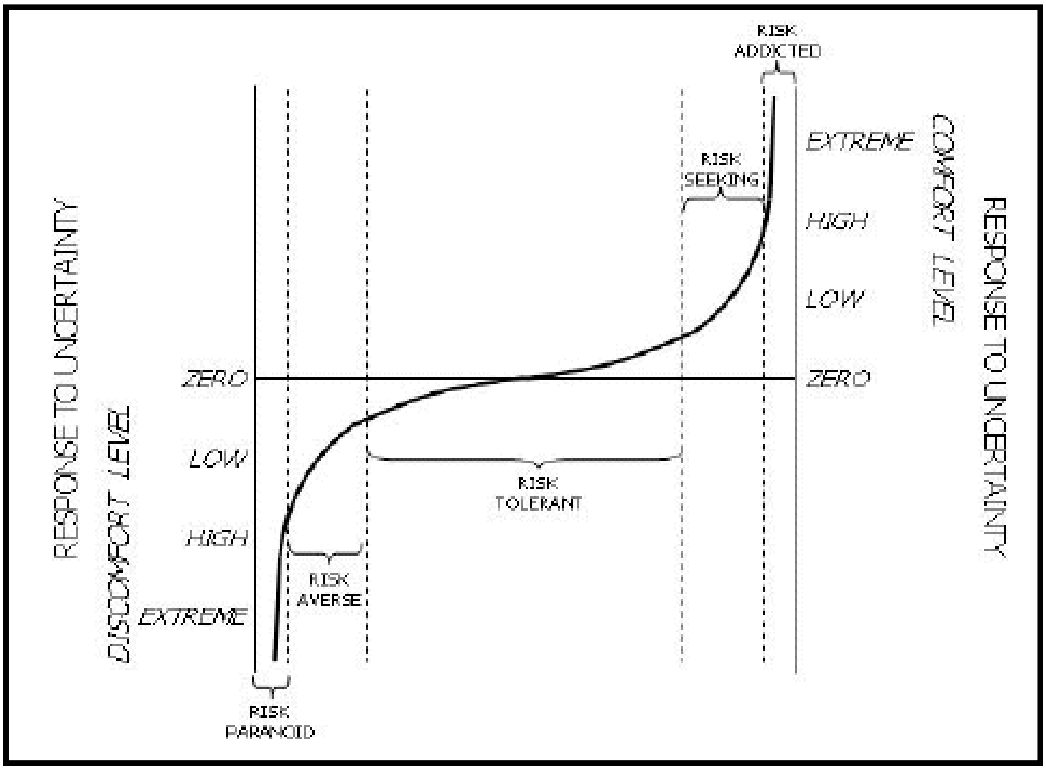


Figure 2.2. Risk Attitude Spectrum (Hillson and Murray-Webster, 2006)

2.2 Risk Management

Wherever risk exists the desire to adequately manage it will be found; where the management actions are taken either intuitionally or systematically. Risk stems from uncertainty which narrow our knowledge about future events. Since ever it was accepted as a fact that people can not know; understand; or control everything. Therefore, the term "risk" has become relative to many aspects of human being daily life. Risk is related to personal circumstances (health, pensions, insurance...etc.), society (terrorism, economic performance...etc.) as well as business (corporate governance, strategy, business continuity...etc.). However, it is believed that mankind incessantly seeks to deal with risk and try to manage it proactively. Consequently, not only risk is found everywhere but also the concept of risk management.

As every aspect of human behaviors is combined with risk; its existence within most of human venture is recognized as unavoidable, subsequently there is a continuous effort to identify and understand risk. Accordingly, within various segments of business the phrase "risk management" has been used to describe the attempts undertaken to identify, understand and respond to risk (Hillson, 2006).

2.2.1 Historical Overview

In the company of the earliest signs for the existence of people colonies the employment of the concept of risk management is found to be noteworthy. The first clues of risk management discovered was related to the group of people named the Asipu who lived in a valley called Tigris-Euphrates during the time 3200 BC. The people within this group were recognized as risk consultants, and the procedure they used to follow is highly comparable with the ones proposed by the recent methodical risk management guidelines. As there procedure starts by identifying the important dimensions of the problem, propose alternative actions, and collect data on the likely outcomes. Then most favorable actions would be selected and reported to the client (Baker et al., 1999).

The practicing of risk management has evolved ever since dramatically. Bortkiewicz has conducted in the 19^{th} century; one of the earliest attempts to apply probability analysis to a risk problem. However, the actual term of "risk analysis" was first created by Hertz in the mid sixties of the last century to derive the probability distribution of the rate of return or the net present value (NPV) of an investment project; in his study he proposed simulating utilizing the computers. Within his research nine factors where recognized to inherent uncertainty; that is: market size, selling price, market growth rate, market share, investment required, useful life of facilities, residual values of facilities, operating cost, and fixed costs (Baker et al., 1999).

On the other hand, when the construction industry is examined it would be found that formal risk management has only become an integral process in the past few decades. One of the drivers for the recent sudden increased need to manage risk is the rapid development of technology; as a result risk and its management have turned to be wholly specialized subject. With the adequate assistance of risk management two essential advantages will be captured, more confidence can be given to the estimated project costs and profits will be maximized. More or less the current risk management procedure includes the following main steps: risk identification, analysis, evaluation, and control. Yet these steps can be further divided to include risk response and monitoring which in turns will result in obtaining a controlled risk environment (Baker et al., 1999). Figure 2.3 depicts the risk management lifecycle.

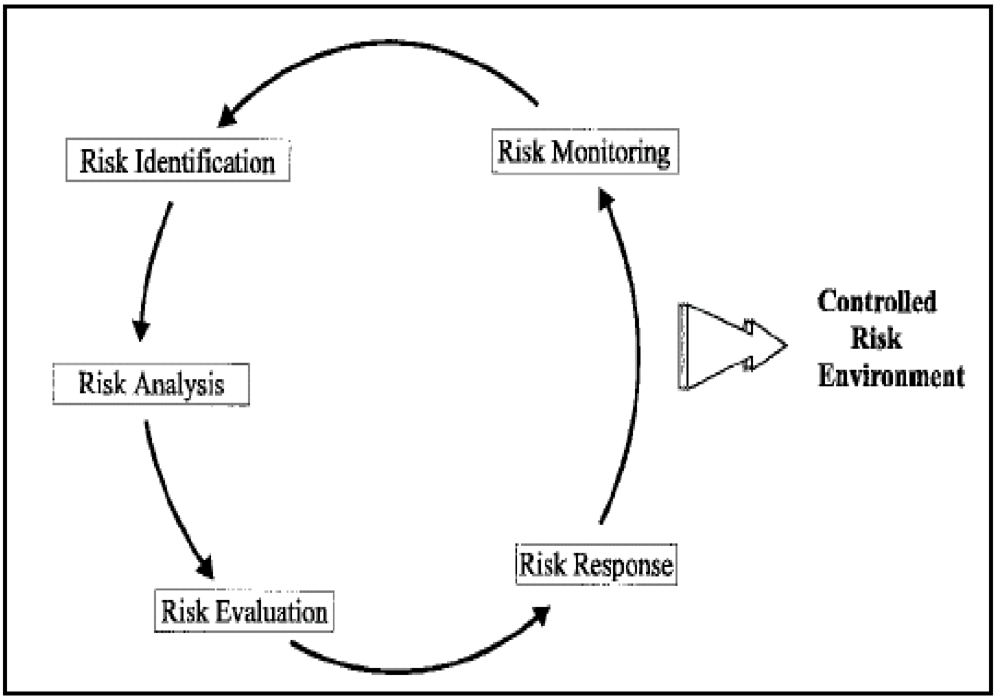


Figure 2.3. Risk Management Lifecycle (Baker et al., 1999)

2.2.2 Risk Management in the Business Environment

Risk Management has retained a fundamental position within the business practices; the application of risk management processes is extended among most industries; both in government and private sectors. Moreover, it has contributed with an important role at all levels in the organizations.

Risk management is acknowledged as an autonomous management discipline, in view of the fact that handling the uncertainty associated with business and projects; at all levels, is credited to risk management. Therefore, several risk management professional bodies have proposed risk management standards and guidelines to be adopted as a tool for dealing with risk that either relative to the organization business objectives or specific project objectives. Moreover, at the project level and according to PMBok guide (PMBok® Guide, 1996) project risk management is considered to be one of the nine project management knowledge areas, the other eight disciplines are to be: project integration management, project scope management, project time management, project cost management, project quality management, project human resource management, project communication management, and project procurement management. Project risk management is associated with identifying, analyzing, and responding to project risk. Simultaneously, there are many guidelines that are intended for integrated risk management which address risks across different levels within the organization.

However, the existence of the guidelines and standards that assist in managing risk within the business environment is not the only indicator for the significance of risk management as an essential management discipline. In fact there are many elements that support the recognition of risk management as inevitable practice when successful achievement of the required objectives is desired.

Hillson (2006) has summarized the fundamental elements as:

- **Academic base**; where most universities and other higher educational institutes provide didactic programs that is relevant to risk management and its practices; whether offer bachelor degree, masters, or doctoral programs.
- **Qualification**; a wide selection of examinations and qualifications are available to risk professionals if they are willing to be recognized as certified risk practitioner; notwithstanding the fact that there are no particular approved qualification certificate within all industries or even countries; professional bodies tend to provide their relevant certificate.
- **Consultancies**; many risk experts provide business solutions to clients who seek guidance from their expertise and experience. Moreover, due to the increased attractiveness of practicing risk management within business environments the number of professionals that assist in the adequate implementation of the risk management process is dramatically increased.
- **Literature**; effortless review to literature indicate the availability of several journals that cover the risk management subject. Moreover, there are numerous numbers of books claim to cover essential aspects of risk management. This is to be added to the available national and international risk management standards and guidelines which were mentioned earlier; Table 2.1 Provides a comprehensive list for the most conventional risk management standards and guidelines.
- **Tools**; as information technology (IT) becomes essential tool for business development; promising software that provide support in all risk management aspects have emerged. Further, there are solutions provided for integrated risk management which assist in managing risk across the organization.

- **Process**; regardless of the various available guidelines for risk management that adopt diverse perspectives; there is a consensus on the essential components for effective risk management process. Most guidelines start the process with planning step to describe the scope and level of details desired. The next step is identification of risk and then assessing and prioritizing risk using qualitative and quantitative techniques, according to the outcomes of the assessment process appropriate responses should be developed and the agreed actions should be implemented. Finally, risk communication and review should take place.
- **Professional bodies**; several professional societies and institutes provide support to the discipline of risk management. Table 2.2 lists a number of the most well-known professional bodies.

On the other hand, thoughtful examination to the available standards and guidelines would reveal that they take on different scopes; while some implement the extensive perspective for risk management, others have limited scope and aimed for project-based business and assist in handling project specific risk.

Moreover, it is understood that effective risk management is a crucial element while conducting business. Therefore, risk management involves with various subjects as it is relevant to different business objectives. Though, even when it is impracticable to propose an extensive list for the types of risk management which may be examined within today's business practices; some of the types that were addressed by Hillson (2006) are: strategic risk management; corporate governance; financial risk management; business continuity and disaster recovery; reputational risk management; risk-assessed marketing; operational risk management; project risk management; environmental risk management; legal and contract risk management; technical risk management; fraud risk management; and counter-terrorism risk management.

Table 2.1 Risk Management Standards and Guidelines (Hillson, 2006)

Reference/title	Standards body/publisher	Date
AS/NZS 4360:2004, Risk Management	Standards Australia, Homebush NSW 2140, Australia, and Standards New Zealand, Wellington 6001, New Zealand	2004
BS 6079-3:2000, Project Management – Part 3: Guide to the Management of Business-related Project Risk	British Standards Institution, London, UK	2000
BS 8444-3: 1996 (previously issued as 300-3-9:1995), Risk Management – Part 3: Guide to Risk Analysis of Technological Systems	British Standards Institution, London, UK	1996
CAN/CSA-Q850-97, Risk Management Guideline for Decision Makers	Canadian Standards Association, Ontario, Canada	1997
CP142 Operational Risk Systems and Controls	Financial Services Authority, London, UK	2002
IEEE 1540-2001, Standard for Software Life Cycle Processes – Risk Management	The Institute of Electrical and Electronic Engineers, Inc., USA	2001
ISO 14001: 2004, Environmental Management Systems – Requirements with Guidelines for Use	International Organization for Standardization, Geneva, Switzerland	2004
ISO/IEC 17799:2005, Information Technology – Security Techniques – Code of Practice for Information Security Management	International Organization for Standardization/International Electrotechnical Commission, Geneva, Switzerland	2005
IEC 62198:2001, Project Risk Management – Application Guidelines	International Electrotechnical Commission, Geneva, Switzerland	2001
JIS Q 2001:2001 (E), Guidelines for Development and Implementation of Risk Management System	Japanese Standards Association, Tokyo, Japan	2001
PAS 56:2003, Guide to Business Continuity Management	British Standards Institution, London, UK	2003
PD 6668:2000, Managing Risk for Corporate Governance	British Standards Institution, London, UK	2000

Table 2.1 Risk Management Standards and Guidelines (continued) (Hillson, 2006)

Reference/title	Standards body/publisher	Date
PD ISO/IEC Guide 73:2002, Risk Management – Vocabulary – Guidelines for Use in Standards	British Standards Institution, London, UK	2002
A Guide to the Project Management Body of Knowledge (PMBok®), 3rd edn., ch.11 Project risk management	Project Management Institute, Philadelphia, PA, USA.	2004
A Risk Management Standard	Institute of Risk Management (IRM), Association of Insurance and Risk Managers (AIRMIC) and National Forum for Risk Management in the Public Sector (ALARM), London, U.K.	2002
Continuous Risk Management Guidebook	Software Engineering Institute (SEI), Carnegie Mellon University, USA	1996
Enterprise Risk Management – Integrated Framework	The Committee of Sponsoring Organizations of the Treadway Commission, USA	2004
Guidelines for Environmental Risk Assessment and Management	DETR, Environment Agency and IEH/ The Stationery Office, London, UK	2000
Guidelines on Risk Issues	The Engineering Council, London, UK	1995
Management of Risk – Guidance for Practitioners	UK Office of Government Commerce (OGC)/The Stationery Office, London, UK	2002
Project Risk Analysis & Management (PRAM) Guide, 2nd edn.	Association for Project Management / APM Publishing, High Wycombe, Bucks, UK	2004
Risk Analysis and Management for Projects (RAMP) 2nd edn.	Institution of Civil Engineers, Faculty of Actuaries and Institute of Actuaries/Thomas Telford, London, UK	2005

Table 2.2 Risk Management Professional Bodies (Hillson, 2006)

Professional body	Web address
Association for Project Management Risk Management Specific Interest Group (APM Risk SIG)	http://www.eurolog.co.uk/APMRiskSIG
Association of Insurance and Risk Managers (AIRMIC)	http://www.AIRMIC.com
European Institute of Risk Management (EIRM)	http://www.EIRM.com
Federation of European Risk Management Associations (FERMA)	http://www.ferma-asso.org
Global Association of Risk Professionals (GARP)	http://www.GARP.com
Institute of Risk Management (IRM)	http://www.theIRM.org
International Association of Contract and Commercial Managers (IACCM) Business Risk Working Group	http://www.IACCM.com/risk.php
International Council on Systems Engineering Risk Management Working Group (INCOSE RMWG)	http://www.INCOSE.org
Project Management Institute (PMI) Risk Management Specific Interest Group (PMI Risk SIG)	http://www.RiskSIG.com
Risk Management Association (RMA)	http://www.RMAhq.org
Society for Risk Analysis (SRA)	http://www.sra.org

2.2.3 Comparative Summary for Some of the Available Risk Management Standards and Guidelines

Section (2.2.2) has demonstrated that there are numerous standards and guidelines which aim at providing guidance to business practitioners for effectively utilizing risk management practices in order to enhance their business performance. Yet, the perspectives from which these guidelines are published differ widely; some are general and meant to be utilized in any types of business and may be applied to either projects or organizations; others are limited to certain scopes and are not applicable for others; though their publishers states that it can be adapted to be used otherwise.

To understand the differences and capture the similarities between the various standards it would be handy to undertake a comparison between the major steps for practicing risk management proposed by these standards. However, it would be neither practical nor useful to compare all and every available guideline; as not all of them serve the same scope and some of them have limited scope for implementation, thus major differences may be encountered which will impede the achievement of effective comparisons.

Raz and Hillson (2005) have undertaken a comparative review of nine major risk management standards; they focused on their scope, process steps and specific emphasis. Moreover, they have discussed their resemblance and differences; to demonstrate how they harmonize each other in some areas. The standards have been chosen after a comprehensive survey; where they have selected six national or international standards that have been developed or accepted by standardization bodies along with three standards that were created by professional organizations. On the other hand, some other standards which were considered initially have been disregarded from the survey due to their limited or specific scope of application.

The survey distinguished between two different scope categories: project and organization. The two categories are dependent on the scope of implementation, where "project" category indicates that the standard documents declare that the process, steps and procedures are intended to be implemented at the project level; while "organization" indicates that the standard is meant to be applied by the entire organization and is also applicable for both project/non-project based organizations. Raz and Hillson (2005) have stated that it was relatively easy to classify the standards with respect to their scope; yet they have exempted IEEE standard 1540-2001: standard for software lifecycle processes- risk management which is specifically designed for software, as it is stated in its documents that the proposed risk management process can be customized for use at organization level or project level. Moreover, the chosen standards are meant for application either to projects or organizations in any area of activity. Yet again IEEE standard is an exception since it is specific to software, and CEI/IEC 62198:2001 which is intended for projects with a technological content; however it is stated in its scope that it may be applied to other projects. Table 2.3 lists the compared standards together with their scopes. It is shown in Table 2.3 that four of the chosen standards scoped to be implemented at project level where the other five apply more general view.

As the main intention for the comparative analysis is to capture the degree of similarities between the chosen standards with respect to their proposed processes and steps; the emphasis was to examine the main process described by the selected standards. Accordingly, it was found that the major steps for applying risk management with regard to the nine different standards can be stated as follow: planning, identification, analysis, treatment, and control. However, it should be pointed out that the used terminology may be different from standard to another; yet the formation of the process is identical. Raz and Hillson (2005) have given some examples of such variation in terminologies used within the standards, like the alternative usage of the terms "analysis" and "assessment"; while some standards have used the term "analysis" other have used "assessment". Moreover, in some standards "analysis" is divided into "estimation" (determining the probabilities and consequences of the risk events) and "evaluation" (prioritization of the risk events by determining their overall magnitude).

Table 2.3 The Risk Management Standards Reviewed (Raz and Hillson, 2005)

Title	Author	Year	Scope
National and international standards			
IEEE Standard 1540-2001: Standard for Software Life Cycle Processes – Risk Management	Institute of Electrical and Electronic Engineers, USA	2001	P/O
CEI/IEC 62198:2001: International Standard Project Risk Management: Application Guidelines, 1st edition, 2001-04	International Electrotechnical Commission, Switzerland	2001	P
JIS Q2001:2001 (E): Guidelines for Development and Implementation of Risk Management System	Japanese Standards Association	2001	O
AS/NZS 4360:2004: Risk Management	Standards Australia/ Standards New Zealand	2004	O
BS 6079-3:2000: Project Management – Part 3: Guide to the Management of Business-related Project Risk	British Standards Institution (BSI)	2000	P
CAN/CSA-Q850-97: Risk Management: Guideline for Decision-Makers	Canadian Standards Association (CSA)	1997	O
Professional standards			
Risk Management Standard	Institute of Risk Management (IRM)/National Forum for Risk Management in the Public Sector (ALARM)/ Association of Insurance and Risk Managers (AIRMIC), UK	2002	O
Project Risk Analysis & Management (PRAM) Guide, 2nd edition	Association for Project Management (APM), UK		P
Guide to the Project Management Body of Knowledge (PMBok®): Chapter 11, Project Management, 3rd edition	Project Management Institute, USA	2004	P

*** P = Project; O = Organization**

Raz and Hillson (2005) have presented their comparison between the nine standards into separate tables. Each table is customized in a way that the rows represent the nine standards under consideration while the columns correspond to the steps. In addition, they have included the sections of the standard that represent the step compared and its corresponding number as it appears in the standard.

In one table they have compared the different approach proposed by the standards for conducting the planning step; this step addressed the most inconsistency between the standards with respect to the scope and level of detail. As some standards adopt the extensive approach by including in this step organization related issues, as establishing the risk management policy, defining roles and responsibilities, and establishing the process to be followed, other standards follow a more precise approach; including planning the application of the existing risk management process to a specific project or case.

Further, the next table puts side by side the core steps in the risk management process which include: identification, analysis and treatment; these steps are found to be proposed mainly in comparable manner by the standards, Table 2.4 shows these steps. To avoid repetition and for the sake of clarity; the researchers have prepared a separate table (Table 2.5) which has contained tools and techniques proposed by the different guidelines for identifying risk through the risk identification process.

Moreover, Table 2.4 shows that in the analysis step two main activities are to be distinguished namely: risk estimation and risk assessment. The former activity refers to an assessment of the probability of occurrence of the risk events identified in the identification step; and the possible consequences in case of their occurrence, while the later activity is related to evaluation of the assessed risk by comparing it to the criteria and thresholds of the decision maker(s) to determine the priority for treatment.

Table 2.4 Elements of the Identification, Analysis and Treatment Steps (Raz and Hillson, 2005)

	Identification	Analysis	Treatment
IEEE 1540-2001	Risk identification	Risk estimation Risk evaluation	Perform risk treatment Selecting risk treatment Risk treatment planning and implementation
IEC 62198	Risk identification (Consider the impact of risks upon all project objectives- cost, time, quality etc.)	Risk assessment Risk analysis (qualitative/quantitative): Risk limits and boundaries; Dependences; Probabilities of occurrence; Impact on objectives Risk evaluation: Risk level vs. tolerability criteria; priorities for treating risk; Risk acceptance	Risk treatment
JIS Q 2001: 2001	Risk analysis -Risk finding -Risk identification	Risk analysis : Risk Estimation Risk Evaluation: Comparison to necessary risk criteria Risk management targets	Selection of risk treatments; Establishment of risk management program; Implementation of risk management program; Additional considerations for emergencies and resumptions; Operative Control
AS/NZS 4360:2004	Risk identification -What can happen -How and why it can happen	Risk analysis; Determine existing strategies and controls Consequences and probability; Types of analysis: qualitative; semi-quantitative analysis; quantitative analysis Sensitivity analysis Evaluation risks	Risk treatment; Identifying options for risk treatment; Assessing risk treatment options; Preparing and implementing treatment plans

Table 2.4 Elements of the Identification, Analysis and Treatment Steps (continued) (Raz and Hillson, 2005)

	Identification	Analysis	Treatment
BS 6079-3: 2000	Risk identification and strategy Risk model clarification	Risk analysis Risk evaluation: unacceptable ; negligible; and acceptable threat; Critical and desirable opportunity	Risk treatment Implementation
CAN/CSA-Q850-97	Preliminary analysis; Defining scope of definition(s); Identify hazards; Beginning stakeholder analysis; Strategy risk information library	Risk estimation; Defining methods for estimating frequency and consequences; Estimating frequency; Estimating consequences; Refining stakeholder analysis; Risk evaluation; Estimating and integrating benefits and costs; Assessing acceptability of risk to stakeholders	Risk Control Identifying Feasible risk control options Evaluating risk control options Assessing stakeholder acceptance Risk financing Assessing stakeholder acceptance
IRM/ALARM /AIRMIC	Risk identification Risk description	Risk estimation: Probability and Consequence: both threats and opportunities Risk analysis methods and techniques Risk profile summarizes results of analysis, and provides a tool for prioritizing risks	Risk treatment
PRAM	Identify phase: search for sources of risk and responses; classify; characterize	Assess phase: Structure: Search/brainstorm/interview; Order risks and responses for discussion purpose; Distinguish specific and general responses Ownership: Allocate responsibility; Approve contractor allocation Estimate and Evaluate	Planning responses phase: Plan risk event responses Plan project risk responses
PMBok®	Risk identification	Qualitative risk analysis Quantitative risk analysis	Risk response planning

Finally, in the risk treatment step it was found that the possible course of action mentioned by most of the compared standards are relatively indistinguishable, it includes the following: avoidance, probability reduction (preventive counter-measures), consequence limitation (including recovery and contingency planning); and risk transfer (including subcontracting). Since all of the previously mentioned treatment actions are relevant to downside risk (threats), two essential exception from the standards are PRAM and PMBok®, as they account for opportunities as well as threats all through the process. Therefore, in addition to the previously proposed risk treatment process they express strategies for treating opportunities, that includes exploitation; probability enhancement; consequence improvement (including contingency planning); and risk sharing including joint-ventures (JVs). Additionally, as PRAM scope is to be implemented within projects it has distinguished between two levels of risk in projects namely: "risk events" and "project risk"; as it separated its treatment step into "Plan Risk Event Responses" which aims at dealing with individual risks, and "Plan Project Risk Responses" which deals with the overall risk likely to be experienced within the project.

Table 2.5 combines all the tools and techniques for risk identification step that were proposed by the compared standards; it is worthy to state that most of the suggested tools and techniques are subjective and qualitative; where very few tools utilize statistical or mathematical techniques.

The study has shown that there are two types of control which are handled in the risk control step: control of risk treatment actions for the project/activity and control of risk management process. The comparison has revealed the fact that great deal of attention is directed towards controlling the effectiveness of the treatment actions which have been chosen in the risk treatment step; this was on the expense of examining and enhancing the risk management process itself.

Table 2.5 Consolidated List of Tools and Techniques for Risk Identification (Raz and Hillson, 2005)

Assumption analysis	Examination of vulnerabilities	Prompt lists
Benchmarking	and weaknesses	Prototyping
Brainstorming	Expert opinion	Questionnaires
Case and effect diagrams	Fault tree analysis	Risk assessment workshops
Checklists	Flow charts	Root cause analysis
Constraints analysis	Hazard and opportunity	Scenario analysis
Delphi technique	studies (HAZOP)	Stakeholder analysis
Diagramming techniques	Historical data	Structured interviews
Documentation reviews	Incident investigation	SWOT analysis
Evaluation of other projects	Influence diagrams	System engineering techniques
Event tree analysis	Interviewing	System analysis
Examination of past risk	Lessons learned	Taxonomies
experience in similar	Nominal group technique	Technology readiness level
organizations	Peer review	Testing and modeling
Examination of past risk	Personal observation	
experience in the organization	Previous experience	
	Project monitoring	

On the other hand, the comparison has disclosed several key differences between the individual standards. Moreover, one of the major conflicts found between the standards is the perspective of defining the term "risk"; as this issue was covered in detail in section (2.1.1), only the definitions of risk proposed by the standards will be listed; Table 2.6 includes list of the nine definitions in order to have an overall image for the different views adopted by the compared standards.

Table 2.6 Definitions of "Risk" (Raz and Hillson, 2005)

Negative definitions	Neutral definitions	Broad definitions
CAN/CSA-Q850-97: "the chance of injury or loss"	AS/NZS 4360:2004: "the chance of something happening that will have an impact upon objectives"	PMBok® 2004: "an uncertain event or condition that, if it occurs, has a positive or negative effect on a project objective"
IEEE 1540:2001: " the likelihood of an event, hazard, threat, or situation occurring and its undesirable consequences; a potential problem"	BS6079-3:2000: "uncertainty… that can affect the prospects of achieving…goals"	IRM/ALARM/AIRMIC 2002: "combination of the probability of an event and its consequence… consequence can range from positive to negative"
	IEC 62198:2001: "combination of the probability of an event occurring and its consequences for project objectives"	PRAM Guide 2004: " an uncertain event or set of circumstances which, should it occur, will have as effect on achievement pf objectives… either positively or negatively
	JIS Q2001 (E): "a combination of the probability of an event and its consequence"	

Finally, following their detailed comparison; Raz and Hillson (2005) have concluded that even when the scope of the standards differ widely as they range between a limited scope which aims to be implemented within certain types of projects or activities; or a much wider scope which can be utilized for any type of activity within the organization; no fundamental differences were located between the two extremes with regard to the structure of the process or their contents. Therefore, they have suggested that the best practices proposed by these standards or even other standards are suitable to be implemented in projects or any other types of activities conducted within the organization. Moreover, the consistency observed between the standards brace the fact that there is a general consensus among risk practitioners about the major components of risk management process.

2.2.4 Risk Analysis and Management for Projects Framework

The previous section has demonstrated the fact that there is a general agreement among risk professionals within different business environments on what should be the major steps for managing risk, yet as this study is relevant to construction project risk and since each construction project encompass unique characteristic in terms of its scope or execution methods; it is believed to be of great importance to have an integral review for the significant issues regarding construction project risk management process; therefore, this section will go through a more relevant process that takes into account the unique nature of the construction industry.

Risk Analysis and Management for Projects (RAMP) is a process for analyzing and responding to risks that can have an influence on the achievement of project (investment opportunity) objectives. RAMP is the resultant of joint working between the ICE and the Faculty of Actuaries and Institute of Actuaries; the process covers the whole project lifecycle from inception to disposal; this framework contains four main activities namely: (1) Process Launch, (2) Risk Review, (3) Risk Management and (4) Process Close-Down, for the context of this thesis the main issues regarding this process will be outlined.

Hitchings and Wilson (2002) have examined risks at project level; they have acknowledged the proposal that recognized three areas of risk: (1) Risk to the health and safety of people, including personal injury and loss of life, (2) Risk to the environment, including pollution, damage to plants and animals and soil erosion, and (3) Risks to the activity (i.e. project or investment), including damage to equipment, loss of output, and resultant contractual delays and penalties. They have further stated that these areas are jointed by a cost that influences the decision about the amount of money and time that should be consumed to reach the accepted level for mitigating risks. This relation is depicted in Figure 2.4.

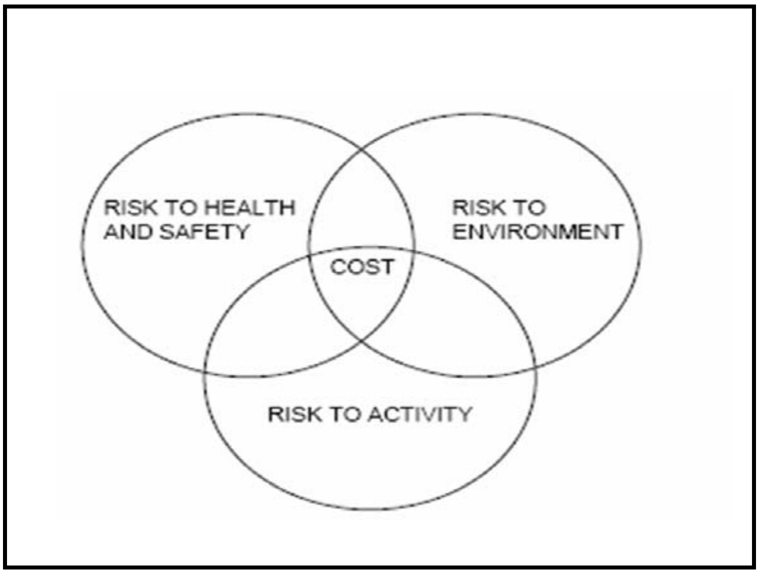


Figure 2.4. The Relation between Risk Areas and Cost (Hitchings and Wilson, 2002)

Moreover, as they have conceded the crucial role for continuous risk assessment, allocation, and management process throughout the project lifecycle, they have discussed RAMP as an effective process for analyzing and responding to risks that can affect the overall project success, where "risk" is defined in the handbook as mentioned in Section 2.1.1 as "the potential impact of threats (or opportunities) which can affect the achievement of objectives for an investment".

Further, they have presented an overview for the process of RAMP referring them to the relevant sections of the previously mentioned RAMP handbook; the next sections shall illustrate the major issues related to RAMP. Additionally, there is a website that is dedicated to RAMP addressed at www.ramprisk.com (2007) which was also referred for reaching an effectual overview to RAMP framework.

2.2.4.1 Investment Lifecycle

The investment lifecycle describes the stages for an investment (Project) progresses. Thus, investment lifecycle is defined as "the lifetime of a project from inspection to ultimate termination", more often than not uncertainty surrounds the duration during which the project will be operated, and hence the investment lifecycle should be estimated according to predetermined assumptions. The relation between the different investment stages to RAMP is explained through Table 2.7.

Table 2.7 Activities, Key Parameters and RAMP Process in each Stage of Investment Lifecycle (Hitchings and Wilson, 2002)

Investment Stage/Objective	Principal Activities	Key Parameters	RAMP Process
Opportunity Identification To identify opportunity and decide whether it is a worthwhile to conduct a full appraisal	Identify business need Define investment opportunity Make initial assessment Decide whether to proceed with appraisal	Broad estimate of capital cost and cash flows Cost appraisal	Preliminary review
Appraisal To decide whether the investment should be made	Define investment objectives, scope and requirements Define project structure and strategy Develop business case Identify funding options Conduct feasibility study Decide whether to proceed with the investment	Refined estimates of capital cost and cash flows Cost of investment planning phase	Full risk review
Investment Planning To prepare for effective implementation of the project	Procurement of funding Obtaining planning consents Preliminary design work Compiling project implementation plan Place advance contracts (e.g. site preparation) Making final decision to proceed with investment	Financial cost Refined estimates of capital cost and cash flows	Risk review (prior to final decision)
Asset creation To design, construct and commission the asset and prepare for operation	Mobilizing the project team Detailed planning and design Procurement/tendering Construction Testing, commissioning and handover Ensuring safety Preparing for operation	Project objectives: Scope* Performance/ quality* Timing* Capital cost	Risk reviews and risk management Between reviews
Operation To operate the asset to obtain optimum benefits for client and other principal stakeholders (including investors and customers)	Operating the service Deriving revenue and other benefits Maintaining and renewing the asset	Operating cost Maintenance cost Cost of renewals Revenue Non-revenue benefits	Risk reviews periodically
Close-down To complete investment, dispose of asset and related business, and review its success	Sale, transfer, decommissioning or termination of asset and related business Post-investment review	Decommission cost Cost of staff redundancies Disposal cost Resale or residual value	Final risk review and RAMP close-down

* These have a potential impact on one or more financial parameters

2.2.4.2 The RAMP Process

The RAMP process consists of four activities; these activities are carried out at different stages of investment lifecycle, the activities together with the times into which they suppose to be conducted are indicated below:

- **Process Launch**: conducted early in the investment lifecycle.
- **Risk Review**: conducted before key decisions or intervals.
- **Risk Management**: conducted continually between risk reviews.
- **Process Close-Down**: conducted at the end of the investment lifecycle or on premature termination.

Furthermore, each activity contains a number of phases which in turns consists of various process steps. More to this point, the number of times for performing each activity differ according to the purpose of conducting them; that is, the start and end activities are performed once as they are related to establishing and closing down the process; however, several risk reviews shall be conducted at critical phases or time intervals within the investment lifecycle. As well, risk management activities are continuous actions performed within risk reviews intervals and with accordance to the analyses, strategies and plans resulted from previous risk review. The RAMP process is depicted in Figure 2.5 and the activities from which this process is consisted are expressed in the subsequent sections.

2.2.4.2.1 Activity A: Process Launch

Prior to the establishment of the RAMP process it is essential to corroborate the perspective from which the risk analysis and management is being performed, in addition to the identification of the key stakeholders according to whom the outcomes are evaluated. The version of RAMP process under consideration assumes that risk is being considered from the owner viewpoint; yet it is specified that the process may be customized to be utilized to other perspectives.

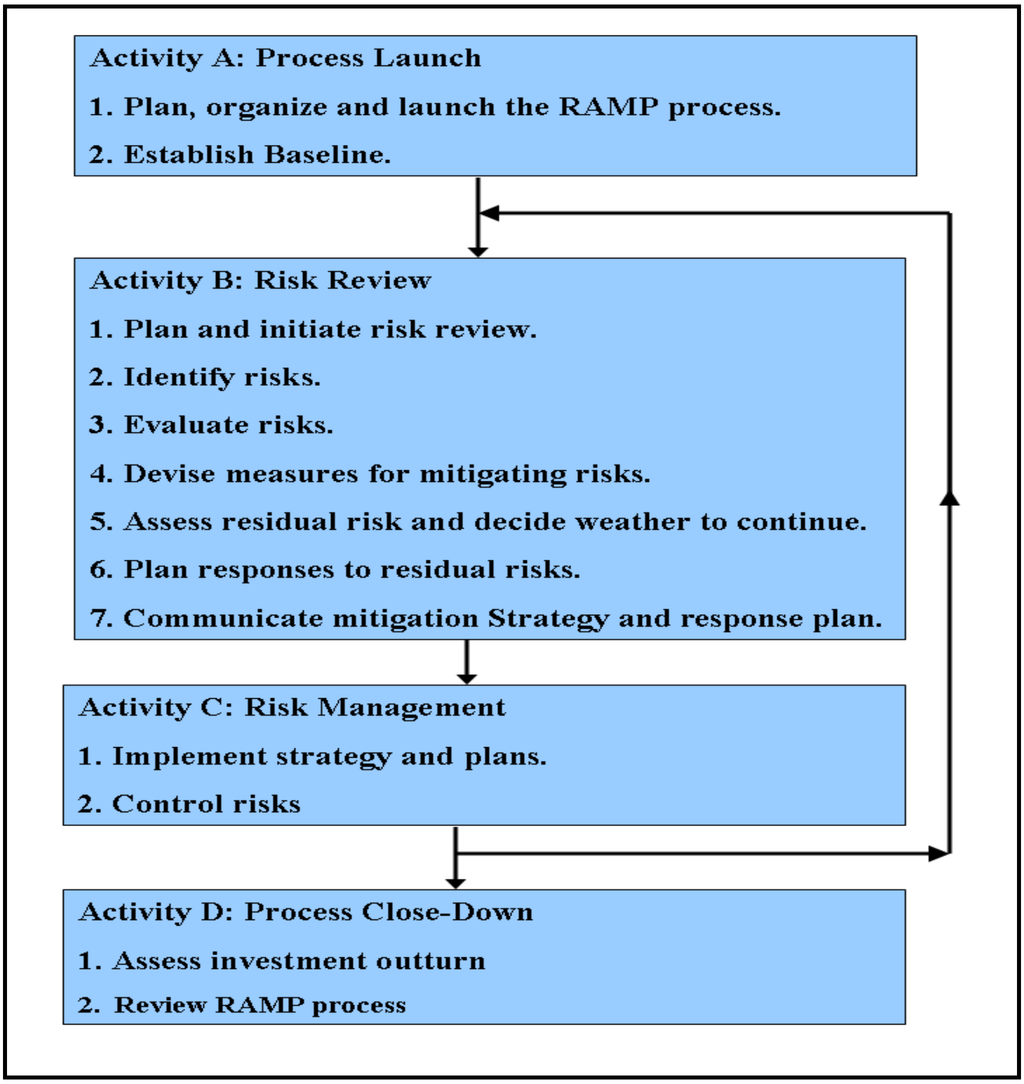


Figure 2.5. The RAMP Process (Hitchings and Wilson, 2002)

After the perspective for analyzing and managing risk is confirmed a risk process manager (the manager who will plan, lead, and co-ordinate the RAMP process) is appointed, hence the manager first mission is to develop the RAMP process plan.

Following the plan preparation an initial brief should be prepared about the objectives, scope, and timing of the risk review. In addition, strategy for risk reviews and management throughout the investment lifecycle should be included; thus the prepared brief takes account for the following issues:

- **Purpose of RAMP**: the objectives of RAMP as applied to the investment (project).
- **Level of risk analysis**: the appropriate level of detail, sophistication, and effort for the investment, given its type, value, complexity, and importance.
- **Scope of review**: the stages in the investment lifecycle (or more specific phases) to be considered.
- **Stage/timing**: times within each stage to conduct risk review.
- **Budget for RAMP**: estimating the required budget for conducting the RAMP process stage-by-stage for the whole investment lifecycle.

Moreover, to make the process more effective it is of great importance to communicate the risk analysis and management strategy to all relevant personnel. The final stage for launching RAMP process is to form a team that will act as risk analysts; where their primary task is the identification and evaluation of risks during the risk review. Parallel to establishing the RAMP process team a baseline is established covering items such as: investment definition, objectives, key parameters, overall measures of investment, investment lifecycle, principal activities, asset component and factors, baseline plans, underlying assumption, investment model, discount rate, initial values and cash flows, and initial overall values. Further, at this stage the manager prepare a risk diary; which is a logbook maintained by the risk process manager which should, contain a record of key events in the planning and execution of the RAMP process, any problems encountered and unforeseen risks which arose, the results of risk reviews and ways in which future risk reviews or the RAMP process itself could be improved.

2.2.4.2.2 Activity B: Risk Review

The risk review plan prepared by the manager includes the aims, scope, and level of the risk review. Where, the aim of risk review is to discover all the significant types and sources of risk and uncertainty associated with each objective. Moreover, the aim includes the determination of the cause(s) of each risk, assess the interrelations between risks, and how the risks should be organized or clustered to be evaluated, then every "significant" or "potentially significant" risk identified is evaluated. Further, many mitigation options are contemplated for dealing with the non negligible risks.

It is clear at this time that the risk review activity contains several major phases which include: risk identification, risk analysis, risk mitigation, financial evaluation and the go/no-go decision; due to the different steps conducted within each phase these stages are examined in more detail.

Risk Identification

It could be predicted out that the aims of this phase of RAMP are to:

- Identify all the significant types and sources of risk and uncertainty associated with each of the investment objectives together with the key parameters relating to these objectives.
- Ascertain the causes of each risk.
- Assess how risks are related to other risks and how risks should be classified and grouped for evaluation.

Risk identification is critical phase, since the result of this phase will have an effect on the succeeding phases; as if this stage misses any risk consequently the following phases will not take it into account. Therefore, if risk is not identified it will not be evaluated and managed.

Searching and responding to risk is iterative process. The first step is to develop individual lists by each risk analyst; each list will contain risks associated to each objective, key parameter, major 'deliverable' or principal activity within relevant analyst's specialization area; the analyst team should cover every aspect of the investment. At the first step no checklists or prompts are used in order to prevent the limitation of the discovery process.

Then, the discovered risks are listed in the risk register. Afterwards, the previous step is repeated with the assistance of the risk matrix and other prompt aids, where risk matrix is the presentation of information about risks in a matrix format, enabling each risk to be presented as the cell of a matrix whose rows are usually the stages in the investment lifecycle and whose columns are different causes of risk. A risk matrix is useful as a checklist of different types of risk which might arise over the life of a project but it must always be supplemented by other ways of discovering risks. The resultant identified risks from the previous steps are then listed in the risk register for later review and analysis, at this stage each risk is listed with provisional choice of the degree of its significance (i.e. "clearly significant", "possibly significant, and "probably insignificant") together with its interrelationships with other risks.

The following step is to conduct a brainstorming session including some or all of the risk analysts, and others who can provide useful contribution. The brainstorming session is to improve the risk register by reviewing the previously identified risks and to discover new risks. Accordingly, reasonable degree of risk identification is reached by identifying as many as feasible risks. Then, the identified risks must be classified and clustered to aid in the evaluation process.

Risk Analysis

Each identified risk; which has a "clearly significant" or "possibly significant" consequence, should be assessed to establish qualitatively the values listed below:

- The likelihood/frequency of the risk occurring per unit of time or some other convenient unit.
- The potential consequence if the risk occurs.
- The most likely frequency of the risk occurring during the whole lifetime of the investment.
- The likely timing of the risk impact.
- The acceptance score, by combining the likelihood with the consequence.

Risks may be related to each other, in this case where risks may be caused by the same sources or the likelihood of one risk is affected by another; the related risks should be evaluated jointly. Then the result of the assessment process, either for individual or grouped risks; should be entered into the risk register. Accordingly, the significance of risks should be reviewed and reclassified; and for the "probably insignificant" risks decision should be made whether they can be ignored or not. On the other hand, great deal of attention should be given to the identification and classifying risks which could have either serious catastrophic consequences or high expected values, or exceptionally favorable consequences; as both categories required special attention while evaluating the risk level of the investment.

Risk Mitigation

To achieve effective risk management it is of crucial importance to select the optimum mitigating strategies for risks to reduce their impact while maintaining desirable rewards from the investment. Moreover, risk mitigation strategies should be implemented throughout the project lifecycle from inception to close-down.

Following are the considered options within the framework of risk management strategy:

- Reducing or eliminating the risk.
- Transferring the risk.
- Insuring the risk.
- Avoiding the risk.
- Absorbing the risk.
- Obtaining better information to reduce the uncertainty.

Then each risk is entered to the risk register accompanying with the chosen mitigation option and the motive behind the choice. A plan is then prepared to undertake each action, as common or related actions; which may be utilized for dealing with several risks; are grouped together. Then, a risk mitigation strategy is assembled containing the action plans and a risk account which shows the costs and benefits of the mitigation measures.

Financial Evaluation

As the net present value (NPV) is a method for cost benefit analysis that is commonly used for analyzing the investment opportunity, after preparing the costs and benefits of the mitigation measures; the NPV is recalculated using the investment model to reflect the mitigation measures adopted. This may be done by calculating the NPV for each possible combination of risk impacts (i.e. all scenarios considered for the purpose of the analysis) or statistical distribution may be produced of the NPV using a computer-based Monte Carlo (MC) simulation, both ways will result in a probability distribution of the project's NPVs which will show the likelihood of occurrence of each NPV. Afterward, the results are evaluated again to reveal if they can be enhanced by eliminating the measures that comprise high cost and low beneficial effect, and for risks that need exhaustive study the available options are reevaluated within this step.

The following step is to finalize a residual risk analysis. This step include assessing the residual risks (those risks which are not avoided, eliminated or transferred in the risk mitigation strategy); allowing for the results of adopting the selected mitigation measures, taking into consideration the secondary risks and the cost of the mitigation measures. The residual risks are then ordered according to their significant for each investment parameter. Next, risk response plan is developed to assign responsibility regarding each residual risk to a "risk custodian". Moreover the following actions are developed to be included in the plan:

- Containment plans to minimize the risks and their impacts.
- Contingency plans to deal with specific residual risks should they occur.
- Contingency budgets, for the potential impact of the residual risks on each of the principal parameters in the investment plan.

<u>Go/No-Go Decision</u>

A major benefit from conducting RAMP process is to decide whether the investment (project) worth to be undertaken; and if there is a better opportunity presented by other investment. Accordingly, the decision to proceed or not is dependent on the combination of the following:

- A description of the project and its baseline.
- A description of the most significant risks and how it is proposed to mitigate them.
- A description of the residual risks and the effect they will have on NPV.
- If there are significant alternative options.
- A recommendation on whether the project should proceed
- Matters outside the scope of RAMP.

The final step within this phase is to receive a formal approval from the client and any other stakeholders for proceeding with the project; where attentions should be given to both arithmetical results together with the intangible factors.

Finally, at the end of the risk review activity, a risk review report is prepared to present a summary of the main results of the review, which include the major risks identified, their likely effects and the overall risk level of the investment. Further, the report includes the comments on the effectiveness of the review, problems experienced, lessons learnt, and recommendation for improving future reviews.

2.2.4.2.3 Activity C: Risk Management

Through this activity the residual risk analysis, risk mitigation strategy and risk response plan are all implemented within the main stream investment, project and operating management processes. Then, actions are monitored to assure their timely and satisfactory completion; where any deviations from the planed actions are directly reported to the manager. Moreover, risks that occur later in the project lifecycle should be monitored. Furthermore, throughout the project lifecycle the residual risk analysis, risk mitigation strategy, and risk response plan are reviewed and the contingency budget is utilized due to risk exposure. In the course of this activity risk review reports are submitted to the client's representative and stakeholders.

2.2.4.2.4 Activity D: Process Close-Down

At the end of the investment lifecycle or on premature termination of the project, a revision is undertaken to determine the effectiveness of the implementation of RAMP process to the investment. A RAMP close-down report is developed using the result of this review. The report compares the performance of the investment with the original objectives. Furthermore, an assessment is performed for the risks and their actual impacts comparing them with those predicted. Finally, the report records the learnt lessons and suggested improvements for future investments.

Bring to a close regarding risk management process issue, and when RAMP process framework is compared with any other standard or guideline examined earlier it can be said without reservation that there is a general theme which is repeated within all the guidelines that is the concentration on the indispensable role for adequate identification and assessment for the risk events and their sources to ensure effective implementation for the subsequent risk management phases. Moreover, no fundamental differences are found between the several guidelines examined regarding the structure of the proposed process for managing risk which lead to a key conclusion that implies the existence of a general consensus between them concerning the main steps for implementing risk management.

The previous sections in this chapter have given immense attention to define terms and expressions associated with risk management such as "risk", "uncertainty" and "risk attitude". In addition, consideration was given to the historical development for practicing risk management within the business environment to understand the essential areas for emphasis when functioning risk management. Moreover, in-depth analysis to the main steps of several well-known risk management standards and guidelines was undertaken to reveal the fundamental processes that should be considered while implementing risk management. More to this point, RAMP process as it is proposed particularly to analyze and respond to construction project risk was examined in great detail. Hence, at this point the depiction regarding risk management process and the crucial role for risk identification and management steps within the overall risk management framework is assumed to be well defined.

CHAPTER 3

INTERNATIONAL CONSTRUCTION PROJECTS RISK ASSESSMENT MODEL

This chapter shall comprehensively presents risk associated with international construction projects via revision to the results obtained from thorough search into the available literature concerning international construction risk assessment. Chapter 2 has discussed the inclusive process of project risk management and demonstrated the indispensable role of adequate identification of risk associated with construction projects in the overall management process. This chapter, on the other hand, will examine several existing models which were proposed for systematic assessment of risk associated with international construction projects. Moreover, a review of the commonly adopted risk analysis and risk assessment techniques will be carried out. This chapter will also include descriptive review to the analytic network process (ANP) together with a step-by-step demonstration of the process undertaken while building the international construction project risk assessment model (ICRM). The closure of this chapter will include the obtained results (i.e. the relative priorities of the risk factors) from the ANP software *SUPERDECISIONS*, which is the used software to develop the ICRM.

3.1 Available Approaches for Assessing Risk Associated with International Construction Projects

The fundamental changes in the global economy have boosted the international construction industry; new attractive opportunities have become obtainable all through the world due to the expanding markets. Such opportunities are offered by developing countries together with the emerging markets in Asia, Eastern Europe and former Soviet countries.

In addition to different international agreements which have created radical changes in the construction industry such as North American free trade agreement (NAFTA) and the "Uruguay Round" in general agreement on tariffs and trade (GATT) (Hastak and Shaked, 2000; Gunhan and Arditi, 2005a; Mahalingam and Levitt, 2005). On the other hand, the severe competition and the scarcity of adequate opportunities due to saturation in local markets have forced local construction organizations to seek new business opportunities abroad. As a result, increasingly than ever local construction organizations have determined to expand their construction activities in the international construction markets. However, prior to entering new market it is essential to analyze potential risks and opportunities likely to be encountered in the aimed market. Risk involved in international markets captured the attention of many researchers and practitioners due to its crucial role in achieving the expected benefits from emerging in the global markets. Furthermore, it will not be astonishing to declare that international construction involves more risk than local construction, and despite the fact that local construction organizations may face threats from external practitioners in their home country; they should not expect the same level of competition in a foreign country where completely different rules of competition exists and contrast competitive advantages may be required to succeed.

Globalization creates new opportunities for local construction organizations to expand their activities abroad. The consequence of the noteworthy changes in the global economy is the existence of attractive opportunities throughout the world. Accordingly, even though international construction is not a novel trend; yet increasingly than ever local construction organizations are turning toward expanding their business into the international construction markets (Hastak and Shaked, 2000; Han and Diekmann, 2001; Han et. al, 2004; Gunhan and Arditi, 2005a; Han et al., 2005; Mahalingam and Levitt, 2005).

Nevertheless, before entering to a new country or even a new project in a given country it is of essential importance to analyze the potential risks expected to be encountered. However, assessing risk associated with international construction is an elaborated mission, as international project success is highly dependent on both country specific risks together with project risks. Thus, to analyze international construction from a project perspective, it is indispensable to identify the impact of country environment as well as specific market environment on that project; this is to be combined with project specific risk (Hastak and Shaked, 2000).

Due to the indispensable need for systematic approaches in assessing risk associated with international construction, numerous studies where conducted to serve this issue. Dikmen et al. (2007a) have proposed a methodology that provides a systematic way for identification and quantification of risks that stem from country and project conditions; the aim of their study was to model cost overrun risk in international construction projects using influence diagrams, and to propose a fuzzy risk rating methodology to calculate an overall cost overrun risk. In their research they have adopted a hypothesis that there are four types of decisions have to be made by contractors willing to expand their business into the international markets. Moreover, they have discussed decision support tools and computational methodologies developed to facilitate each type of these decisions, the decision categories together with the techniques they have utilized are revealed below:

- **Internationalization decision**: the terminology may differ with different researchers; it was defined as international expansion decision by Gunhan and Arditi (2005b), also it is known as international market entry decision (Dikmen and Birgonul, 2004). Dikmen et al. (2007a) argued that before assessing the attractiveness of a specific country/project, contractors should examine whether they are capable to conducted business in international markets. After the internationalization decision is agreed on they can undergo environmental scanning to locate adequate market/project.

- **Market selection decision**: following the decision to expand business into the international market, a desirable country is selected together with the most suitable entry mode. At this point a detailed strengths, weaknesses, opportunities and threats (SWOT) analysis is required combined with an extensive environmental scanning.
- **Project selection decision**: or it may be referred as bid/no-bid decision. The contractor should screen the potential projects and decide whether to bid for a project or not. This decision is taken by assessing attractiveness of the project and competitiveness of the company. Where level of attractiveness is determined by estimating potential profitability and the strategic importance of the project for the company. Moreover, assessing the risk expected and determination of the risk level of the project is crucial at this point. Further, ensuring company's ability to conduct the project is extremely important as it influences the level of attractiveness as well as competitiveness.
- **Markup selection**: subsequent to bid decision for a project, bid price should be determined, where the bid price is a combination of the costs and a percent markup, which in turns is a function of level of uncertainty, probability of winning, and expected profitability.

The conceptual model proposed by Gunhan and Arditi (2005a) can be referred to demonstrate Internationalization decision; in their study Gunhan and Arditi have utilized a compound approach of the AHP and Delphi method to identify the importance of different factors while giving an internationalization decision, also they have proposed an international expansion decision model (Gunhan and Arditi, 2005b) which may be used to support both internationalization and market selection decisions. The proposed tool aids a decision maker to carry out internal and external readiness tests for internationalization, to undertake a country specific analysis in a desired country, and to choose the most appropriate entry mode.

The structured methodology proposed by Ahmad (1990) was discussed as an example of bid/no-bid decision. Ahmad has developed a decision support tool for modeling bid/no-bid decision problems where in his methodology a set of attributes have been defined to find out a desirability score that reflects the strength of decision to bid. International risk assessment model (ICRAM-1) was developed by Hastak and Shaked (2000) to provide a structured approach for evaluating risk indicators involved in international construction projects. Using AHP, the model was designed to assess the risk level of a specific project in a foreign country. Also, an AHP based model for risk and opportunity assessment of international construction project was developed by Dikmen and Birgonul (2006), using their model a decision maker can compare attractiveness of alternative project options. Han and Diekmann (2001) have applied cross-impact analysis in their model "risk-based go/no-go decision-making model" to assess risks associated with international construction. A neuronet model has been developed by Dikmen and Birgonul (2004) as a decision support tool which can classify international projects with respect to their attractiveness and competitiveness based on Turkish contractors experience in international markets.

In addition to risk assessment tools Dikmen et al. (2007a) have reviewed conceptual and analytical risk management models which are applicable to international construction. The conceptual risk management framework developed by Wang et al. (2004) can be adopted by international contractors conducting business in developing countries. Another framework was developed by Han et al. (2004), which is a multi-criteria decision making framework for financial portfolio risk management to be used in international construction projects to integrate risk hierarchies at the project and corporate levels. Bing and Tiong (1999) have conducted a research aimed at studying the effective risk management measures of international construction joint ventures (ICJVs) through case studies to achieve validity for risk management model. In their study, a group of eight measures, namely: partner selection; agreement; subcontract; engineering contract; employment; good relationships; control; and renegotiation, were incorporated into a risk management model for the successful management of international construction joint ventures ICJVs.

Through this thesis study an inclusive risk assessment framework is proposed for assessing risk associated with international construction projects. The framework is aimed to be implemented within bidding decisions (i.e. bid/no bid and bid markup decisions); that is after the organization has decided to enter specific market. Moreover, the risk assessment model developed within this framework is customized for Turkish construction organizations that have expanded their construction activities into the global markets. Thus, the aim of the model is to provide risk rating for a specific international construction project which assists the decision maker to estimate a reliable bid markup; or to give a trustable bid/no bid decision by comparing available alternatives to choose the most appropriate one. However, it should be pointed out that this model should be used in conjunction with other tools that estimate the expected opportunities of a given international construction project which enable the decision maker to assess the attractiveness of the compared alternative projects; hence allows the decision maker to integrate project, market and country levels risks with the opportunities (Dikmen and Birgonul, 2006).

The definition of the term risk was discussed in Chapter 2; where it was pointed out that there are three different perspectives for defining risk which are: risk is all negative (i.e. threat), risk is defined neutrally (i.e. could be threat/opportunity), and risk is explicitly described to include both negative and positive outcomes (i.e. threats and opportunities). Moreover, it was clarified that for the purpose of this thesis risk is seen as wholly negative (i.e. threats). Thus, the study will give emphasis to the sources of risk that may have negative consequences on the predefined project objectives.

The development process of the model has included these key steps:

- **Risk identification**: Identification of risk factors associated with international construction projects through literature review, discussion sessions, and experience.
- **Development of the conceptual model**: Developing a hierarchical risk breakdown structure (HRBS) that includes the clustered risk factors.
- **Employment of the ANP technique**: Conducting brainstorming sessions and using the ANP to calculate the contribution of each risk factor to the overall international construction project risk.

The process of developing the model and a detailed discussion of the steps carried out within each phase will be talked about in more details through the following sections.

3.2 Identification of Risk Factors Associated with International Construction Projects

Section 2.2 reviewed a range of risk management methodologies as was proposed by several professional bodies. All of them regarding their scopes encompass risk identification as primary step before analyzing the risk associated with the activity under consideration. The need to identify risk sources at the outset is emphasized by all approaches to risk management, this would include determining what risk may be present and categorizing them properly (Tah and Carr, 2000).

When identifying risk factors associated with international construction projects the different approaches for considering risk should be clearly distinguished to avoid inconsistency while categorizing risk factors. Risks (i.e. threats) may be seen as sources, consequences or probability of occurrence of negative events; inconsistency is the outcome of misinterpretation between the different perspectives of risk (Dikmen and Birgonul, 2006).

In this thesis, sources of risk that may have an impact on project success criteria are defined as risk factors. Thus, risk is considered as a source rather than a consequence. Moreover, while considering the factors only the ones which are expected to have negative effects on the construction project objectives are recognized in view of the fact that for the context of this study risk is equal to threats. Literature related to international construction was reviewed to identify the potential sources of risk associated with international construction. Then, several discussion sessions where conducted with international construction experts to agree on the different categories that best defines the identified factors. Consequently, identified risk factors were clustered into five main categories namely: country, inter-country, project team, contractual issues, and construction related factors.

3.2.1 Risk Associated with International Construction Projects

This section's center of attention will be to reveal the main sources of threats that await construction projects conducted abroad as were found within literature related to international construction. When literature concerning risk involved in international construction is reviewed, it can be said without doubt that many experts in the area of international construction embrace the belief that risk associated with international construction can be examined through evaluating the political state of the intended countries (Hastak and Shaked, 2000). Moreover, several authors have described risk specific to international construction projects (Hastak and Shaked, 2000; Han and Diekmann, 2001; Dikmen and Birgonul, 2006; Dikmen et al. 2007b). More or less all the researchers gave the risk sourced from country conditions, such as political and economic risk factors the highest attention (Dikmen et al., 2007a). Moreover, the available political risk assessment models consider factors such as political, economic, financial, legal, social conditions, policy, and the foreign exchange system of the host country (Erb et al., 1996; Hastak and Shaked, 2000). However, it is argued that political risk assessment models can only provide a limited view of the construction business environment; and do not provide evaluation of the impact of political instability on the construction market not mention individual construction project in the host country.

Furthermore, political instability may not have a direct impact on a specific construction project, yet it might influence the construction market or an associated market. Consequently, comprehensive understanding of the risk associated with international construction project requires the identification of the expected impact of both country environment and specific market environment on the project (Hastak and Shaked, 2000; Dikmen and Birgonul, 2006). Hastak and Shaked (2000) through their ICRAM-1 affirmed that better understanding of risk related to the international construction market necessitate the analysis of risk at three different levels: (1) Country, (2) Market, and (3) Project. Where country level identifies the overall risk that an international investor may face while conducting business in a foreign country; while market level risk is the risk coupled with a specific international construction market and finally the project level risk recognizes the risk associated with construction project in that specific international construction market. Moreover, all the three levels country, market, and project incorporate a set of tangible (inflation, currency fluctuation …etc.) and intangible risk factors (poor attitude of the host country towards foreign companies, cultural differences, immaturity of legal system…etc.).

3.2.1.1 Country Risk

This section shall spotlight the risk expected when an organization had decided to emerge into a foreign country. In literature concerning country risk assessment several key approaches exist; Hastak and Shaked (2000) clustered them into: (1) The political risk assessment approach, (2) The macro-sociopolitical (MSP) approach, and (3) The exchange instability approach. Moreover, they have demonstrated the key features of these approaches. For instance, the model proposed by Ashley and Bonner (1987) was given as an illustration for the first approach. In their model, Ashley and Boner (1987) have analyzed political risks in international projects and developed a political risk analysis approach using influence diagrams.

In this model the political risk for international construction was segregated into two categories: political source and project consequence and the later category variables were defined as those variables which directly influence the project, such as restrictions or strikes that are directly related to labors. Where the former category which is the political source; its variables were defined as those which indirectly influence the project by their impact on the project consequence variables (Dikmen et al., 2007a). Hastak and Shaked (2000) have criticized the model because in their opinion the model limits risk analysis to the impact of political events on the project and its consequences; furthermore, it does not consider the indirect impact of political factors on the construction and other related markets, and the potential impact of market factors on the project. On the other hand, and with regards to MSP models while they express the political instability factor as a function of various economic, ideological, and social factors, such models assume that political events can affect the development of economic and business conditions in the host country. The complex nature of development in the host country's sociopolitical environment might results in political instability, which leads to extreme changes in the business environment, including expropriation actions by the host government. Yet again, these models have two major shortcomings: they do not analyze the effect of political instability on the actual investment projects or business ventures, and they lack specificity in relating the impact of expropriation. Finally, the exchange rate instability approach analyzes the freedom to convert local currency in a foreign country. This approach considers the financial and payment related risks resulting from the exchange rate instability in the host country. Where change in the exchange rate results from disturbances in the host country's balance of payments or as an outcome of inflation rate, interest rates, productions, and employment level. Kapila and Hendrickson (2001) have identified financial risk factors associated with international construction and have recognized the most effective mitigation measures adopted by construction professionals in managing foreign exchange risk.

More specifically, the models which were designed to facilitate better decision making with regard to international construction projects have proposed several risk indicators at macro levels as well as market and project levels. For the context of this section some of the country specific risk factors identified by these models will be revealed. ICRAM-1 structured by Hastak and Shaked (2000) has identified a total of 73 risk indicators at the three levels that have a potential to influence the project through the country, market, or project levels. Table 3.1 shows the hierarchy of country level risk indicators. Dikmen and Birgonul (2006) in their AHP based model have also identified several risk factors at both project and country levels. Gunhan and Arditi (2005a) and within their combined AHP and Delphi approach they have recognized seven different threats associated with international expansion decision for construction companies, namely and sorted with accordance to their importance weights: loss of key employees (24.6%); shortage of project owner's financial resources (19.1%); inflation and currency fluctuations (13.3%); interest rate increases (12.8%); foreign competitors in host country (11.9%); cultural differences (9.3%); and bribery in the host country (9%). Mahalingam and Levitt (2005) have conducted detailed case studies on four matched international construction projects being constructed in Taiwan and India; two in each country. Through their study they have observed four key sources of problems within work practices that led to major challenges on the projects. The first was "rules vs. results orientation"; which has been recognized as one of the most prominent issues. This issue is related to the conflict that has occurred between certain groups that would insist on following the exact wording of the contract; and other groups that were more oriented towards practicing engineering judgments and attempting to progress the works as quickly and as efficiency as possible. The second matter is "bureaucratic vs. craft administration"; where Mahalingam and Levitt (2005) have explained that decision making in a bureaucratic administration is centralized; while the nature of the construction projects required craft administration as the organizations or crews on the site make most local decisions independently. The third recognized source of problems is the "master-slave relationship"; where the client in the Indian projects is used to deal in a highly dictatorial manner with the local contractors who were unable to protest due to the threat of blacklisting them from future jobs.

Table 3.1 Hierarchy of Country Level Risk Indicators as was Depicted in ICRAM-1 (Hastak and Shaked, 2000)

Criteria	Sub-criteria	Sub-sub-criteria
Operational risk	Host government	Political continuity
		Attitude towards foreign investors and profit
		Nationalization/expropriation
		Enforceability of contracts
		Government incentives
	Economic & financial	Monetary inflation
		Economic growth
	Administration	Bureaucratic delays
		Communication and transportation
		Professional services other than construction
Political risk	External causes	Hostilities with neighboring country or region
		Dependence on or importance of major power
	Internal causes	Fragmented political structure
		Fractionalization by language, ethic, and regional groups
		Restrains to retaining power
		Mentality, including nationalism, corruption, and dishonesty
		Social conditions (e.g. population density& wealth distribution
	Symptoms of instability	Social conflicts (e.g. demonstrations, strikes, & street violence)
		Instability because of non-constitutional changes
Financial risk	Legal framework	Actual laws versus practices for repatriation of capital
	Foreign exchange generation	Current account balance
		Capital flow
	International reserves	Foreign exchange reverses
		Gold and other reserves
	Foreign debt assessment	Debt as GDP converted to U.S dollars
		Capacity service debt
	Budget performance	Extent of deficiency/ surplus
		Sources of revenue and major spending

However, the international contractors were not anxious about this issue; which makes them more aggressive. The last trouble encountered was related to "safety and quality issues"; as the foreign contractors were used to implement high standards of safety and quality on their projects. Yet the safety and quality standards implemented in India and Taiwan were very poor.

Dikmen et al. (2007a) have created an influence diagram of country risk to be utilized within their proposed methodology for risk assessment of international projects; the methodology uses influence diagramming method for developing a model that is appropriate for international projects together with fuzzy risk rating approach for estimating cost overrun risk in international construction projects. The influence diagram of country risk is presented in Figure 3.1. According to their influence diagram the success of international construction projects is affected by the host country conditions such as economic; political; legal factors; international relations; and cultural differences. Where, the factors that may influence the degree of country risk are defined as experience of the company in the country as well as the existing contract clauses about allocating risk between the parties.

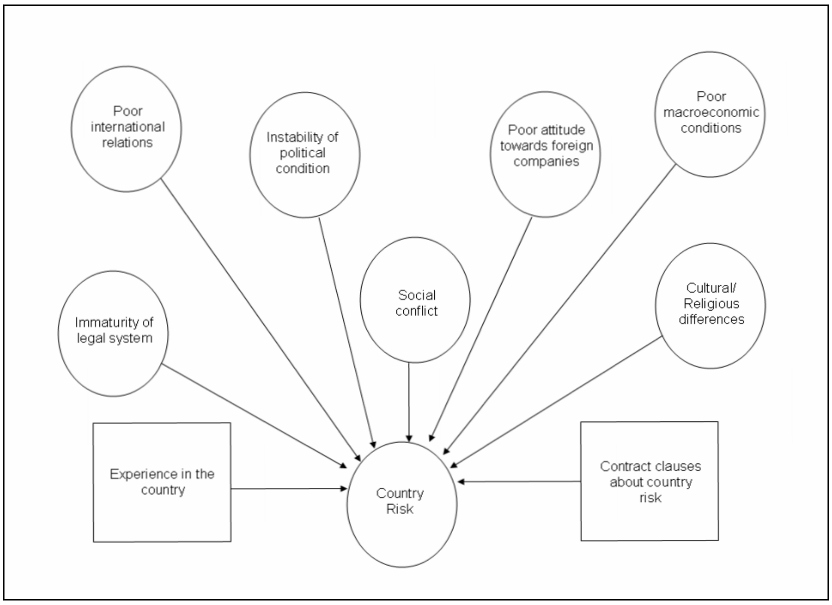


Figure 3.1. Influence Diagram of Country Risk (Dikmen et al., 2007a)

On the other hand, and within the context of evaluating the degree of risk level for a country; there are many services that provide measures or indexes for country risk, to do so they integrate a range of qualitative and quantitative information about the target country into a single index or rating (Erb et al., 1996). These services include:

- Bank of America World Information Services,
- Business Environment Risk Intelligence (BERI) S.A.,
- Control Risks Information Services (CRIS),
- Economist Intelligence Unit (EIU),
- Euromoney,
- Institutional Investor,
- Standard & Poor's Rating Group (S&P),
- Political Risk Services: International Country Risk Guide,
- Political Risk Services: Coplin-O'Leary Rating System, and
- Moody's Investors Services.

To exhibit the techniques these service providers utilize to create country indexes; a revision will be conducted for the methodologies used by two of the leading providers of risk rating namely: Institutional Investor and International Country Risk Guide (Erb. et al., 1996).

Institutional Investor

Institutional Investor (II) country credit ratings (CCR) are based on survey of leading international bankers, through the survey the experts are asked to rate each country on a scale from 0 to 100 (100 % maximum creditworthiness). II averages these ratings, where greater weights are provided to respondents with greater worldwide experience and more sophisticated country analysis systems.

Since the survey is used to rate the creditworthiness subjectively, it is difficult to exactly define the parameters taken into account. More to this point, an expert's recommendation, at any point in time; will be built on factors the experts believe to be relevant.

Therefore, to be able to know the factors that have been taken into account by its survey participants; II requests from the participants to rank the factors they consider in preparing country ratings. The result of the survey is presented in Table 3.2. It can be seen through the given ranks that the bankers rank the factors differently in each different group of countries, what is more, is the variation of the rankings across the time for the same country group. Further, the ranking of factors affecting organization for economic cooperation and development (OECD) country ratings seems to have been the most unstable through the fifteen years period from 1979 to 1994.

Table 3.2 Rankings of Critical Risk Factors in Institutional Investor's Country Credit Ratings by Rankings, 1979 and 1994 (Erb. et al., 1996)

	OECD		Emerging		Rest of World	
Factor	**1979**	**1994**	**1979**	**1994**	**1979**	**1994**
Economic outlook	1	1	2	3	3	4
Debt service	5	2	1	1	1	1
Financial reserves/ current account	2	3	4	4	4	3
Fiscal policy	9	4	9	7	6	6
Political outlook	3	5	3	2	2	2
Access to capital markets	6	6	7	9	8	9
Trade balance	4	7	5	5	5	5
Inflow of portfolio investment	7	8	8	8	7	8
Foreign direct investment	8	9	6	6	9	

International Country Risk Guide

International country risk guide (ICRG) observes on monthly basis data on a range of political, financial, and economic risk factors to calculate risk indexes with respect to each of these categories, and a composite-risk index which is a simple function of the three base indexes. The guide considers 5 financial, 13 political, and 6 economic factors. While each factor is given a numerical rating within a specified range, the allowable range particularly set for each factor reflects the weight attributed to that factor; the higher the rate the lower the risk. Moreover, political risk assessment scores are based on subjective staff analysis of the available information, economic risk assessment scores use objective analysis of quantitative data, and financial risk scores utilize a mix of quantitative and qualitative information. Furthermore, to calculate the individual indexes simply sum up the point scores for each factor related to each risk category. While the composite rating is a linear function of the three individual indexes' point scores. However, it should be noticed that political risk is given (100 points) which is twice the weight of financial and economic risk (50 points each). ICRG, similar to many of the other country indexes providers, considers two primary components of country risk: ability to pay and willingness to pay. Political risk is associated with willingness to pay, while financial and economic risks are associated with ability to pay. ICRG groups country composite scores into ordinal risk categories to assist in quick interpretation and comparison of country scores. Table 3.3 presents this categorization. Moreover, the factors considered under each risk category are exposed in Table 3.4, and the formulas for calculating these risk indexes are as follows: $PR = \Sigma PR_i$, $ER = \Sigma ER_i$, $FR = \Sigma FR_i$, and $CR = 0.5 (PR + ER + FR)$, Where PR is political risk, ER is economic risk, FR is financial risk, and CR is the composite-risk rating.

It seems that the factors taken into account by each provider of country risk ratings and even the audiences to whom it looks for informing are different, yet the methods these providers utilize have considerable similarities. Further, the majority of the providers convert widely used quantitative economic indicators in approximately the same manner. However, the significant differences are found in the degree of and specific factors considered in the qualitative component of the risk index measure.

Table 3.3 ICRG Risk Categories (Erb. et al., 1996)

Risk Category	Composite Score Range
Very high	0.0 – 49.5
High	50.0 – 59.5
Moderate	60.0 – 69.5
Low	70 – 84.5
Very low	85.0 – 100.0

Table 3.4 Critical Factors in the ICRG Rating (Erb. et al., 1996)

Factor	Points	% of Individual Index	% of Composite
Political			
Economic expectation versus reality	12	12	6
Economic planning failures	12	12	6
Political leadership	12	12	6
External conflict	10	10	5
Corruption in government	6	6	3
Military in politics	6	6	3
Organized religion in politics	6	6	3
Law and order tradition	6	6	3
Radical and national tensions	6	6	3
Political terrorism	6	6	3
Civil war	6	6	3
Political party development	6	6	3
Quality of the bureaucracy	6	6	3
Total political points	100	100	50
Financial			
Loan default or unfavorable loan restructuring	10	20	5
Delayed payment of suppliers' credits	10	20	5
Repudiation of contracts by governments	10	20	5
Losses from exchange controls	10	20	5
Expropriation of private investments	10	20	5
Total financial points	50	100	25
Economic			
Inflation	10	20	5
Debt services as a percentage of exports of goods and services	10	20	5
International liquidity ratios	5	10	3
Foreign trade collection experience	5	10	3
Current account balance as percentage of goods and services	15	30	8
Parallel foreign exchange rate market indicators	5	10	3
Total economic points	50	100	25
Overall points	200		100

3.2.1.2 Market Risk

Where the majority of the experts merge this risks with country and project level risks; Hastak and Shaked (2000) have created this level of risk in their ICRAM-1 to account for the additional risks which may be faced by international contractors in a given country besides the country and project risks. These risks include bidding procedures, availability of contractors, and availability of resources. Moreover, they revealed other factors; these factors comprise: technological advantage over the local market, role of the construction industry in the foreign country's overall economy, availability of construction resources, complexity of regularity processes, attitude of the foreign government toward the construction industry, and financing opportunities. Similarly to the country level, Hastak and Shaked (2000) have created a hierarchy of construction market level risk indicators which is depicted in Table 3.5. On the other hand, in order to overcome the risks associated with the construction market in the host country, several international contractors have formed ICJV which is one of the widely accepted forms of risk mitigation in the international markets. However, although it may assist the foreign contractors by taking advantage from the knowledge and experience of their local partners; yet sometimes it is a drawback for the international contractors due to lack of proficiency of local professionals in a host country (Hastak and Shaked, 2000). Therefore, selecting the most appropriate complementary partner is crucial for the success or failure of ICJV in achieving its objectives (Mohamed, 2003).

3.2.1.3 Construction Projects Risk

Construction activities are subject to different types of risks, numerous studies have been conducted to determine risk associated with construction projects and to adequately categorize them. Moreover, construction activities encounter the involvement of diverse parties throughout the lifecycle of the construction projects. Risk is seen in different ways according to the perspective of each party.

Table 3.5 Hierarchy of Construction Market Level Risk Indicators (Hastak and Shaked, 2000)

Criteria	Sub-criteria
Technology	Investor's technological advantage
	Technology protection system
	Market suitability for advanced technology
	Availability of basic construction/ technologies and equipment
Contracts and legal requirements	Type of partnership
	Types of contracts
	Enforceability of construction contract
	Procedure for bidding and design approvals
Resources	Availability and quality of local contractors
	Availability of construction materials
	Availability of skilled and unskilled workers
	Labor cost / productivity
	Availability of equipments and parts
Financing	Medium and long term financing for construction projects
	Tax and non-tax incentives in construction industry
	Special construction industry index
Business cultural differences	Interaction of foreign management with local contractors
	A/E/C firms client or owner relationship
	Competitive/negotiated bidding
Market potential	Current market volume in core competency
	Future market volume in core competency
	Bidding volume index

That is, project parties including: owners, engineers, and contractors; each represent different perspective toward risk. Therefore, it turned to be critical to determine the ownership of risk, to adequately allocate risk to the party that can best handle it (Smith and Bohn, 1999; Hastak and Shaked, 2000; Kartam and Kartam, 2001). However, resolving on a specified risk factors and categorization strategy is a very complicated task. When literature is reviewed it is not viable to locate a single list or risk breakdown structure (RBS) that is agreed on within all the experts in the area of construction. Each published technical paper or research study focus on risk from different perspective which particularly best serve its objectives for conducting the study. However, there are key risk factors which are found in more than one risk checklist or repeated within several RBSs. Such factors include but not limited to: availability of resources/subcontractors, design risks, physical conditions, project financing risk, and contracts and legal issues (Smith and Bohn, 1999; Hastak and Shaked, 2000; Dikmen and Birgonul, 2006; Dikmen et al., 2007a).

Hastak and Shaked (2000) have reviewed risk factors associated with construction projects which were proposed by several authors. From client's point of view, risk factors include vagueness whether costs will escalate unpredictably; structure will be faulty and need frequent repairs; and the project will simply be abandoned and partially paid for but incomplete and useless. Likewise, contractors would have concerned from facing inclement weather; delays in site availability; unforeseen subsoil conditions; inadequate detail drawings; late material deliveries; unanticipated price changes; faulty subcontracting; and unproductive labors and strikes. Dikmen and Birgonul (2006) have discussed the absence of universally accepted definition of risk and lack of standard risks checklist in international projects. Therefore, in their study they have stated that their first objective is to propose a risk breakdown structure to facilitate identification of risk sources in international projects. Through their proposed RBS, it can be seen that risk from their perspective was categorized into project and country. Project risk then had been divided into eight main categories which are: complexity; poor performance; unavailability; delay; vagueness; poor productivity; constraints/ restrictions; and strict requirements. The last level of the RBS contained the attributes considered under each category.

Some of the conducted studies focused on certain project objective and tried to identify risk factors that are likely to have influence on that objective. For instance, Nasir et al. (2003) have conducted a research to evaluate risk related to construction schedule. The key objective of their study was to develop a comprehensive construction schedule risk model to provide suggestions for the upper and lower activity duration limits. Identifying construction schedule risks was a supplemental objective. They have identified the sources of risk from diverse references including the published literature; procedure manuals; questionnaire surveys; interviews; and brainstorming sessions of experts and practitioners. They have developed 10 categories of risk which is specific to building construction schedules. However, they have declared that there is scarcity of researches that specifically consider construction schedule risks; and the main assistance obtained from literature was through the indirect links of the risk factors to the schedule. The considered categories are:

- **Environment**: They have found that weather effects are one of the critical sources of schedule risk. Since the progress of construction works is affected by weather conditions such as snow; cold/hot temperature; humidity; and rainfall. Moreover, weather conditions influence labor productivity either directly or indirectly.
- **Geotechnical**: Differing site conditions is recognized as one of the sources of construction schedule risk. Soil type may influence the time required for excavation.
- **Labor**: As labor productivity has a remarkable consequence on construction progress. Where labor productivity is affected by labor strikes; and labor injuries. Labor scarcity has crucial influence on the construction schedule.
- **Owner**: In this category they have considered factors such as poor communication; slow decision making; inexperienced management; inadequate supervision; financial problems; and late payments.

- **Design**: This category affirmed that design changes are a major risk to construction projects. Moreover, the experience of the design team with similar projects can affect the project. Additionally, incomplete drawings; inaccurate design; incomplete specifications; innovative design; undefined scope; and frequent changes in scope have a considerable effect on the project.
- **Area Conditions**: Performing a construction project in the city center is combined with several risks. Further, traffic conditions near and around the site are another source of risk; the requirement for road permits and approval to mobilize equipments and materials is another source. What is more; sometimes the access to the site is restricted; security is tight; or there is a restriction of working at the site. Some construction projects required working at operating facility which may lead to compliant of the users of the facility.
- **Political**: Political risks may be resulted from government instability; changes in requirements of permits or approvals; and other institutions that have power in the community. Moreover, the community attitude towards the project may have a noteworthy influence on the schedule.
- **Contractor**: The risk related to the contractor starts from the prequalification of the contractor and the subcontractors. The experience of subcontractors and their ability to meet the project requirements is a major source of risk. Moreover, adopting new technology or new construction methods may affect the construction schedule; also construction errors may require rework.
- **Contractor Non-Labor Resource**: In this category they have included basic sources such as: availability of equipments and quality of the equipment; as disruption of work due to deficiency of the equipment would affect the schedule. One way to avoid this risk is to evaluate the subcontractors and suppliers.
- **Material**: This category concerns the availability or scarcity of materials and the expected late delivery or procurement of materials.

In the same way, Dikmen et al. (2007a) have proposed a fuzzy risk rating approach for estimating cost overrun risk in international construction projects; in their research sources of cost overrun risk in international projects were defined as well as the factors that may affect levels of risk. They had assumed that level of project risk depends on construction risk; design risk; payment risk; client risk; and subcontractor risk. Then they have defined the influencing factors as experience of the company in similar projects and existing contract clauses about project risk.

Kartam and Kartam (2001) have conducted a questionnaire base survey within the largest Kuwaiti contractors which aimed at reporting a perspective of construction risk and the effective actions taken to manage risks; particularly related to time and finance. Their study focused on the assessment; allocation; and management of construction risks. In the questionnaire they have included 26 risk types based on an extensive literature review and consultation with the local experts who have participated in the survey. Figure 3.2 depicts the results of their survey on risk significance. Moreover, within the context of the survey the authors have asked the participant to allocate the risk to one of these three options: contractor; owner; or shared by both the owner and contractor. The result of risk allocation is listed in Table 3.6.

Owing to risk inherent within construction industry; where in most countries the construction practitioners faced with extreme competition coupled with high risks and low margin of profit; contractors have to employ solid and reliable strategies to establish their profit and risk margins for their quotations (Dikmen et al., 2007b). Within this framework a research was conducted by Smith and Bohn (1999) to define risk factors considered by small and medium contractors in establishing their contingency (i.e. risk) markup. With no considerable efforts they found that all contractors use contingency for every contract. Smith and Bohn (1999) have created eight tables from the information they have found in the work of several authors in the area of construction. Within these tables project risk was classified into eight main categories namely: natural; design; logistic; financial; legal and regulatory; political; construction; and environment.

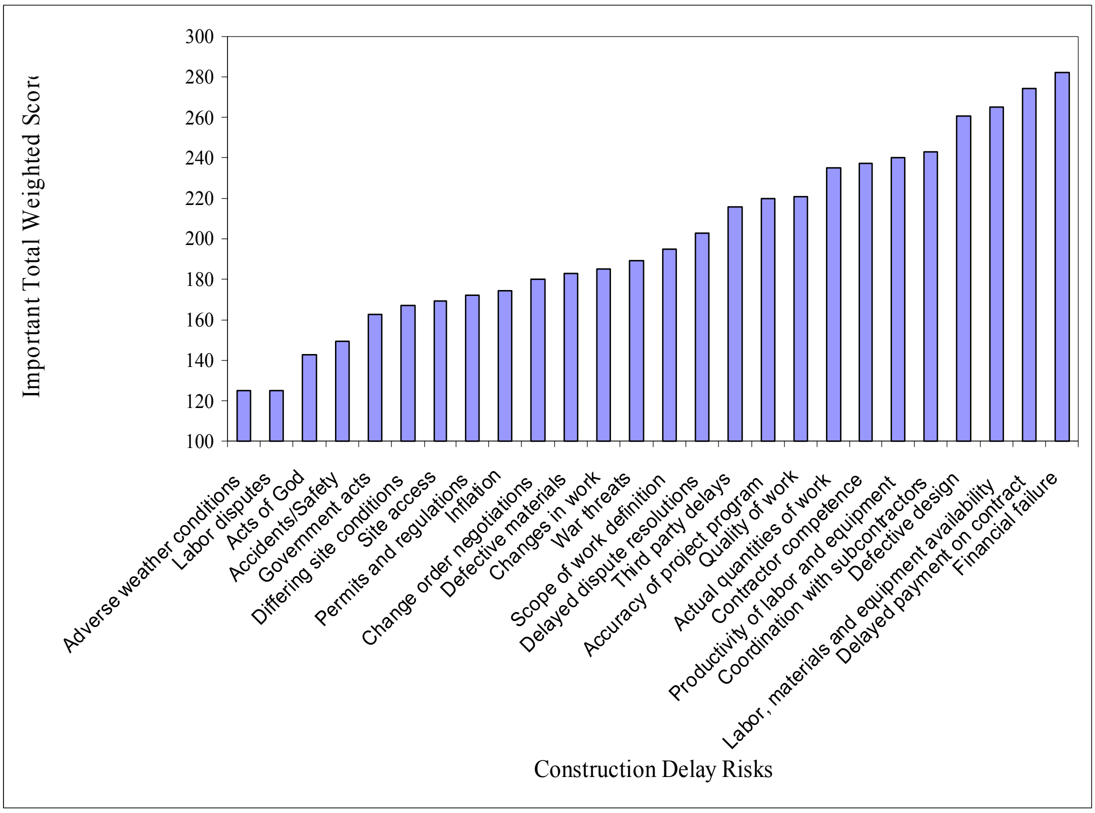


Figure 3.2 Results on Risk Significance (Kartam and Kartam, 2001)

Table 3.6 Results of Risk Allocation (Kartam and Kartam, 2001)

Risk allocation	**Risk description**	**Risk allocation**	**Risk description**
Contractor	Labor, material and equipment availability	Owner	Delayed payment on contract
	Labor disputes		Permits and regulations
	Productivity of labor and equipment		Changes in work
	Coordination with subcontractors		Scope of work definition
	Accidents/Safety	Shared	Change order negotiations
	Quality of work		Acts of God
	Accuracy of project program		War threats
	Contractor competence		Financial failure
	Defective materials	undecided	Site access
	Differing site conditions		Defective design
	Actual quantities		Government acts
	Adverse weather conditions		Third part delays
	inflation		Delayed disputes resolution

In their study, each project risk category was subdivided into types of risk, risk classification, party responsible, and methods of management. Risk was classified into internal or external. Where internal risks are those found within the project and are more likely to be controlled. While external risks refer to the risk which is created outside the project; and generally it is not a controllable risk. In risk type another indicator is used which is predictability; which measures the responsible party's ability to anticipate the likelihood of the risk occurrence. That is, predictable risk has sensible certainty to occur, whereas, unpredictable risks are those that occur randomly. The final classification under risk type reflects the source of risk. Either risk is contractual; that is risk stems from the contract documents, or it could be construction risk when the source is assumed to occur from project execution. However, in some occasions the risk exposure can be attributed to both contractual and construction.

The natural risk category reveals forms of natural risks including catastrophic events, loss due to accidents, and fire. Most of these risks are commonly considered within the contracts; and their risk is also usually minimized through insurance. Yet, if contract clauses disregard natural risks, the contractor should assume complete risk of these losses. Which means that contingency is the only mitigation action for managing physical risk, in this case contingency will play the role of self insurance. The following category addresses the risk associated with design. Usually the owner assumes most of these risks; in this case the owner project budget should assume some contingency for these risks. However, the contractor is also exposed to design risk when new technology is required to be used. In this case the contractor is faced with difficulties regarding estimating the productivity or expected delays since there is no basis for making judgment. Further, in the case of design-build or construction management it is common to add some contingency amounts for the unknown and difficulties. Moreover, contractors would include some contingency for the case of scope changes without adequate contract language. However, proper allocation in the changed condition clause for scope change is more recommended method. Differing site conditions and changed design should be handled in the same way.

The third considered risk category is logistics risks, these risks are related in general to the contractor. Mitigating logistic risks through better planning is a common risk management suggestion. Smith and Bohn (1999) have suggested that logistics risks should include information flow and relationships. Other critical risk categories are financial and legal and regulatory risks. Also political risk is considered as significant risk source; political risks are external to the project and unpredictable with respect to their frequency and magnitude. Construction risks were also considered by Smith and Bohn (1999). Finally, environment risks are the last category considered within their extensive research regarding risk considers by contractors while estimating contingency.

The major conclusions from the previous detailed review of various available researches regarding identification of risk specific to construction projects would support the initial view of the state of risk identification within literature. It was found that there is lack of agreement upon a unique checklist of risk. What is more is the existence of diverse perspectives from which risk is identified, that is risk is seen by the owner from different view than the contractor, and the designer is involved with project risk from different position than the owner and so forth. However, there is a consensus among almost all the construction experts and some practitioners regardless of their perspectives on the indispensable need for adequate and systematic approaches for identifying risk associated with construction projects. Moreover, there are essential risk sources that are considered within most of the proposed research which reflects their crucial contribution as potential barriers to achieve the ultimate goal of most of the researches; that is obtaining the desired project success.

Within the context of this thesis, risk is considered from contractor's perspective. Further, risk is defined for an international construction project conducted by Turkish contractor which is expected to form a joint venture (partnership) with local construction organization in the host country.

Moreover, while recognizing the critical risk factors the overall success criteria are considered. That is the project is desired to be completed within the defined time framework, budget, and quality requirements, and the stakeholders' satisfaction is considered as key objective. The risk factors that are incorporated within the model are discussed briefly in the following section.

3.2.2 Risk Factors considered in the International Construction Project Risk Assessment Model

Following the in-depth review of the available risk checklists and RBSs, several discussion sessions where arranged with experts in the area of international construction. Through constructive discussions with experts and in parallel with the detailed review of the relative literature, it was conceived that even with the numerous defined risk sources; there exists several risk sources that structure the basic framework for any model. Therefore, to avoid complication and repetition of not needed sources; only the ones that were believed to have tangible influence on achieving project success were considered. The model included a total of 28 risk sources; where some of the defined risk sources may represent a compound of sources that was believed to be best represented under one umbrella rather than considering several sources that are incomparable if included under the same category. These sources encompass extreme similarity in terms of their influence on the project. An example of which is the "design"; rather than considering different sources of design risk such as complexity; incomplete design; or design errors all of these sources where integrated into one source which was named "design risk". The identified risk sources were grouped under 5 main risk categories; namely: country, inter-country, construction, project team, and contractual issues. Risk factors considered within country and construction clusters were 7 for each; 6 under contractual issues cluster; and 4 in each of inter-country and project team.

3.2.2.1 Country Risk Cluster

This category contains risk factors which stems from the characteristics of the host country. It concerns the political situation, economic conditions, unethical practices, legal system maturity, and the stability and level of security in the country. The factors considered under this category are: bribery, government instability, tension/conflicts/terrorism, bureaucratic difficulties, immaturity/unreliability of legal system, change of regulations/laws (government interventions), and instability of economical conditions (inflation/currency fluctuation).

Bribery

This factor is considered by more than a few studies which are related to international construction. Several authors and experts in the area of international construction have recognized this factor as a considerable threat while conducting construction activities in a foreign country (Hastak and Shaked, 2000; Mohamed, 2003; Gunhan and Arditi, 2005a). Hastak and Shaked (2000) have considered this factor as one of the county level risk indicators within the internal causes of political risk criterion; in their country risk hierarchy they have focused on the mentality in the host country regarding nationalism, corruption, and dishonesty. However, according to their assessment this factor as well as social conditions captures the lowest weight when compared with the other country risk indicators. Their finding complies with what Gunhan and Arditi (2005a) reported. They have declared that despite the fact that unethical practices in foreign countries are recognized and denounced, they have found through experts evaluation that bribery in the host country is the least important threat faced by foreign contractors when compared with other threats associated with international construction such as financial and economical factors. Yet, recently corruption and bribery are seen as criminal actions almost all around the world, and prevention actions are taken by several states.

Government instability

At this point the political stability of the host country is taken into account. The majority of international construction experts believe that the political instability of the host country may threat the progress of a construction project (Hastak and Shaked, 2000; Nasir et al., 2003; Dikmen and Birgonul, 2004; Dikmen and Birgonul, 2006; Dikmen et al., 2007a). Moreover, there are models that are dedicated for assessing the influence of the political risk in a given country on the successful achievement of a construction project in that country. Additionally, it is assumed that the political incidents in the host country may affect the development of its social, economic, and business environments.

Tension/conflicts/terrorism

Due to the increasing lack of security all around the globe, precisely within the countries where Turkish contractors usually conduct their construction business, the recognition of this factor as a potential source of risk is increasing radically. Besides, there are some events which occur locally and isolated from the neighboring countries which its influence may tide upon project activities. Hastak and Shaked (2000) have found that social conflicts in the host country including demonstrations, strikes, and street violence are one of the most significant risk indicators in the country level risk.

Bureaucratic difficulties

In general every construction activity requires prior approval to be executed. Starting from site acquisition, where the contractor need permits and licenses to mobilize and to prepare the site for establishing the construction. Through executing the facility, that each activity needs prior approval from the owner or his representative and when executed it requires acceptance. Even when the project is finally conducted the contractor call for approval to submit it.

Furthermore, the destination from which the contractor needs to achieve approval or even information diverse widely according to the nature of the activity under consideration. During the construction project lifecycle the contractor deals with different parties to obtain permits/approvals or information to proceed. That is, when the issue is relative to the design the contractor may prepare request for information (RFI) to receive what is needed. Likewise, with the issues which are related to governmental approval the contractor may cooperates with the owner to receive the aimed permits. While if it is related to the construction activities the contractor needs to communicate with the owner or owner's consultants, also when it is related to material procurement the contractor may contact the material suppliers, and so forth the cyclic process continues. If one ring of this chain is not adequately performing then the project continuity is jeopardized. Since one of the key characteristics of construction projects is the limited period of time which is usually defined at the outset and before starting the project, any discontinuity in the progress will have unfavorable consequences on the contractor. Therefore, the risk of facing bureaucratic difficulties/delays due to the bureaucratic nature of conducting business in the host country was considered by several studies related to international construction (Hastak and Shaked, 2000; Dikmen and Birgonul, 2004; Mahalingam and Levitt, 2005; Dikmen et al., 2007b). Moreover, this issue is not only related with the construction of the facility, but also the progress of solving the potential conflicts or disputes during or even after the construction period. The nature by which decision making flows within the involved parties; together with the time consumed to achieve the required resolution for a given situation is highly influenced by the mentality of conducting business in the host country. The rule oriented and the bureaucratic structure of the host country may retard the progress in the construction site (Mahalingam and Levitt, 2005).

Ling and Lim (2006) have conducted a study to identify cross cultural differences between foreign Architectural, Engineering and Construction companies (AEC) practitioners and Chinese when executing projects in China.

Through their case studies they have revealed that managing projects in China involves dealing with the bureaucracy as there is government intervention in every stage of the project. They have referred the bureaucratic culture to the government's enthusiasm in protecting the local construction industry. Their interviewees have commented on the difficulties encountered when applying for construction permits, as they have mentioned that bureaucratic culture is evident during this procedure. According to an American project manager who was interviewed and with respect to this issue, he stated that:

If you knew somebody in the government, you could get it settled in a day, if not, the firm could wait for one month and it might still not be done. Construction wise, the local contractors could start work even before they obtained the construction permit. But it is especially different for foreign firms as the government likes to keep a close eye on them. Hence foreign firms have to make sure they wait for one month and receive the permit before they start construction.

Immaturity/unreliability of legal system

Contractors often face conflicts with other parties involved within the construction process. Moreover, in many cases the early prepared design is subject to changes according to the owner's requirements during the construction phase; especially if the scope is not adequately defined in advance. Therefore, change orders are an ordinary phenomenon within construction projects which represents a major source of disputes between the parties. Another key source of disputes is the late progress payments which is obligatory payable for the contractor through the signed contract. Depending on the severity of the disagreement and the degree to which it is related to legal issues; the process to resolve the situation differs widely. In many occasions, negotiations may assist in ending the problem when a possible agreement is seen in the horizon. However, when negotiation reaches closed end and no mutual understanding is reached, either arbitration may be applied or eventually the conflict is transferred to the courts.

If the legal system in the host country is to be applied on the construction contract then the level of maturity/reliability of the legal system is crucial for the contractor. Unbiased and mature legal system would means that the contractor will have a solid ground to rely on while believing that the conflict is going to be solved fairly, adequately; and within a reasonable period of time. Otherwise the contractor will be faced with the risk of loosing his rights due to the undependable legal system.

To illustrate this point the case of foreign contractors who conduct business in China will be referred once more. Ling and Lim (2006) have concluded through their case studies that parties involved into the signed contract did not constantly rely on it. Since they felt that it is pointless to enforce the contract through arbitration or the courts. That is even when a foreign firm commenced legal proceedings; the chance of winning the case on the grounds of breach of contract was not high. The interviewees revealed that to overcome this, contractors have to read and stamp on every page of the contract. This would ensure that there was no misunderstanding of the specifications and contractors will realize their obligations under the signed contract. On the other hand, Ling and Lim (2006) have discussed the case when a dispute arise, they found that in this case foreign contractors search the contract in detail to locate the exact amount they should claim for. Where negotiating will take place through the contractual process and long meetings, after which the final decision will be made by the top management.

Change of regulation/laws (government interventions)

This factor is highly relative to the political stability of the host country. It was pointed out earlier that political instability may lead to radical changes in the host country business environment; where most of these changes would have destructive consequences mainly on the expected profit and sometimes on other contractor objectives.

At the edge, the consequences of political changes may include increased tax rates, imposition of price controls, government interference in the contract, and restrictions on remitting the project earning to the parent company; either by forcing unfavorable tax rate on the project income or requiring the investment of certain percentage of the cash flow into the host country (Kapila and Hendrickson, 2001). On the other hand, international construction involves transferring contractor's employees to the aimed country. Changes in the immigration laws and the requirements for providing working licenses or passes for foreign workforce will affect the procurement strategy as planned by the contractor, as it will not be effortless to locate the suitable replacement staff in a timely manner (Bing and Tiong, 1999). Besides, there are many aspects regarding the construction activities which are related to the governmental regulations. These regulations include but not limited to: obtaining construction permits, environment protection regulations, safety requirement, required percentage for hiring local employees, obligatory utilization of local resources, and residence regulations. In order to be able to prepare adequate quotation, the contractor usually assumes certain state of the host government during the bidding process; any variation in the assumed circumstances will certainly influence the contract and eventually the contractor. However, in many cases the severity of the consequences of unstable laws and regulations in the host country depends on the degree of relation between the changes which have taken palace and the construction market or related markets in the host country.

Instability of economical conditions

This factor considers the financial risks that result from the potential unstable economic conditions in the host country. Financial risks include changes in exchange rate, interest rate, and inflation rate (Han et al., 2004). These risks are expected to have detrimental effects on the contractor's expected benefits from conducting business in the international construction market. Exchange rate risk is the outcome of fluctuations in the currency exchange rates or conversion restrictions which are beyond the control of an individual organization (Kapila and Hendrickson, 2001).

Further, change in the exchange rate could be the result of inflation rate, interest rates, productions, and employment level (Kapila and Hendrickson, 2001). Moreover, Kapila and Hendrickson (2001) have stated that for a foreign company, inflation represents a critical source of problems. They have further explained that with high inflation, the value of the cash flows received from the project will descend as the country's currency depreciates on the foreign exchange market. Therefore, the choice of currency is a key issue that international companies frequently deal with in their business, as the international markets contains many different currencies, some strong and others that are not as strong (Isacsson et al., 2004). Isacsson et al. (2004) have conducted a research to understand the motives behind choosing a currency in international business, where they have recognized risk as an important issue with regard to the choice of currency for international business. They have further explained that "companies cannot accept every currency because they do not know how much it is worth the next day". Moreover, they have demonstrated this fact by giving Argentina as an example. They have elucidated that Argentina has gone through an enormous crisis (1998-2002) and its currency has lost much of its value in a short period of time. Within the same context, Isacsson et al. (2004) have defined three types of currencies, namely: hard currency (currency such as the U.S. dollar, British pound and euro that are expected to be stable), strong currency (a currency that has a high value with low fluctuations in comparison to other currencies), and weak currency (a currency that has a low value with high fluctuations in comparison to other currencies). They have added that, international companies prefer to use hard currency such as the U.S. Dollar or Euro. However, they have pointed out that even when choosing a hard currency the companies are not taking away the risk completely, which means that companies are always exposed to such risks when doing international business.

3.2.2.2 Inter-Country Risk Cluster

This category takes into account the factors that are resulted from the differences encountered between the contractor's home country and the country into which he is planning to conduct his business. Four factors where considered under this cluster, which are: cultural differences, geographic distance, poor attitude of the host country towards foreign companies, and poor international relations with Turkey.

<u>Cultural Differences</u>

Culture has an essential influence on the behaviors of the project parties, and the deviation from the predicted performance of the parties is referenced to their diverse cultural backgrounds (Fellows and Liu, 2006). Combining with the escalating trend towards globalization of construction activities, the potential impact of culture on construction is intensifying. Even though domestic construction projects may encounter different cultural environments, nonetheless, the risk of being faced with different cultures increases in global markets. Nevertheless, despite the continuing recognition of culture impacts on performance, in-depth analyses of the core causes and the potential consequences of cultural risk in the global markets remain uncommon. More to this point, most of the studies gave more emphasis on the political risk assessments which have considered the political, economic and financial issues on the expense of the cultural risk. Accordingly, considering culture as an important factor of risk/uncertainty at all levels of construction industry is inevitable (Bu-Qammaz et al., 2006; Fellows and Liu, 2006).

According to Hofstede culture is, "…the collective programming of the mind which distinguishes one category of people from another" (Fellows and Liu, 2006). More specifically, the term culture can be used from construction business perspective to reflect the "beliefs, customs, habits and the ways of conducting business in a society that will have an impact on how a construction project is conducted and managed" (Bu-Qammaz et al., 2006).

Therefore, a noteworthy anxiety is resulted from the different cultural backgrounds from which the project participants have achieved their beliefs and values, which will result in diverse criteria, constructs and measures of performance. Thus, culture and its materialization are important components of risk associated with international construction projects (Fellows and Liu, 2006). Moreover, Fellows and Liu (2006) have argued that appreciation of such cultural factors, sensitivity of the project to them, and appropriate accommodation of their evident requirements, will enable the achievement of their positive impacts on performance.

Bu-Qammaz et al. (2006) have conducted a research to reveal the sources of cultural risk associated with international construction. Within the context of their study they have utilized ANP to achieve the relative priorities of the identified factors. In their cultural risk model they have tried to integrate the individual sources of cultural risk which were found in literature into a comprehensive model. The identified cultural risk factors were clustered into two main criteria, namely: host country, and project (construction) environment specific risk. Through this section the consideration will be to cultural risks which stems from the cultural differences between the contractor's home country and the host country; into which he is planning to conduct his business. Moreover, in their model country risk category was divided into two sub-criteria, which are: cultural risk related to cultural distance, and cultural risk related to social environment of the host country. Bu-Qammaz et al. (2006) with their recognition of the term “Cultural Distance” they have adopted the national cultural framework proposed by Hofstede. Hofstede specifically examined the role of national culture in work-related values and information system design. They have further explained that Hofstede has constructed this framework on a review of sociological and anthropological theories and work. The initial four dimensions of national culture which were considered in the framework are: power distance, individualism/collectivism, masculinity/femininity, and uncertainty avoidance. Then, a fifth dimension of long-term orientation was included following studies which were conducted in Asia (Bu-Qammaz et al., 2006; Fellows and Liu, 2006).

Hofstede has provided representative definition for each term of his framework. Power distance reflects "the degree of inequality of power between a person at a higher level and a person at a lower level, this dimension focuses on the nature of human relationship in terms of hierarchy". Where, individualism measures "the relative importance of individual goals compared with group or collective goals, this dimension focuses on relationship between the individual and the group". Next is masculinity that concerns "the extent to which the goals of men dominate those of women". And uncertainty avoidance focuses on "how cultures adapt to changes and cope with uncertainty. Its emphasis is on the extent to which a culture feels threatened or is anxious about ambiguity". The fifth dimension which is long-term orientation focuses on "the degree to which the society embraces a long term devotion to traditional forward thinking values or not" (Bu-Qammaz et al., 2006).

The other aspect of cultural risk under country criteria is the risks which stems from the social environment of the host country. These factors may include difference in traditions, language barriers, and religious inconsistency (Bu-Qammaz et al., 2006). Bu-Qammaz et al. (2006) have stated that the language(s) of the host country are generally agreed to be the ruling language in case of disputes; therefore the contractor's familiarity of the language(s) used in the host country is an essential advantage for the contractor. On the other hand, when the contractor is unfamiliar with the host country language(s) he may be faced with the risk of misinterpretation of contract clauses or requirements; this may results in conflicts. Ling and Lim (2006) have found that one of the cultural problems faced by foreign contractors in China is that Chinese employees are not proficient in English and foreigners are not proficient in Mandarin. Such type of problems may lead to definite communication troubles when the contractor has to work with the local employees. The other two factors under this category, which are traditions and religious inconsistency, are mainly related to the general behaviors of the host country citizens, both traditions and religious differences have a noteworthy influence on the project and it may be a major source of conflicts if a wide gap exists between the contractor and the host country attitudes (Bu-Qammaz et al., 2006).

Therefore, it is believed that potential cultural conflicts, which are likely to be faced within the project environment, require adequate management practices if project success is intended. The major burden of effective cultural differences management lies on the foreign contractors, since they need to overcome the differences between their employees who came from their home country and the local employees with whom they are required to work in the host country (Ling and Lim, 2006).

Geographical Distance

When conducting business abroad the contractor needs to create subsidiaries or branches of the main office in the host country to control the project under consideration. Therefore, effective transportation facilities between the contractor's home country and the host country is a key requirement to simplify the mobilization process. Moreover, more often than not the contractor tends to utilize a number of his local employees to take charge of the work in the intended market. Further, with certain types of projects some of the required equipments are exported from the contractor's home country to the host country. Geographical distance between contractor's home country and the host country has a crucial influence on all the previous practices. Therefore, consideration of this factor as a potential source of risk was agreed upon by several authors. For instance Dikmen et al. (2007b) have considered this factor as a risk factor which could affect bidding decisions.

Poor Attitude of the Host Country towards Foreign Companies

A consensus among several authors in the area of international construction to regard this factor as a potential source of inter-country risk is found (Hastak and Shaked, 2000; Dikmen and Birgonul, 2004; Ling and Lim, 2006; Dikmen et al., 2007a) When people of the host country carry aggressive attitude towards foreign business practitioners, they will retard the progress of their business activities. On the edge, and depending on the degree of hostility of the community attitude towards foreign contractors, the project may be temporary stopped or even a bonded entirely (Nasir et al., 2003).

Poor International Relations with Turkey

When countries establish strong relations with each others, they tend to reflect these relations by enforcing mutual understandings between their countries within many sectors, such as: political, economical, educational and cultural, free trade, and business practices. As a result many agreements will be born to support such trend. Construction sector in Turkey, similar to many other business sectors, benefits from the international cooperation agreements that take place between Turkey and the aimed country, since the nature of such agreements usually reflects the desire to reinforce the cooperation in several domains. However, with the absence of international relations between the contractor's home country and the host country several obstacles will be encountered by the contractor. Therefore, poor international relations between the host country and the contractor's home country, which is in this case Turkey, was recognized as a source of risk.

3.2.2.3 Construction Risk Cluster

According to Hastak and Shaked (2000) this dimension of risk considers the risk associated with a construction project in a specific international construction market. Moreover, it was revealed in section (3.2.1.3) that Smith and Bohn (1999), and after detailed review of literature, have categorized construction project risk into eight main categories, including: natural, design, logistics, financial, legal and regulatory, political, construction, and environment risks. Moreover, each risk indicator was classified according to risk type. Risk type includes three attributes: controllability, predictability, and source of risk. In the first classification, risk is classified as internal or external. Internal risks are generated within the project and are usually controllable. While external risks are created outside the project and in many cases, are out of the contractor's control. The second classification concerns the degree of risk predictability. Predictable risks have sufficient certainty of their potential occurrence, while unpredictable risks are those risks that occur randomly.

Finally, source of risk may be contractual when risks stems from contract documents or it may be construction if they are expected to be sourced from project execution. For the context of this section risks related to the construction business environment in the host country is considered from contractor's perspective. Therefore, risk sources included under this category are: adverse physical conditions, design, managerial complexities, shortage of client's financial resources, technical and technological, unavailability of subcontractor, and unavailability of resources.

Adverse Physical Conditions

The construction facility is to be constructed on specified site where the contractor needs to mobilize his staff and equipments to undertake the project. In addition, the contractor has to prepare adequate site offices for the owner and his representatives within a reasonable period of time in-order to achieve the notice to proceed. Nasir et al. (2003) have defined several factors under this criterion as they have defined a source of risk named area conditions which has included the construction area (site location) since they have proposed that construction at the downtown inherent more risk of congestion than when the project is to be undertaken in an open site. Another factor is the potential demolition, rehabilitation required in an operating facility, if the project is reconstruction project. Traffic conditions are an essential risk as traffic may affect mobilizing people, material, and equipments to the site. Besides, several factors may be included under this category such as: on-site congestion, traffic permits and approvals, intense security in the construction area, and working hour restrictions. On the other hand, this factor may also include weather obstacles such as extreme hot/cold weather or humidity which will retard the progress in the construction site. In addition the topography of the construction site will have crucial influence on the construction activities.

Design

This factor considers risks that stems from the characteristics of the design. It includes incomplete design, design errors, complex design. Moreover, changes of scope, inadequate specifications, and design changes may be considered under this risk criterion. Although the owner traditionally assumes most of these risks yet the contractor still faces the potential delays or loss due to the design related factors.

Managerial Complexities

One of the unique characteristics of construction projects is the involvements of several diverse parties in the construction activities. Each of which contributes with different task to achieve the desired success, which creates the project team. The team spirit is an essential component for a successful construction project, therefore different parties in the contract including; owner, architect, construction manager, contractor, and even subcontractors, should provide adequate team effort (Chan et al., 2004). However, individual persons within the project team carryout distinguished culture, both on business and social levels. Hence, when a contractor decides to conduct business abroad, hard times during practicing project management should be expected. Organizations usually adopt certain hierarchy/network to distribute responsibilities/authorities of its employees. When project team is constructed from parties with different cultural backgrounds, several problems are anticipated to be encountered. One of the main issues regarding adequate management of a construction project is the presence of efficient communication foundation. Adequate communication reflects the capability of effective interaction with others at all levels within and outside the organization. Well-organized communication allows faster execution of the construction project. Moreover, collaboration between the various parties involved in the project would prevent reworks or idle times as each party including the main contractor, subcontractors, designer, and consultant will understand exactly his task and the optimum time to conduct it.

One more critical issue which may be considered under this risk factor is the accepted level of authority given by the contractor to his project manger, together with the power given to each employee within the project's organization chart. The project manager is an essential stakeholder in a construction project, and his capability is the main driver for project planning, scheduling, and communication (Chan et al., 2004). Skills and characteristics of the project manager, his commitment, competence, experience, and authority are the key drivers for successful project management (Chan et al. 2004). The nature of the organization structure varies with different cultures. As it was discussed under potential cultural difference, cultural distance has noteworthy influence on the progress of the project, since the dimensions considered under this framework have the potential to generate impending conflicts.

Shortage of Client's Financial Resources

In business like the construction industry where the need for new facilities is the main driver for the demand, clients are the force which creates the market for the construction industry (Olatunji, 2006). Since the products of the construction industry are not pre-manufactured, rather they are specifically executed to satisfy individual clients. The source from which the contractor receives the required budget to execute the project is the client to whom the project is being conducted. Therefore, the availability of satisfactory financial resources of the client is critical factor. Seeing that the project progress will be jeopardized and potential delays are expected, which may lead to endless disputes, especially if the client represents the governmental sector where, in most countries, bureaucracy is the essential stigma of governmental practices.

Technical and Technological

This factor combines the risk of potential technical problems due to complex design or insufficient experience, and the risk of utilizing new technology. In the case of the later criterion the contractor is faced with the risk of ambiguity corresponding with lack of experience needed in the installation of new technology. Moreover, it will not be easy to estimate the productivity or potential delays when using new technology without prior knowledge (Smith and Bohn, 1999).

Unavailability of Subcontractors

Subcontracting certain percentage of the construction project to specialized subcontractors is a common practice within the construction industry. Typically the maximum magnitude of the subcontracted activities is agreed upon in the contract where certain percentage is defined. More often than not the contractor is required to name the subcontractors that are expected to perform in the project within his proposal in order to achieve the owner's approval for them. Therefore, scarcity of qualified subcontractors will have destructive consequences on the progress of the project not mention the quality of the work. Particularly for the activities that require specialization such as electrical, mechanical, plumbing, heating, ventilation, air conditioning, steel structures, paintings, and water proofing works or any other activity where the contractor suffer shortage of experience and expertise.

Unavailability of Resources

For the project to be successfully undertaken several resources are needed throughout the execution period. Such resources would include both materials and manpower. Specification, and sometimes enforced with drawings, of the project usually defines specifically the required materials in term of quality, dimensions, colors, erection techniques and in certain incidents the suppliers of the required materials.

If the required materials or suppliers are hard to be located then the contractor will be in a critical situation, where he needs to explain the troubles of locating the materials according to the contract documents to the owner (or his representative) and then provides substitutes materials in a timely manner. Similarly, if the contractor can not find trustable workers in the host country then delays is faced, since all the construction activities are executed by labors who work under the command of specialized engineers, hence the different construction activities can not be completed without workers both skilled and non skilled. Yet, for Turkish contractors this problem may not be severe since most of the contractors prefer to employ Turkish workers (Öz, 2001). Nevertheless, the risk of scarcity of resources in the host country needs adequate apprehension.

3.2.2.4 Project Team Cluster

This cluster considers characteristics of the key stakeholders in an international construction project. That is client, consultant, designer, and joint venture.

Client

Construction clients can be classified according to their knowledge-ability, organizational type and size, and purpose of ownership. In terms of Knowledge some clients are knowledgeable, where others do not have the required amount of knowledge. With respect to the size clients organizations may be small, medium, or large. Besides, some clients do not represent an organization, yet they are individual construction clients. Moreover, clients could be private or public. According to the characteristics of the construction clients' demands in the industry, several types of demand and supply chain systems are created. Therefore, clients’ criteria for evaluating the project together with their views, opinions, decisions and requirements are the most important aspects of project success that the project team should accomplish (Olatunji, 2006).

Thus, under this risk factor client-related factors are considered, they include client characteristics, client type and experience, knowledge of construction project organization, client confidence in the construction team, and client's risk aversion. More specifically, it concerns client's experience, which examine the client whether sophisticated or specialized. In addition, whether the source from which the client is funded is privately or publicly. Also, the client emphasis on low construction cost, high quality of construction, and quick construction should be investigated. Moreover, the capabilities of the client should also be examined, that is, the client's ability to brief, makes decision, and defines roles. Also whether the client involved in the design and construction or not is an important factor (Chan et al., 2004).

Consultant

Consultant is the client representative who in most of the cases acts as a connecting agent between the client and the contractor, particularly if the owner does not have the adequate experience to run the project. In this case the consultant has the role of depicting project state to the owner in order to reach the most appropriate decision. If the consultant carries an aggressive attitude towards the contractor then the consultant will create noteworthy obstacles to the contractor and eventually to the progress of the site activities, since each activity required certain approval procedure which in most of the cases should pass through the consultant. On the other hand, and even when the consultant does not carry any hostility towards the contractor, but he lack of experience and his business practices encompass bureaucracy and errors then the consultant will also create barriers to smooth progress.

Designer

The designer is a key stakeholder in any construction project, and his role is extended from inception to project completion (Chan et al., 2004). Therefore, designer experience and the time that the design team consume to provide the required drawing or to respond to the RFI is vital for the project continuity.

That is because the contractor can not carry on the work without the approved design drawings. Again the attitude of the design team toward the contractor plays an important role on their behavior throughout the project.

Joint Venture/Partner

Joint ventures (JVs) have reserved a considerable position in international contracting as a preferable strategy to reduce business risk (Bing and Tiong, 1999; Mohamed, 2003). JVs is created by legal agreement which takes place between two or more legally separate organizations to form a jointly owned entity in which they involve in investment and several decision making activities (Mohamed, 2003). Moreover, Mohamed (2003) has stated that a JV can be called international when at least one of the parties is from outside the country where the venture is taking place. JV is a common strategy in international construction, it allows combining parties with different strengths and weaknesses where each party complement the other's weakness and benefit from his partner strengths (Mohamed, 2003). However, Bing and Tiong (1999) have revealed that although JVs can avoid some business risk, yet it presents other risks that have the potential to influence business performance. Further, they have suggested some risk factors which included financial, government policies, project relationship, economic conditions, and subcontracting. Therefore, Bing and Tiong (1999) have studied the effective risk management measures of ICJVs through case studies. In their study they have considered several risk factors associated with ICJVs among these factors were factors such financial problems faced by partner's parent company, disagreement on accounting of profits and loss, employees from each partner distrust each other, policy changes in partner's parent company towards international joint venture (IJV), partner's lack of management competence and resourcefulness, disagree on some conditions, disagreement on allocation of staff positions in IJV, and disagreement on allocation of works. To close with, the experience of the joint venture partner and the degree of mutual trust between the partners, together with the existence/absence of previous cooperation between the JV parties have great influence on the success of ICJVs.

3.2.2.5 Contractual Issues Cluster

This risk category accounts for factors that are related to the legal and contractual issues which stem from the contract related policies, regulations, and conditions. The risk factors considered under this category are: low percentage of the advance payment/requirements of advance payment, strict environment regulations, strict safety and health requirements, strict quality requirements, tight schedule/high liquidated damages, and vagueness of contract conditions about risk allocations.

Low Percentage of the Advance Payment/Requirements of Advance Payment

To establish the construction activities the contractor needs a considerable amount of cash at the outset; that is before starting up the project. Moreover, the contractor should provide several facilities on the construction site before he could earn the client's approval to start the construction activities. Therefore, the advance payment, which is the payment provided by the owner to help out the contractor manage his obligations towards the contract, is of critical important to the contractor as it will prevent him from utilizing his own cash. Usually the advance payment represents a percentage from the total amount of the contract. If the percentage is low or there are several prerequisites to receive it then the contractor should rely on his own resources or the risk of delays will be encountered due to the contractor shortage of cash.

Strict Environment Regulations

In the midst of the global trend towards protecting the environment, several countries have issued strict environment protection regulations to be respected when conducting business in a location where potential damage to the environment is expected. Depending on the nature of the construction project and its purpose the influence of such regulation on the construction progress could differ widely.

Strict Safety and Health Requirements

According to Barrie and Paulson (1992) "safety hazards are those that pose imminent danger of causing injury or death to workers or damage to materials, equipment, or structures". Safety hazards are the outcome of both physical dangers and human factors. Human factors would include lack of training, poor supervision, attitudes, poor planning, and sometimes workers who are familiar with the work that they become oblivious to it. On the other hand, and with regards to health hazards in construction, Barrie and Paulson (1992) have included heat, radiation, noise, dust, shocks and vibration, and toxics chemicals. More recently it is being regarded that occupational diseases have been serious problem in construction (Barrie and Paulson, 1992). When conducting business abroad the contractor should investigate the attitude towards safety and health practices in the host country. Mahalingam and Levitt (2005) have found that the differences in the adopted standards by the foreign contractors and the ones adopted within the host country would lead to considerable problems. However, sometimes clients exaggerate in their safety and health requirements which create several problems to the contractor, some of the obstacles would include work suspensions and extra costs.

Strict Quality Requirements

Quality is an important issue in the construction business. For long period of time the key indicators of construction project success have been considered as conducting the project within the expected budget, time, and according to the quality requirements. Poor quality of work may leads to loss of money and time, as the owner has the right to ask for rework when the executed job is not complying with the agreed quality standards. Yet again, similarly to the safety and health case, sometimes clients overstate in their quality requirements which create several problems to the contractor.

On the other hand, Dikmen and Birgonul (2004) have demonstrated that where strict quality requirements exist, the competitiveness of Turkish contractors decreases. This indicates that quality differentiation is not among the major strengths of Turkish contractors in the international markets.

Tight Schedule/High Liquidated Damages

Construction projects are time restricted undertaking; that is each construction project is a temporary activity and should be completed within a predefined time period. When the allowed construction duration is limited, then the contractor will have to undergo several actions during schedule development; in order to be able to complete the project within the required duration. One of the frequently used actions is duration compression which is a special case of mathematical analysis that seeks ways to shorten project schedule without changing project scope (PMBok, 1996). According to project management body of knowledge (PMBok, 1996), the techniques often used in duration compression include:

- **Crashing**: which involves cost and schedule trade-offs analysis to determine the optimum amount of compression that results in the least incremental cost. However, crashing does not always provide viable alternative and usually results in increasing costs.
- **Fast tracking**: This means doing activities in parallel that would normally be done in sequence. Yet, fast tracking often result in rework and usually increases risks.

It is obvious that tight schedule is a critical source of risk that restricts the contractor to act in certain manners if successful project is aimed. However, not all the actions taken lead to timely completion, yet some actions may increase both time and cost consumptions. On the other hand, and to ensure the contractor's commitment towards the project, some owners set high liquidated damages in case the contractor behaviors cause delays beyond the determined completion date. This creates another considerable source of risk.

Vagueness of Contract Conditions about Risk Allocations

Contract conditions represent the legal reference that organizes the relation between the contract parties. Risks associated with construction projects should often be clearly allocated to the responsible party through the contract conditions. When the contact conditions related to risk allocation are vague and are not adequately written then several problems may be encountered, in view of the fact that risk is related to every aspects of the project. If any conflict is faced and the contract conditions does not provide sufficient assistant to resolve the conflict then this may lead to endless disputes. Contract conditions should not be subject to interpretations, yet they should be clearly written and mutually understood by all parties.

Up to this point we have reached the last risk factor that was considered under the legal issues category and also the last but not least factor included in the model. During the identification process great deal of assistance was received from literature related to international construction, therefore, it was believed that it is necessary to reveal the references into which the previous factors were found. Table 3.7 includes all the risk factors considered in the model combining with an inclusive list of their references in literature.

Table 3.7 Consolidated List of Literature References for Risk Factors Associated with International Construction Projects

Risk Factor	References
Bribery	Erb et al. (1996); Mohamed (2003);Hastak & Shaked (2000); Gunhan & Arditi (2005a)
Government Instability	Erb et al. (1996), Hastak & Shaked (2000); Tah & Carr (2000); Mohamed (2003); Nasir et al. (2003); Dikmen & Birgonul (2004); Dikmen and Birgonul (2006); Dikmen et al. (2007a); Dikmen et al. (2007b)
Tension/Conflicts/Terrorism	Erb et al. (1996); Smith & Bohn (1999); Hastak & Shaked (2000); Kartam & Kartam (2001); Mohamed (2003); Dikmen & Birgonul (2006); Dikmen et al. (2007a); Dikmen et al. (2007b)
Bureaucratic Difficulties	Erb et al. (1996); Hastak & Shaked (2000); Kartam & Kartam (2001); Mohamed (2003); Mahalingam & Levitt (2005); Dikmen & Birgonul (2006); Dikmen et al. (2007b)
Immaturity/Unreliability of Legal System	Erb et al. (1996); Hastak & Shaked (2000); Dikmen & Birgonul (2004); Dikmen & Birgonul (2006); Dikmen et al. (2007a); Dikmen et al. (2007b)
Change of Regulations (Government Interventions)	Bing & Tiong (1999); Kartam & Kartam (2001); Kapila & Hendrickson (2001); Mohamed (2003)
Instability of Economical Conditions (Inflation, Currency Fluctuation)	Erb et al. (1996); Hastak & Shaked (2000); Tah & Carr (2000); Kartam & Kartam (2001); Mohamed (2003); Dikmen & Birgonul (2004); Han et al. (2004), Gunhan & Arditi (2005a); Dikmen & Birgonul (2006); Dikmen et al. (2007a); Dikmen et al. (2007b)
Cultural Differences	Hastak & Shaked (2000), Mohamed (2003), Dikmen & Birgonul (2004), Gunhan & Arditi (2005a), Mahalingam & Levitt (2005), Dikmen & Birgonul (2006), Dikmen et al. (2007a), Dikmen et al. (2007b)
Geographical Distance	Dikmen & Birgonul (2004); Dikmen et al. (2007b)
Poor Attitude of the Host Country Towards Foreign Companies	Hastak & Shaked (2000); Dikmen & Birgonul (2004); Dikmen & Birgonul (2006); Dikmen et al. (2007a)
Poor International Relations with Turkey	Dikmen & Birgonul (2006); Dikmen et al. (2007a); Dikmen et al. (2007b)
Adverse Physical Conditions	Hastak & Shaked (2000); Tah & Carr (2000); Kartam & Kartam (2001); Nasir et al. (2003); Dikmen & Birgonul (2006); Dikmen et al. (2007b)

Table 3.7 Consolidated List of Literature References for Risk Factors Associated with International Construction Projects (continued)

Risk Factor	References
Design	Hastak & Shaked (2000), Tah & Carr (2000); Kartam & Kartam (2001); Nasir et al. (2003); Dikmen & Birgonul (2006); Dikmen et al. (2007a); Dikmen et al. (2007b)
Managerial Complexities	Hastak and Shaked (2000); Tah & Carr (2000); Mohamed (2003); Dikmen & Birgonul (2006); Dikmen et al. (2007a)
Shortage of Client's Financial Resources	Erb et al. (1996); Hastak & Shaked (2000); Tah & Carr (2000); Kartam & Kartam (2001); Dikmen & Birgonul (2004); Gunhan & Arditi (2005a); Dikmen & Birgonul (2006); Dikmen et al. (2007a); Dikmen et al. (2007b)
Technical and Technological	Hastak & Shaked (2000); Tah & Carr (2000); Mohamed (2003); Dikmen & Birgonul (2004); Dikmen & Birgonul (2006); Dikmen et al. (2007a); Dikmen et al. (2007b)
Unavailability of Qualified Subcontractors	Hastak & Shaked (2000); Tah & Carr (2000); Mohamed (2003); Nasir et al. (2003); Dikmen & Birgonul (2006); Dikmen et al. (2007a)
Unavailability of Resources	Hastak & Shaked (2000); Tah & Carr (2000); Kartam & Kartam (2001); Mohamed (2003); Nasir et al. (2003); Dikmen & Birgonul (2006); Dikmen et al. (2007a); Dikmen et al. (2007b)
Client	Tah & Carr (2000); Nasir et al. (2003); Dikmen & Birgonul (2004); Dikmen & Birgonul (2006); Dikmen et al. (2007a); Dikmen et al. (2007b)
Consultant	Kartam & Kartam (2001); Dikmen & Birgonul (2006)
Designer	Kartam & Kartam (2001); Dikmen & Birgonul (2006)
Joint Venture/Partner	Kartam & Kartam (2001); Mohamed (2003); Dikmen & Birgonul (2006)
Low % of Advance Payment/Requirements of the Advance Payment	Dikmen & Birgonul (2006)
Strict Environment Regulations	Tah & Carr (2000); Dikmen & Birgonul (2006)
Strict Safety and Health Requirements	Hastak & Shaked (2000); Mahalingam & Levitt (2005); Dikmen & Birgonul (2006)
Strict Quality Requirements	Hastak & Shaked (2000); Dikmen & Birgonul (2004); Mahalingam & Levitt (2005); Dikmen & Birgonul (2006); Dikmen et al. (2007b)
Tight Schedule/High Liquidated Damages	Hastak & Shaked (2000); Tah & Carr (2000); Dikmen & Birgonul (2004); Dikmen & Birgonul (2006); Dikmen et al. (2007b)
Vagueness of Contract Conditions about Risk Allocation	Hastak & Shaked (2000); Tah & Carr (2000); Dikmen & Birgonul (2006); Dikmen et al. (2007a); Dikmen et al. (2007b)

3.3 Development of the Conceptual Model

Generally speaking the key components of any risk management process would include risk identification, assessment/analysis, evaluation, response, and monitoring. In order to adequately perform risk management, it is essential to link identification/assessment steps with their management actions through sufficient understanding (Hillson, 2003). It was mentioned earlier that there are numerous techniques for risk identification; table 2.5 has provided a consolidated list of tools and techniques for risk identification. Moreover, the previous section from this chapter has utilized two of the commonly used tools for locating risk associated with construction projects, which are literature review and experts' opinions via discussion sessions. However, usually identification techniques tend to provide unstructured list of risks which does not help to direct the attention of the risk management actions in the most appropriate direction (Hillson, 2003). Yet, it was pointed out earlier that while identifying risk associated with international construction projects, an effort was given to properly categorize them in a way that would assist in better understanding. That is why risk sources were categorized under 5 main categories which are country, inter-country, construction, project team, and contractual issues; and these criteria were believed to best reflect the nature of the considered risk sources. In spite of that, the identification process has resulted in great deal of unstructured data; the results may be seen as risk taxonomy, which makes it difficult to create a conceptual model for the assessment process. Hillson (2003) revealed that structuring is an essential strategy to ensure formal generation and understanding of the information. Further, Hillson (2003) has sated that "risk data can be organized and structured, to provide a standard presentation of risk which facilitates understanding, communication, and management". The hierarchical representation of risk sources is known as a hierarchal risk breakdown structure (HRBS) (Tah and Carr, 2000; Hillson, 2003). HRBS can be defined as "a source-oriented grouping of risks that organizes and defines the total risk exposure of the project or business. Each descending level represents an increasingly detailed definition of sources of risk" (Hillson, 2003).

The HRBS is a hierarchical structure of expected risk sources; it is very useful tool to adequately understand predicted risks likely to be faced by the project. Thus, HRBS can be used to structure and guide risk management process (Hillson, 2003). Depicting the risk sources into a hierarchical structure can results in many advantages, as visualizing any problem occupies a crucial position in the process of successfully managing it. That is, the spots where additional attention is required will be revealed and the management actions can be prepared more efficiently. Another advantage of developing HRBS is to use it as a basis for a formal model of risk assessment (Tah and Carr, 2000). Several classifications can be adopted to create the HRBS, for instance risks can be separated into those are related to the management of internal resources and those that are externally sourced. Risks which are sourced from the external environment are relatively uncontrollable; these risks include inflation, currency fluctuation, and changes of laws and regulations. The nature of those risks requires continues monitoring to control its effects. On the other hand, internal risks are usually controllable and depend on the project circumstances. Internal risks include availability of resources, contract conditions, and location of the project. Another classification could be global or local risks depending on the effect of the risk. For the purpose of this thesis risk sources were grouped under criteria that describe the nature of risk. Hence, the 5 risk categories described earlier were used to develop the HRBS. The HRBS is depicted in Figure 3.3; the hierarchy was constructed of three levels. The first level of the hierarchy represents the aim of the identification process which is finding the risk sources associated with international construction; that is, the first level has included the international construction project risk (ICPR). The second level includes the main criteria for the classification of risk sources that is the main categories of risks. Finally, the third level includes the identified risk factors which are associated with international construction project. This HRBS is the conceptual model from which the ANP model was built up.

As it was mentioned out earlier, one of the key objectives of this study is to assess risk associated with international construction projects while overcoming the independence hypothesis encountered in most of the available risk assessment models.

Thus, the ANP model was created from the proposed HRBS through increasing the level of relationships and examining the potential significant dependence between the risk categories and risk sources which were included in the model; this has resulted in a network of relationships.

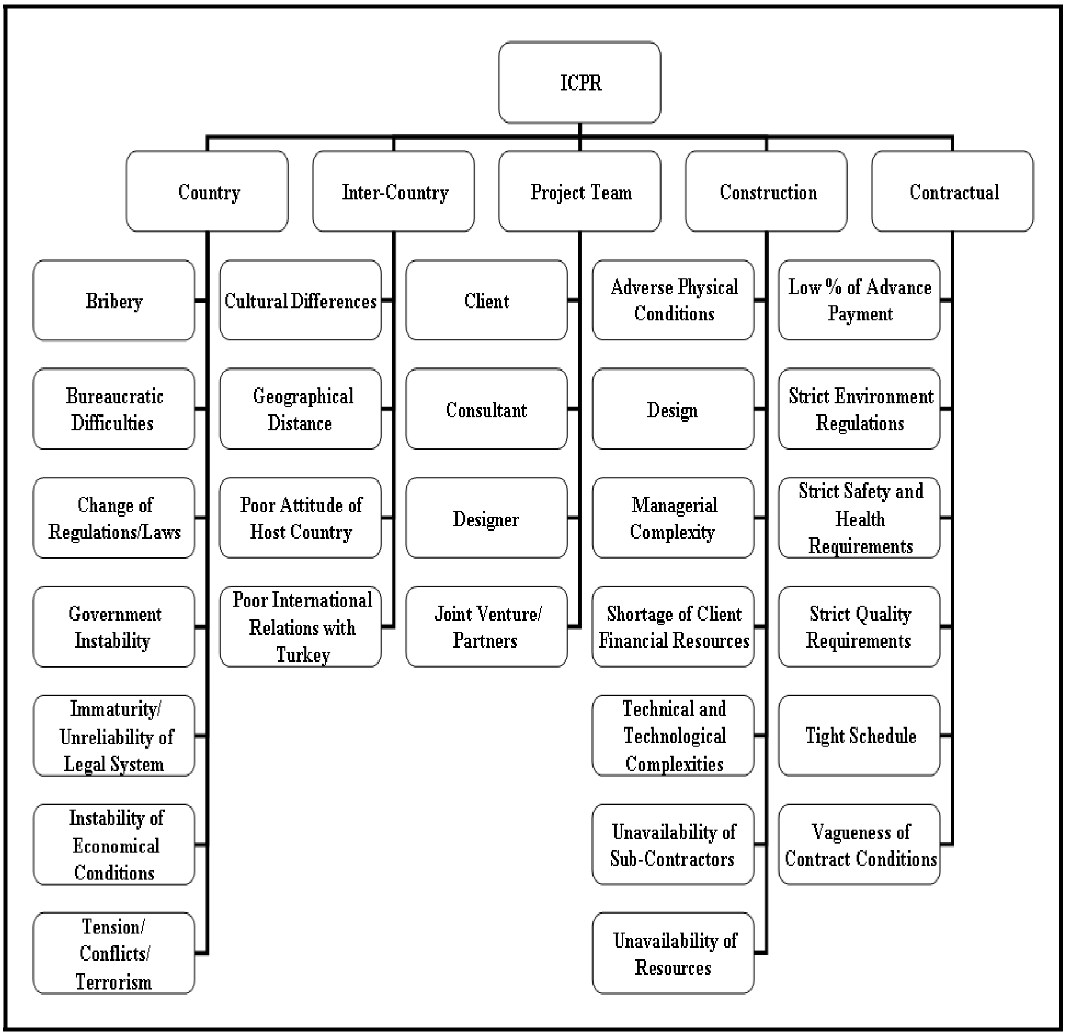


Figure 3.3 Hierarchical Risk Breakdown Structure for International Construction Projects

3.4 The Analytic Network Process Risk Assessment Model

Following the identification step, the assessment/analysis process of risk factors should takes place. The interference between risk factors should be well thought-out during the assessment process and risk propagation from one level of risk to another should not be overlooked. Hence, most of the conventional techniques for risk assessment could not handle the complexity of international construction projects risks, and alternative approaches become required to aid in achieving a reliable risk assessment model. This can be reached through a comprehensive risk assessment methodology where all the possible influences between the risk factors are encountered, and the independence hypothesis is disregarded.

In risk management process two diverse terminologies should be clearly distinguished, namely, assessment and analysis (estimation). The former term means the evaluation of risk factors with respect to importance criteria of decision maker to determine their priorities. In the assessment process the importance weights of the risk factors are delivered and the corresponding performance rating is given to each factor depending on the specific project risk situation. While the analysis (estimation) process concerns the determination of the likelihood of risk events occurrence and the possible consequences in case of their occurrence. That is risk analysis refers to the process of finding the probability of occurrence of risk events jointed with their impact when the risk events take place (Raz and Hillson, 2005). Considering both dimensions in analyzing risk is very essential. Given that, an uncertain event with high probability of occurrence but little or no impact on objectives, if it occurs, is considered to be not significant. In the same way, if a risk event has a low probability it may not worth attention even if it is expected to have significant impact (Hillson and Hulett, 2004). Due to the difficulties associated with finding the probabilities that certain risks might occur, risk assessment provides a very practical alternative since assigning the importance weights to risk indictors is a competent task when compared with finding their probabilities of occurrence.

Hillson and Hulett (2004) have revealed several problems associated with assessing the probability of project risks. In their study they have started with the term itself. Since "Probability" has a specific statistical meaning, that is, "a measure of the relative frequency or likelihood of occurrence of an event, whose values lie between zero (impossibility) and one (certainty), derived from a theoretical distribution or from observations". Yet, its general utilization is not as clear as the previous definition, an example of which is its use within the risk management process. Since, within the context of projects there are several problems with assessing the probability of risk. These problems stem from the characteristics of the projects which have a noteworthy influence over assessment of risk probability. According to Hillson and Hulett (2004) these characteristics include: uniqueness of the projects, non-availability of risk actuals, unknowable risks, and estimating vs. measuring.

Projects are unique

Several definitions were proposed for a project and all of them emphasized on its unique nature, or at least the uniqueness of some of its aspects. A project can be defined as "a temporary endeavor undertaken to create a unique product, service, or result", or "a unique process, consisting of a set of coordinated and controlled activities with start and finish dates, undertaken to achieve objective confirming to specific requirements, including the constraints of time, cost, and resources" (Hillson and Hulett, 2004). Since each project is a unique undertaking, previous experience can not always be exploited to predict the probability of an event to take place. Moreover, the objectives of a certain project are likely to be different from those of previously undertaken projects; hence the effects of risks associated with the new project are expected to be different. Further, the specific circumstances surrounding each project create a different working environment, which means that it is very hard to locate helpful data on the probability of occurrence of certain risk events.

Non-Availability of "Risk-Actuals"

It is accepted as a fact that some of the risk events are generic and expected to join the execution of any project. However, even with this type of risks, previous projects data are often absent. The reason behind the shortage of previous data is the flaw which exists in the project closure process in most of the organizations. Even though it is believed that organizations should benefits from their previous experience in order to improve their performance and learns from their mistakes. Many organizations lack of effective approaches of learning from completed projects to enhance their performance in the forth coming projects. Consequently, it is not common to locate an organization which performs post-projects reviews to identify and documents risk-related lessons to be utilized in future projects. The absence of such "risk-actuals" makes it more difficult to assess the probability of risks for a new project.

Unknowable Risks

In the process of identifying risk; experts cannot assign detailed information about all the recognized risks, as some risks details may be unknowable. Therefore, it is likely to identify a risk yet its probability is not known. This case could be encountered when the occurrence of risk is dependent on events that take place outside the project environment, and sometimes project team lack of the necessary knowledge to understand and evaluate the risk, or when the risk occurrence is related to chance events.

Estimating vs. Measuring

Risk events are expected to take place in the future; that is they are future events that have not yet happened. Consequently, their probability of occurrence cannot be measured yet it can only be estimated. This fact creates the concern that assessing risk events probability will be influenced by a wide range of subjective and unconscious of estimating bias.

3.4.1 Risk Analysis and Risk Assessment Techniques

Literature related to the construction industry is enriched with numerous researches that are relative to risk assessment and analysis. Several techniques and methodologies were proposed by diverse authors to serve this area of knowledge. Decision tree is one of the quantitative techniques used for risk analysis. Decision trees can help project managers to obtain decisions in uncertain situations. A simple example of decision tree is the case of a main contractor who is facing a high penalty for every calendar day late delivery. The contractor has to decide which subcontractor to use for a critical activity while minimizing the expected cost (Hulett and Hillson, 2006). The decision tree for this problem is depicted in Figure 3.4.

If it is hypothetically assumed that the "low-but-risky bidder" quotation is $ 110,000, yet there is a 50% chance that there will be 90 days delay. The other contractor, which is the "high-but-reliable bidder", on the other hand gave a bid of $ 140,000, and it is assumed that there is a 10 % chance of 30 days delay. A decision tree can assist in choosing the best alternative. To use decision tree, first the major decisions (decision nodes) and the major uncertainties (event nodes) should be identified. Then, construct the decision tree starting from the decision and moving to its consequences. Later, estimate the costs and benefits of each alternative decision and calculate the value for each path starting from the first decision and cumulating the values to the final branch. Next, the probability of each uncertain outcome should be estimated to solve the decision tree. Solving the decision tree should start with path values at the far right hand of the tree and then moving left (folding back). Event nodes values are found by calculating the expected monetary value (EMV); that is multiplying the values of uncertain alternatives with their probabilities. The value of a decision node is the highest value of the succeeding branches leading from the node. For this simple example, it is clear that the "high-but-reliable bidder" is the best choice, since its on time reliability overcomes its high initial bid (Hulett and Hillson, 2006).

Decision tree technique is a viable choice when the decision problem is unsophisticated, and the key determinant is the expected cost as it calculates the EMV for each possible outcome of the situation under consideration. However, decision tree technique encompasses several drawbacks. As it can be expected, it can not handle complex situations, since as the number of decisions and their corresponding uncertainties increases the branches of the tree also increase, until it reaches a point that it would be unreliable to solve the decision tree. Besides, finding the probability for each expected outcome is an essential component in the process of solving the tree, which is not an easy task as there are no helpful databases from which this information can be achieved. Therefore, attention should be given while collecting data to avoid poorly informed or bias decisions; hence experts' judgment is required (Hulett and Hillson, 2006).

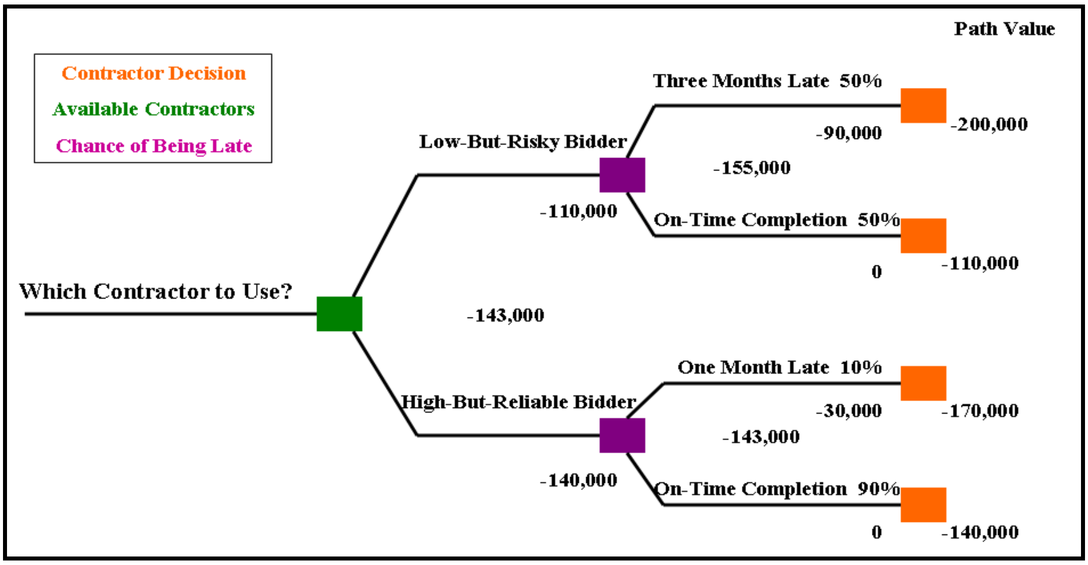


Figure 3.4. Decision Tree for Subcontractor Selection (Hulett and Hillson, 2006)

Another commonly used risk analysis technique is Monte Carlo (MC) simulation. Simulation "is a procedure in which random numbers are generated according to probabilities assumed to be associated with a source of uncertainty" (Chance, 2004). Output from the MC simulation can then be summarized as probability distributions for the outcome of the events (Nasir et al., 2003). MC simulation can be used in estimating both project duration and project cost in the presence of uncertainties. In the case of estimating construction project duration, MC simulation uses probability distributions, mainly beta distributions, to represents activity duration. Where beta distributions can be described with three values: most likely, pessimistic, and optimistic value (Nasir et. al, 2003). One completed project run is derived by using random numbers to extract one duration estimate from each activity duration distribution. Then the critical path calculations are performed for that run to find project duration. In the same manner several runs are performed, and then the project duration from each completed run is combined to construct probability distribution function for the project outcome. When using MC simulation to estimate project duration, there is no independence assumption between activities. Moreover, MC simulation provides the possibility to calculate criticality index (CI), which shows the frequency with which an activity lies on the critical path. In addition, cost and duration can be determined for each run of the simulation process. Similarly, MC simulation can be used for cost estimation. Initially, cost items should be listed. Then, risk factors associated with each cost item should be identified. After that, the type of probability distribution functions for cost items should be determined. Finally, one completed cost estimate run is derived by using random numbers to extract one cost estimate from each cost item distribution. In the same manner several runs are performed, and then the project cost from each completed run is combined; which will results in the probability distribution function of construction project cost. However, whether using MC simulation to estimate project duration or project cost, defining the probability distribution for each activity represents a considerable source of problems (Nasir et. al, 2003).

Construction projects involves several complicated multi-criteria decision making (MCDM). In MCDM the optimal alternative is to be determined among multiple, conflicting, and interactive criteria. In literature, there are many proposed methodologies, which are based on multiple attribute utility theory (MAUT). For instance, methodologies such as weighted sum and the weighted product methods were proposed to resolve the MCDM problems. The major concept behind MAUT is to aggregate all criteria into the same dimension which is known as utility function, in order to be able to evaluate alternatives (Yu and Tzeng, 2006).

Bidding for a new construction project is a decision that involves in numerous criteria. Dozzi et al. (1996) have developed a bidding model which applies utility theory to several bidding criteria to obtain a bid markup for a construction project. In their model, an expected utility value is derived for a newly tendered project and is compared to a markup utility function to obtain a bid markup. Moreover, the model allows the contractor to customize each utility function to meet the contractor's own requirements and preferences.

Within the framework of risk analysis, simple multi attributes rating technique (SMART) is a MCDM method which has been used as a risk rating tool. It is capable of handling the situation when several project objectives are considered to choose among couple of alternatives. Besides, it can be used when the probability of occurrence of risk events and their impact can not be determined analytically. That is, it is a risk assessment technique, where importance weight and an estimated risk rating for each risk factor are assigned. When using SMART, an absolute measurement method is used by defining a physical scale, and then using this scale for assigning values for risk factors. Accordingly, the assigned value to each risk factor is unconditional and independent from the other factors (Dikmen and Birgonul, 2006). On the contrary, the analytic hierarchy process (AHP) is also a MCDM method, which is a "decision hierarchy, containing a goal or mission statement, objectives or criteria, and alternatives of choice and is evaluated by deriving ratio scale priorities from pairwise judgments" (Saaty and Niemira, 2006).

Thus, in the AHP the problem is structured as a hierarchy, and then a process of prioritization is required. Prioritization entails seeking judgments in the form of experts' response to questions about the dominance of one element of the hierarchy over another when compared with respect to a specific criterion. A judgment is developed through numerical comparisons between two elements of the model with respect to a common criterion. In the AHP a nine-point evaluation scale for relative pairwise comparison is used. The judgments can be represented in a square matrix in which the set of elements is compared with itself. Where, each judgment reflects the dominance of an element in the criterion list relative to another element in the same list. The pairwise comparisons which are carried out will result in conditional importance weights. Hence, the derived value for each risk factor is dependent on what other factors values it is being compared with. That is, with different comparison, a risk factor can obtain different importance weight (Saaty and Niemira, 2006; Dikmen and Birgonul, 2006). By using the AHP, it is not required to define a subjective scale and utility curves that reflect preferences of decision maker (Dikmen and Birgonul, 2006). However, ratio scales, proportionality, and normalized ratio scales are central requirements for comparison needed to determine and synthesize priorities, either in the AHP or any other MCDM method (Saaty and Niemira, 2006).

Hastak and Shaked (2000) have developed an international construction risk assessment model; which is ICRAM-1; it is based on the AHP. Following the identification process, pairwise comparisons according to the AHP matrix format were conducted to calculate importance weights of risk, then risk rating (assessment) was identified for each project by taking into account the impact of country and market level risks on the project, finally, the overall risk rating is quantified by multiplying importance weights with the rating to derive the individual weighted assessment and then adding them up (Dikmen and Birgonul, 2006).

A major strength of the model is the consideration of the impact of both country and market level on the project level risk. However, the process of developing the model encompasses several assumptions that have weakened the advantage of recognition of interrelations between the different risk levels.

For example, although the authors have claimed that the model represents an integrated approach which takes into account the individual risk at country, market, and project levels, together with the influence of risk from one level to another, the model disregarded the relation between criteria, sub-criteria, and risk indicators which are at the same level of the hierarchy. This is revealed in the first assumption which stated that: "the criteria, sub-criteria, and indicators are related to each other according to the hierarchy but are independent of each other within their own level of the hierarchy". Assuming that, the impacted indicators by an upper level (the macro and/or market level) are not impacted by specific indicators in the upper level but by the overall risk environment of that level, represents another critical assumption. This is true for the reason that, not all the risk indicators included in country and/or market levels will essentially have an influence on a risk indicator incorporated in market or project level.

Another worth mentioning application of AHP is the model developed by Dikmen and Birgonul (2006); who have proposed an AHP based model for risk and opportunity assessment of international construction projects. The risk and opportunity rating procedure used in the model uses the general concept of AHP; that is, it uses relative measurement not absolute measurement, yet, there are several dissimilarities from the basic AHP method. In this model the magnitude of risk is determined by multiplying the relative impact of problems expected to take place due to a given risk source; with the relative probability of occurrence of these problems, finally, the overall risk level of a project is found by summing up the individual risk magnitudes. Accordingly, the model provides risk analysis rather than assessment, that is, it replaces the importance weights and performance ratings used in the AHP, with the impact and probability values.

The major advantage of this model is the integral consideration of risk and opportunities while ranking project alternatives, the model undertakes a risk and opportunity assessment process to assist in developing reliable bib/no-bid decisions.

Hence, the main contribution of this model, in the area of risk assessment, is that its represents a new methodology that incorporates opportunity into risk assessment process. However, there are a number of limitations associated with this methodology. The model has regarded both risk and opportunities together while rating the available alternatives for the bidding decision, yet it did not consider the issue of competitiveness, where the level of competitiveness of a company is one of the major determinants of the bidding decision, since it reflects the probability to win the project. Therefore, the model outputs should be further evaluated to select the adequate project. Moreover, although the model can be used to compare as many as available alternatives, yet as the number of compared projects increases the size of the AHP comparison matrices will increase, hence extra effort is required for calculation even with the essentially required computer support. Moreover, the proposed methodology calculates relative ratings rather than absolute ratings. Consequently, the results do not provide any information about the actual risk ratings of the projects; therefore, the methodology can not be used during the risk mark-up process since actual risk and opportunity rating of projects can not be quantified. Another shortcoming is that the model can not be used to determine attractiveness of a single project since it is based on comparison between alternatives.

Gunhan and Arditi (2005a) have also utilized the AHP to facilitate expansion decision for construction companies into the international construction market. In their study they have originated a new approach which has combined both AHP and Delphi method. The Delphi method is "an exercise in group communication among a panel of geographically dispersed experts". It comprises a series of questionnaires sent to a pre-selected group of experts; the questionnaires should be designed to capture individual responses to the considered problem and to enable the experts to refine their judgments as the group's work progresses.

The main advantage of the Delphi method is that it allows overcoming the disadvantages of conventional communication action, since while conducting group meeting it is expected to face the issues of, "follow the leader, tendencies and reluctance to abandon previously stated opinions" (Arditi, 2007).

Gunhan and Arditi (2005a) have used the Delphi process to collect information about the AHP pairwise comparisons. Thus, experts were asked to conduct relative comparisons between pairs of factors using the AHP 1 to 9 scale, where 1 reflects equal importance while 9 means that one of the factors is extremely important than the other. Convergence between two Delphi rounds was monitored to check whether consensus between experts was reached or not. It was revealed through their study that the reason behind using Delphi method was to ensure that the lowest possible consistency ratio was obtained, since consistency is a critical issue in the AHP in view of the fact that it reflects the quality of judgments, thus it is important that consistency ratios in the AHP modeling are below 10%.

The main problem with the previous discussed MCDM techniques is the assumption of preferential independence, thus dependence and feedback effects cannot be considered. Yet, it is believed that in the real-life situation the dependence and feedback effects are measured at the same time while making decisions (Yu and Tzeng, 2006).

As for this thesis, the analytic network process (ANP) is utilized to develop the risk assessment model. The ANP, the general form of the AHP, was proposed in to overcome the problem of dependence and feedback among criteria or alternatives. Since it has been released, the ANP has been adopted to facilitate several MCDM problems such as project selection, product planning, strategic decision, and optimal scheduling. Another major advantage of the ANP beside its ability to account for dependence and feedback is its applicability for both quantitative and qualitative data types (Yu and Tzeng, 2006).

Moreover, this thesis concerns risk assessment, and the identification process resulted in a structured risk sources rather than risk events. That is, the aim is to obtain the importance weights (priorities) of risk factors according to experts' evaluation. Then each risk factor will be rated according to the international construction project specific risk circumstances.

Prioritizing the risk factors and then assigning a case specific performance rating for each risk factor assists in developing adequate risk management actions. As for the developed model through this thesis, it is aimed to be utilized in the initial stages of an international construction project. That is, by providing an integral risk rating of a given project, the model helps in achieving reliable bid/no bid or bid markup decisions. Through the process of developing the international construction risk model (ICRM) several assumptions were accepted to facilitate the development procedure and adoption of the ANP technique, some of these assumptions were revealed earlier, yet it is believed to be more adequate to combine all of the assumptions in one spot, therefore, the assumptions are declared under:

- The risk criteria and risk factors (sources) are related to each other in a network format.
- The risk is evaluated from Turkish contractors' perspective, the contractors are assumed to be performing their construction activities in a foreign country.
- It is assumed that a Turkish contractor will be forming a joint venture with a local contractor in the host country.
- Normal construction conditions were assumed, that is sufficient amount of data will be available from the beginning, and the contractor will have enough capabilities (i.e. experience in similar projects, and experience in the country/similar countries) to conduct the project.
- During the assessment process the project delivery system and the contract type were disregarded.

3.4.2 The Analytic Network Process

The ANP is "a multicriteria theory of measurement used to derive relative priority scales of absolute numbers from individual judgments that also belong to fundamental scale of absolute numbers" (Saaty, 2005). The judgments reflect the relative influence, of one of two elements over the other in a pairwise comparison process on a third element in the system, with respect to underlying control criterion (Saaty, 2005).

In the ANP, pairwise comparisons of the elements in each level are conducted with respect to their relative importance towards their control criterion. Once the pairwise comparisons are completed for the whole network, the vectors corresponding to the maximum eigenvalues of the constructed matrices are computed and a priority vector is obtained. The priority value of the concerned element is found by normalizing this vector (Bu-Qammaz et al., 2006). The outcome of the comparison process is used in the development of the supermatrix, where forming the supermatrix involves the arrangement of matrices of column priorities.

The ANP provides a general framework to deal with decisions; its key difference from the AHP is that, it does not make any prior assumptions about the independence of higher level elements from lower level elements and about the independence of the elements within a level as in the AHP, this is revealed in its usage of a network without specifying levels to be an essential requirement (Saaty, 2005). On the other hand, while the ANP is recalled as a general form of the AHP, its major similarity to the AHP lies in their basic concept, since both methodologies regard the concept of relative importance of influence as a central concept. Indeed, in the ANP, judgments are provided from the fundamental scale of the AHP through answering two kinds of questions to demonstrate the strength of dominance: given a criterion, which of two elements has greater influence on that criterion? , or given a criterion, which of two elements is influenced more by the given criterion? (Saaty, 2003). The fundamental scale of absolute numbers used in both the AHP and the ANP is shown in Table 3.8.

An essential issue in the comparison process is the consistency in making judgments, that is, in each set of comparison matrices the same criterion should be used to make all the comparisons, where this criterion is called the control criterion. Saaty (2005) has emphasized on the importance of a control criterion while making judgment, as it is an important way to focus thinking while answering the question of dominance. Thus, the ANP initially involves in decomposing a complex problem with a variety of influences and then pulling it back together by using the weights of these influences.

Saaty (2005) has also acknowledged the concept of influence to be essential in decision making, since influence is a force that creates changes, order, or chaos. That is why when we are in the process of decision making, it is essential to examine all the potential influences and not simply the influences from top to bottom or bottom to top as in the case of hierarchy.

Table 3.8 The Fundamental Scale for Making Judgments (Saaty, 2005)

Intensity of Importance	Definition	Explanation
1	Equal Importance	Two activities contribute equally to the objective
2	Weak or Slight	
3	Moderate Importance	Experience and judgment slightly favor one activity over another
4	Moderate Plus	
5	Strong Importance	Experience and judgment strongly favor one activity over another
6	Strong Plus	
7	Very Strong or Demonstrated Importance	An activity is favored very strongly over another; its dominance demonstrated in practice
8	Very, very strong	
9	Extreme Importance	The evidence favoring one activity over another is of the highest possible order of affirmation

Most of the decisions are analyzed with respects to what is important to a person or a group and what is seen as preferred in making a choice. However, Saaty (2005) argues that when we allow feedback, then what is expected to turn out as a consequence of all the influences is what we really want to know. In this case the resulting priorities enable one to take the necessary actions while choosing the best available alternative. Moreover, through sensitivity analysis one would insure that not only the most preferred outcome will results but also that it remain stable in the face of influences that may take place after it is implemented.

To clearly understand the ANP, the difference between a hierarchy and a network will be demonstrated, Figure 3.5 illustrates the difference. A hierarchy has a goal or source cluster. And in case of including the available alternatives in the model it will have a sink node or cluster that represents the alternatives of the decision. Moreover, a hierarchy is a linear top down structure with no feedback from lower to higher levels. Yet again, when alternatives are included, it does have a loop at the bottom level showing that each alternative in that level depends on itself; hence, the elements are considered to be independent from each other. On the contrary, a network allows influence to be transmitted from a cluster to another (outer-dependence) and back either directly from the second cluster or by transiting through intermediate clusters through a path; the path depends on the nature of the problem and the level of dependence within the network. Moreover, a system may be generated from a hierarchy by increasing its connections gradually, to create the network by connecting components as desired and some components have inner dependence loop.

In a network, each priority vector is derived and included in it corresponding position as a column vector in a supermatrix of impacts with respect to the control criterion. In the ANP and like the AHP, criteria must be weighted. However, the weights cannot be reliable by simply assigning numbers to the criteria, yet, the criteria need to be compared with respect to an objective (or multiple objectives).

Saaty (2005) has declared that comparisons not only have mathematical necessity, yet they are our heritage from our biology. He has further explained that, "comparisons require judgments. Judgments are associated with feelings, feelings with intensities, intensities with numbers, numbers with a fundamental scale, and a set of judgments reflected by a fundamental scale to priorities". It was pointed out earlier that the fundamental scale that represents dominance of one element in the network over the other is an absolute scale and the derived priorities are normalized to yield an absolute scale.

However, in the assessment process, a problem may occur regarding the consistency of the pairwise comparisons. The consistency ratio (CR) provides a numerical assessment of how inconsistent these evaluations might be (Bu-Qammaz et al., 2006). Several authors have suggested the required algorithms to calculate CR (Cheng and Li, 2005). As for the ANP model proposed in this thesis, it is assumed that if the calculated consistency ratio is less than 0.10, consistency is considered to be satisfactory (Saaty, 2003).

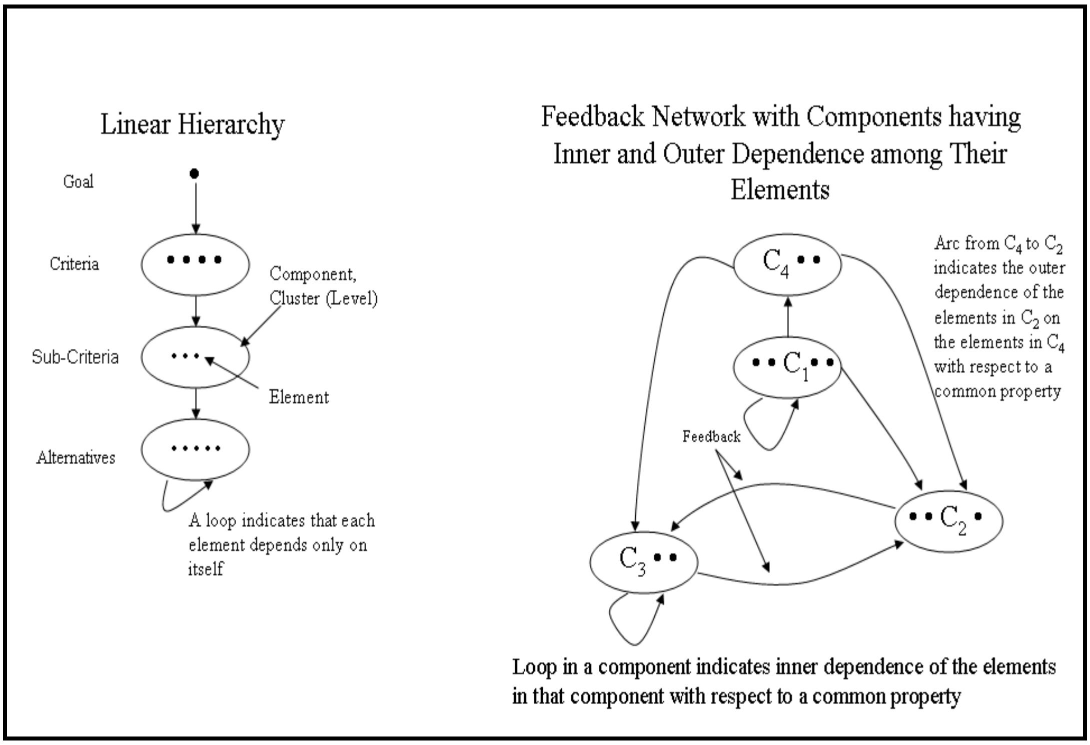


Figure 3.5. How a Hierarchy Compares to a Network (Saaty, 2005)

3.4.2.1 The Supermatrix of the Analytic Network Process

Saaty (2005) has explained the supermatrix of a feedback system, to do so, he has assumed a system of *N* clusters or components, where the elements in each cluster interact, have an impact on, or are themselves influenced by some or all of the elements of that cluster or of another cluster with respect to a criterion which govern the interactions of the entire system. Then he suggested assuming that a cluster named *h*, denoted by C_h, h = 1, ..., N, has n_h elements, which are denoted by e_{h1}, e_{h2} ,…, e_{hnk} .

Through paired comparisons a priority vector is derived, which represents the impact of a given set of elements in a component on another element in the system. Saaty (2005) has explained the situation when an element has no influence on another element, by stating that its influence priority in this case is not derived, yet it is assigned as zero. The pairwise comparison matrices will result in the priority vectors, which are each entered as part of some column of a supermatrix. Saaty (2005) has further explained that, the supermatrix represents the influence priority of an element on the left of the matrix on an element at the top of the matrix. A supermatrix combined with an example of one of its general entry *i, j* block are depicted in Figure 3.6, and 3.7 respectively. The first figure shows the cluster C_i at the side of the supermatrix which includes all the priority vectors derived for nodes that are "parent" nodes in the C_i cluster.

3.4.2.2 Stochasticity of the Supermatrix

Saaty (2005) has made it known that interaction in the ANP supermatrix may be measured with reference to several different criteria. As a general framework, he explained that in order to display and relate the criteria, ones need to create a separate control hierarchy that includes the criteria and their priorities.

Hence, for each criterion the components are compared according to their relative impact/absence of impact on each other component at the top of the supermatrix, this will yield to develop priorities to weight the block matrices of eigenvector columns under that component in the supermatrix.

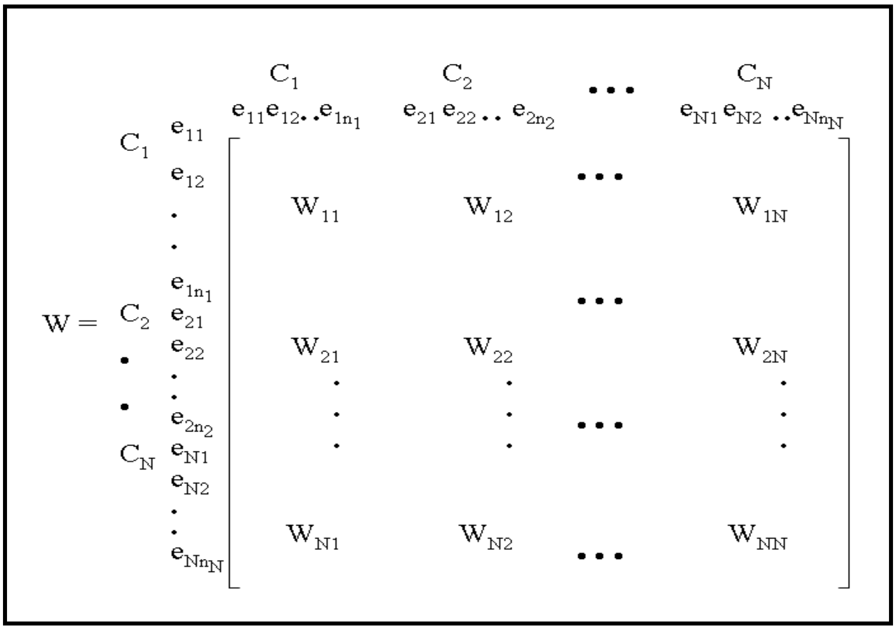


Figure 3.6. The Supermatrix of a Network (Saaty, 2005)

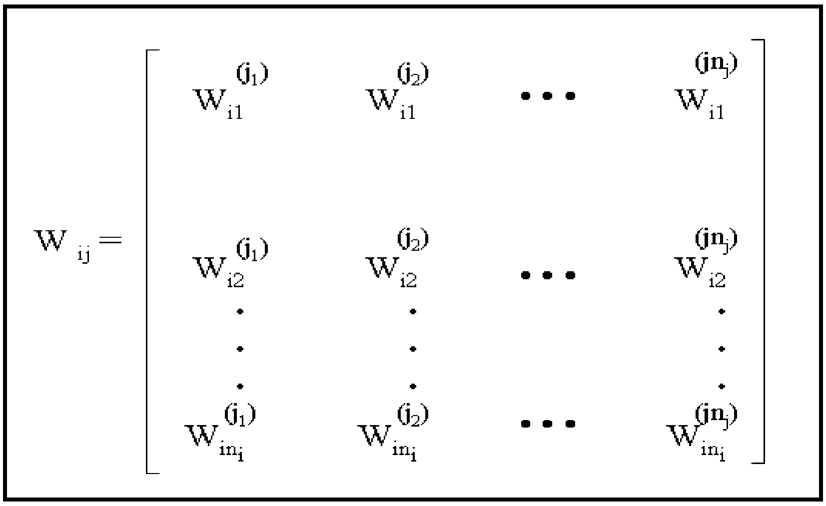


Figure 3.7. Detail of a Matrix in the Supermatrix of a Network (Saaty, 2005)

The resultant of weighing the components of the unweighted supermatrix is a stochastic matrix which is named as the weighted supermatrix. Saaty (2005) has emphasized that the supermatrix needs to be stochastic to obtain significant limiting priorities.

Moreover, initially the supermatrix should be reduced to a matrix before taking the limit, where each of its column sums to unity, which will result in a matrix that is called a column stochastic matrix. Normally, a supermatrix is not stochastic. The reason is that, its column are made up of several eigenvectors whose entries in normalized form sum to one, and therefore, each column in the supermatrix sums to the number of its nonzero eigenvectors. That is why we need to compare its clusters to convert it to a stochastic matrix. The clusters are compared according to their impact on each other with respect to the general control criterion we have been considering, and thus, in case of several control criteria we need to repeat it several times for a decision problem once for each control criterion. For each control criterion, several comparison matrices are needed. That is, each matrix is used to compare the influence of all the clusters on a given cluster to which they are connected. This will results in an eigenvector of influence of all the clusters on each cluster. A vector will have zero components when there is no influence. The priority of a component of such an eigenvectors used to weight all the elements in the block of the supermatrix that corresponds to the elements of both influencing and the influenced cluster. The outcome is a stochastic supermatrix.

3.4.2.3 The Control Hierarchy

Although for the context of this thesis it will be shown that the use will be only to a single general control criterion, a single decision network, and supermatrix, it is essential to explain the idea of a hierarchy of control criteria, as it will assist in explaining some relative aspects of the developed ANP model.

Saaty (2005) has defined the control hierarchy as "a hierarchy with criteria, called control criteria that serve as a basis for making pairwise comparisons about influence". Where the influence could be: economic influence, social influence, environmental influence… etc. For each of the control criteria, the priorities from a limit supermatrix should be obtained and then the several sets of priorities are combined by weighting them by the priorities of the control criteria to obtain an overall outcome.

In general, Saaty (2005) has explained that analysis of priorities in a system can be thought of in terms of a control hierarchy with dependence among its bottom-level subsystem arranged as a network. Where dependence can take place between the clusters and within them. In some intense dependence cases a control network can replace a control hierarchy at the top with dependence among its clusters.

A component or cluster in the ANP is "a collection of elements whose function derives from the synergy of their interaction and hence has a higher-order function not found in any single element" (Saaty, 2005). Saaty (2005) has further explained that the clusters of a system should be synergistically from the elements they combine, or they would represent a mechanical collection with no inherent meaning.

Another essential concept is the fact that the criteria in the control hierarchy that are used to compare the clusters are usually the major parent criteria whose sub-criteria are used to compare the elements in the component. Since the criteria used to compare the clusters need to be more general than those which are used to compare the elements, this is referred to the previous mentioned functional complexity of the clusters. Although, and for practicality, comparisons of both clusters and elements are conducted in terms of the same control criteria in the control hierarchy.

The concept of a control hierarchy is critical for the ANP analysis, as it provides dominant criteria for comparing each type of interaction that is intended by the network representation. Saaty (2005) has defined two different types of control criteria (sub-criteria).

The first type is when a control criterion is directly connected to the structure as the goal of a hierarchy if the structure is a hierarchy. In this case the control criterion is called a comparison-"linking" criterion. Alternatively, a control criterion does not connect directly to the structure but "induces" comparisons in a network. In that case the control criterion is called a comparison-"inducing" criterion. As for this thesis the first type of control criterion is used, since we have utilized the HRBS developed in the risk identification step to develop the ANP model, and then we have increased the interrelations between the risk factors to develop the network structure. The general control criterion in the model was recognized to be the level of the ICPR.

To sum up, a control hierarchy is a hierarchy of criteria and sub-criteria that assist in thinking about the spread of influence. In the general form of ANP, priorities are derived for the control criteria with benefits, opportunities, costs, or risks are taken in mind. In some cases, it would be easier to use the criteria to compare the clusters of a system, and the sub-criteria to compare the elements in the clusters. The generic question for comparison is: given an element in any cluster, how much more does a given element of a pair influence that element with respect to a control sub-criterion (criterion)? And the same type of question is asked to compare clusters. The weights of the clusters are used to weight the blocks of the supermatrix corresponding to the cluster being influenced.

Saaty (2005) has mentioned that within each block of the supermatrix, a column is either a normalized eigenvector which may include some zero entries, or all of its elements are equal to zero. Either way, it is weighted by the priority of the corresponding cluster on the left. If it is zero, that column of the supermatrix must be normalized after being weighted by the cluster's weights.

Owning to the complex nature of the ANP models, due to the existence of several comparison matrices to deal with, and to avoid potential human errors due to manual works, the proposed model ICRM was developed with the appreciated assistance of the *SUPERDECISIONS,* the ANP software. The next section shall illustrate comprehensively the process of developing the model and achieving the outcomes.

3.4.3 Development of the Analytic Network Process Model with the *SUPERDECISIONS* Software

The ANP is implemented in the software *SUPERDECISIONS*. It was demonstrated that the ANP is a compound of two essential parts. The first consists of a control hierarchy or network of criteria and sub-criteria that control the interactions in the considered system. The second component of the ANP is a network of influences among the elements and clusters. The network is dependent on the criterion, as for each criterion the network of influence is different, and a supermatrix of limiting influence is computed for each control criterion. Then, each of these supermatrices is weighted by the priority of its control criterion and the results are synthesized through addition of all the control criteria (Saaty, 2003).

3.4.3.1 Demonstration of Building the International Construction Projects Risk Assessment Model

The first step in building the ANP model is to decide on the logical groupings of the nodes and clusters that structure the problem. For ICRM, the HRBS depicted in Figure 3.3, was used as the basis for the ANP model, thus, the general control criterion according to which the clusters are compared is ICPR. The clusters that build the model are the following risk categories: project team, construction, country, inter-country, and contractual issues. Further, the nodes that build the clusters are the risk factors that were included within each risk category. Figure 3.8 shows a snapshot of the ANP Model which was developed with the *SUPERDECISIONS* software.

The purpose of ICRM is to estimate the priorities of risk factors associated with international construction projects. The model consists of a single network which has all clusters and their nodes in one window. Thus, there are no sub-networks. Therefore, all the comparison questions are asked from the perspective of what is more important with respect to international construction projects risk.

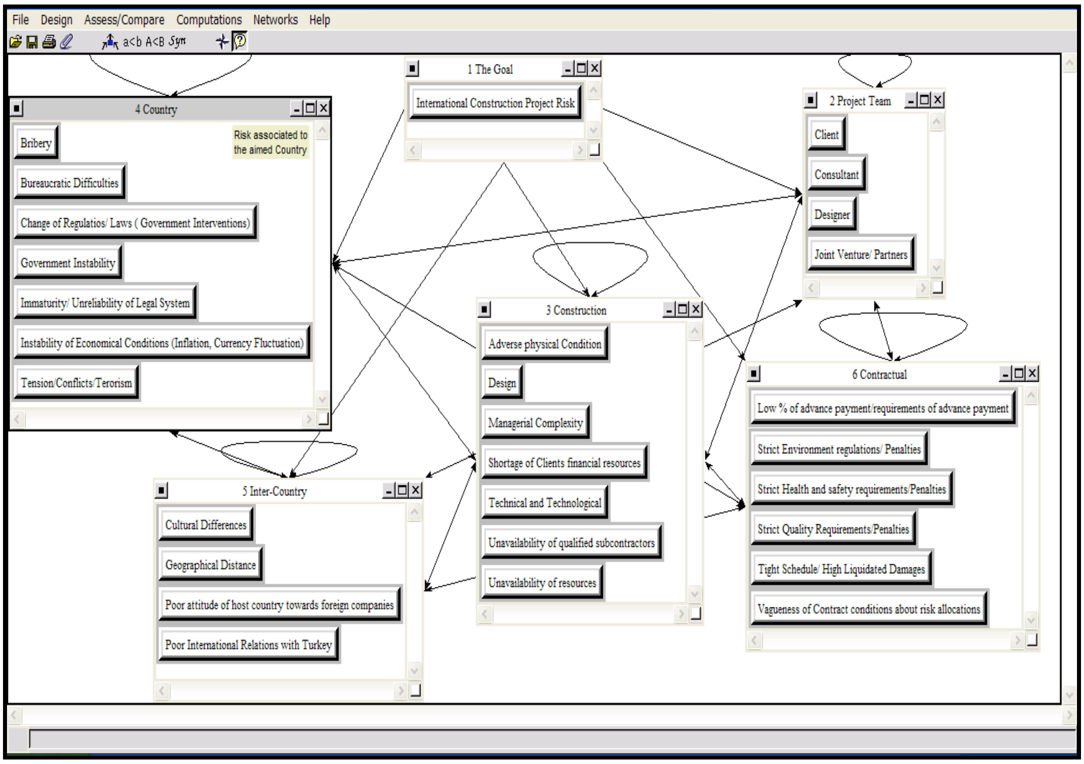


Figure 3.8. Snapshot of the ANP Model for Risk Assessment of International Construction Projects

In Figure 3.8 the loops indicate inner dependence among the elements in the cluster. Pairwise comparisons for the nodes in each cluster that belong to a parent node should be conducted for all the parent nodes in the model. The comparison can be carried out by selecting the Assess/Compare command, then selecting cluster and the node to serve as the parent node.

To start comparisons with respect to a selected node, first the Node Comparisons command from the drop-down menu should be selected, then the cluster which has the nodes desired to be compared with respect to the selected parent node is selected. This process will introduce the comparisons screen in the questionnaire mode which is shown in Figure 3.9.

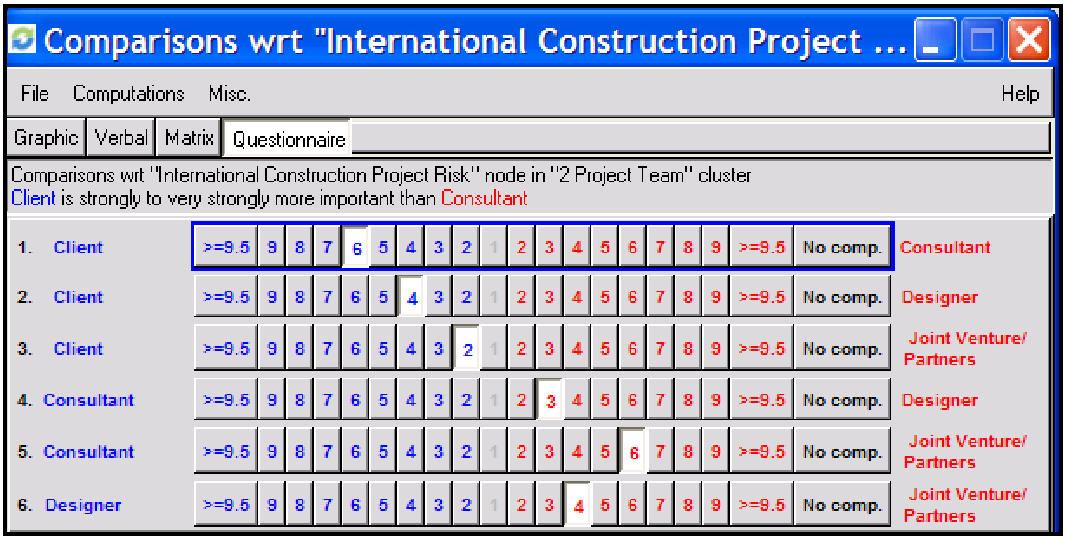


Figure 3.9. The Questionnaire Mode for Comparisons

The user of the *SUPERDECISIONS* software can select from several ways to do comparisons, the available ways are: graphic, verbal, matrix, and questionnaire. To switch to the matrix mode from the questionnaire mode one should click on the matrix tab in the comparison window. The matrix mode for the previous comparison questionnaire is shown in Figure 3.10.

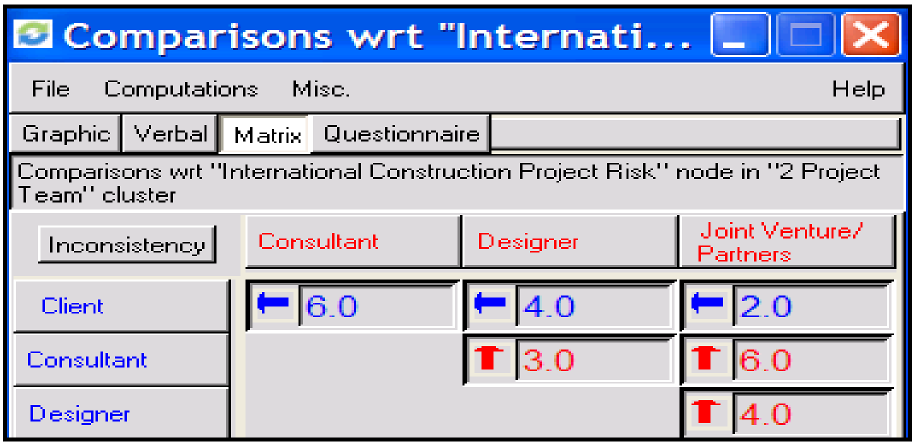


Figure 3.10. The Matrix Mode for Comparisons

A judgment should be entered in each cell. A cell contains the comparison for the pair listed at the top and at the side. The arrows in the matrix mode point toward the preferred node of the pair. Hence, the top node is preferred when the arrow is red and directed to the top, while the side node is preferred when the arrow is blue and directed to the left. After each comparison matrix is filled, local priorities associated with the assigned judgments can be calculated, to compute these local priorities, one should select the Computations, Show New Priorities command. Thus, the priorities of the nodes in the project team cluster with respect to ICPR node will have the form as shown Figure 3.11. Consistency for each comparison matrix is directly listed with in the local priorities screen, the software also assists in improving the consistency.

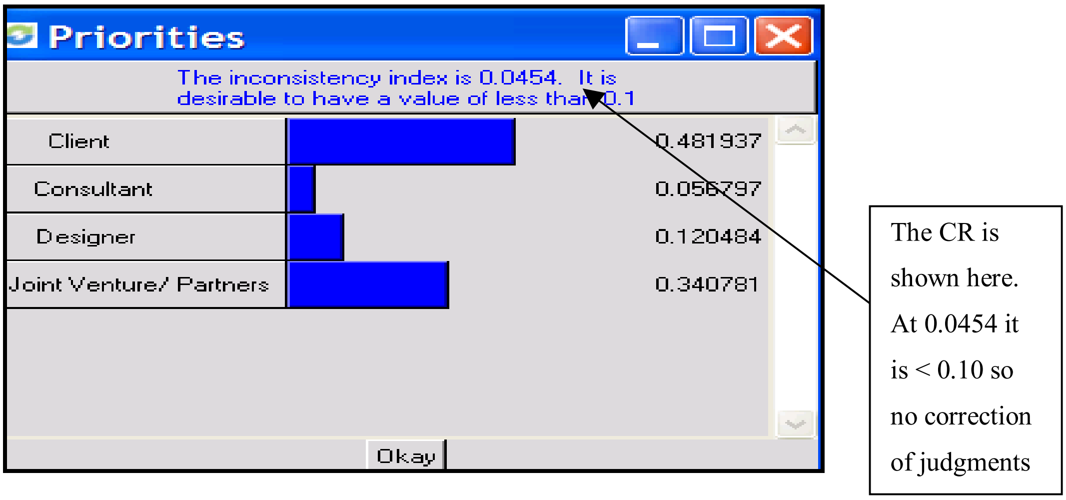


Figure 3.11. The Local Priorities for Nodes in "Project Team" Compared with Respect to ICPR

While filling in the comparison matrices experts' judgments were called for, thus discussion sessions were held with three Turkish experts in the area of international construction. The comparison matrices resulted from constructing the ICRM were prepared in table forms and grouped into several sets according to the governing parent nodes. A questionnaire was set from the prepared matrices and a brief description of the problem was given at the outset to focus attention on the desired objective of the research.

The experts were also asked to check the proposed relationships between the elements by giving their comments on the prepared questionnaire; the model was intended to be modified accordingly. Then, several discussion sessions were conducted together with the three Turkish experts in the area of international construction. The average total experience of the experts was 10 years in international construction. Due to the great amount of concentration and focused discussion required, it was agreed on to limit each session to a maximum of two hours to maintain efficiency and avoid inconsistency. A total of 4 discussion sessions were conducted. The total number of matrices which were filled by the experts was 127 matrices for node comparisons and 6 for cluster comparisons. This is after several modifications which have took place to the model as a result of the experts' suggestions. All the comparison matrices were consistence with CR less than 0.1.

3.4.3.1.1 The Supermatrix

While using the software there are various computations involved with the supermatrix. To show the different supermatrices, the Computations command should be selected. There are three supermatrices associated with each network: the unweighted supermatrix, the weighted supermatrix, and the limit supermatrix. The unweighted supermatrix contains the local priorities derived from the pairwise comparisons throughout the network. Hence, the results of all the pairwise comparison are entered in the unweighted supermatrix. Figure 3.12 shows part of the unweighted supermatrix of the ICRM. Saaty (2003) has defined a component in a supermatrix, it is the block defined by a cluster name at the left and a cluster name at the top of the supermatrix.

The weighted supermatrix is derived by multiplying all the elements in a component of the unweighted supermatrix by the corresponding cluster weight. Segment of the weighted supermatrix for the ICRM is shown in Figure 3.13.

Super Decisions Main Window: International Construction Risk ...

Local Priorities of the Project Team Cluster

Cluster	Node Labels	1 The Goal: International Construction Project Risk	2 Project Team: Client	2 Project Team: Consultant	2 Project Team: Designer	2 Project Team: Joint Venture/ Partners	3 Construction: Adverse physical Condition	3 Construction: Design	3 Construction: Managerial Complexity
1 The Goal	International Construction Project Risk	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2 Project Team	Client	0.481938	0.000000	0.626697	0.625013	0.683341	0.322612	0.113124	0.325739
	Consultant	0.056797	0.249310	0.000000	0.238487	0.116850	0.160536	0.061333	0.114857
	Designer	0.120485	0.157056	0.093616	0.000000	0.199810	0.061950	0.591134	0.076251
	Joint Venture/ Partners	0.340781	0.593634	0.279687	0.136500	0.000000	0.454903	0.234409	0.483153
3 Construction	Adverse physical Condition	0.089666	0.111650	0.175229	0.000000	0.000000	0.000000	0.052769	0.000000
	Design	0.132182	0.000000	0.000000	0.459688	0.055447	0.093934	0.000000	0.117221
	Managerial Complexity	0.073471	0.066367	0.109503	0.149345	0.132557	0.176130	0.115068	0.000000

Done

Figure 3.12. Part of the Unweighted Supermatrix for the ICRM

Super Decisions Main Window: International Construction Risk ...

Cluster	Node Labels	1 The Goal: International Construction Project Risk	2 Project Team: Client	2 Project Team: Consultant	2 Project Team: Designer	2 Project Team: Joint Venture/ Partners	3 Construction: Adverse physical Condition	3 Construction: Design	3 Construction: Managerial Complexity
1 The Goal	International Construction Project Risk	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2 Project Team	Client	0.050820	0.000000	0.037422	0.037321	0.040804	0.054836	0.021581	0.055368
	Consultant	0.005989	0.014887	0.000000	0.014241	0.006977	0.027287	0.011701	0.019523
	Designer	0.012705	0.009378	0.005590	0.000000	0.011931	0.010530	0.112772	0.012961
	Joint Venture/ Partners	0.035935	0.035447	0.016701	0.008151	0.000000	0.077322	0.044719	0.082124
3 Construction	Adverse physical Condition	0.015839	0.018230	0.028611	0.000000	0.000000	0.000000	0.004617	0.000000
	Design	0.023350	0.000000	0.000000	0.075056	0.009053	0.007322	0.000000	0.009138
	Managerial Complexity	0.012979	0.010836	0.017879	0.024384	0.021643	0.013730	0.010067	0.000000

Done

Figure 3.13. Part of the Weighted Supermatrix for the ICRM

The Limit supermatrix is derived by raising the weighted supermatrix to powers by multiplying it times itself. When the columns of numbers become identical, it is said that the limit matrix has been reached. Consequently, the matrix multiplication process is stopped. Figure 3.14 shows a section of the limit supermatrix for ICRM.

Super Decisions Main Window: International Construction Risk ...

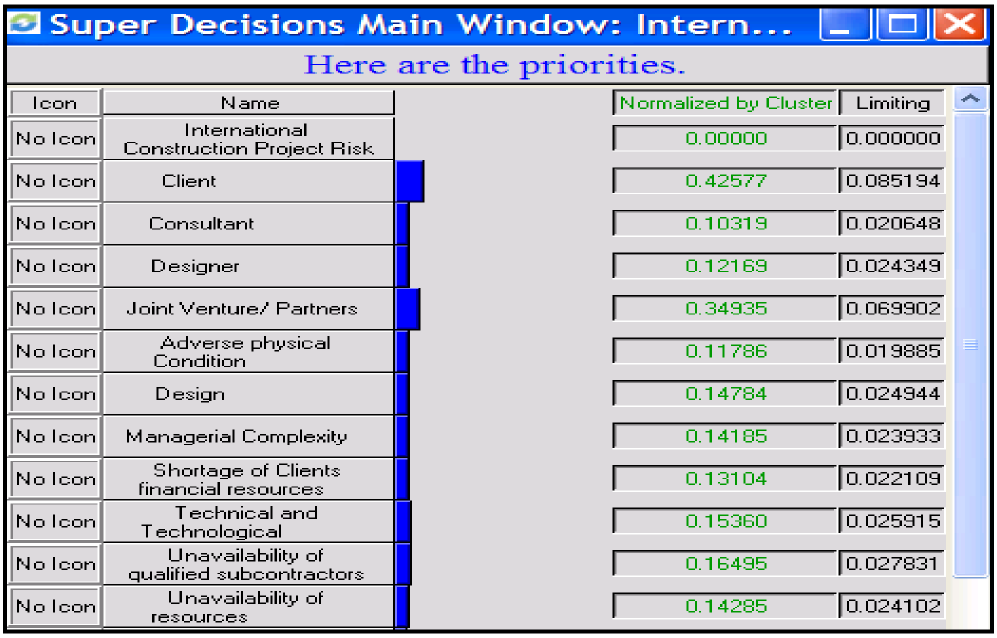
Cluster Node Labels		1 The Goal	2 Project Team				3 Construction		
		International Construction Project Risk	Client	Consultant	Designer	Joint Venture/ Partners	Adverse physical Condition	Design	Managerial Complexity
1 The Goal	International Construction Project Risk	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2 Project Team	Client	0.085194	0.085194	0.085194	0.085194	0.085194	0.085194	0.085194	0.085194
	Consultant	0.020648	0.020648	0.020648	0.020648	0.020648	0.020648	0.020648	0.020648
	Designer	0.024349	0.024349	0.024349	0.024349	0.024349	0.024349	0.024349	0.024349
	Joint Venture/ Partners	0.069902	0.069902	0.069902	0.069902	0.069902	0.069902	0.069902	0.069902
3 Construction	Adverse physical Condition	0.019885	0.019885	0.019885	0.019885	0.019885	0.019885	0.019885	0.019885
	Design	0.024944	0.024944	0.024944	0.024944	0.024944	0.024944	0.024944	0.024944
	Managerial Complexity	0.023933	0.023933	0.023933	0.023933	0.023933	0.023933	0.023933	0.023933

Done

Figure 3.14. Section of the Limit Supermatrix for the ICRM

The key importance of the limit supermatrix is that it provides the priorities for the different factors that structure the problem. Since the columns of the limit supermatrix are all identical, the priorities for all the elements in any cluster can be read directly from any column. Moreover, the Computations Priorities command on the menu displays the priorities in two different ways, both as they appear in the limit supermatrix, and with the priorities normalized by cluster. Figures 3.15a and 3.15b display the Priorities as obtained from limit supermatrix. When alternatives are included in the model, the software can synthesize them to give the best available alternative according to the provided judgments.

However, in ICRM model no alternatives were included since the aim was to derive the relative priorities of the risk factors to provide general tool for risk assessment rather than comparing specific alternatives. The obtained priorities will be discussed in more detail in Chapter 4 were they are going to be validated through post-project risk assessment.



Icon	Name	Normalized by Cluster	Limiting
No Icon	International Construction Project Risk	0.00000	0.000000
No Icon	Client	0.42577	0.085194
No Icon	Consultant	0.10319	0.020648
No Icon	Designer	0.12169	0.024349
No Icon	Joint Venture/ Partners	0.34935	0.069902
No Icon	Adverse physical Condition	0.11786	0.019885
No Icon	Design	0.14784	0.024944
No Icon	Managerial Complexity	0.14185	0.023933
No Icon	Shortage of Clients financial resources	0.13104	0.022109
No Icon	Technical and Technological	0.15360	0.025915
No Icon	Unavailability of qualified subcontractors	0.16495	0.027831
No Icon	Unavailability of resources	0.14285	0.024102

Figure 3.15a. The Priorities from the Limit Supermatrix

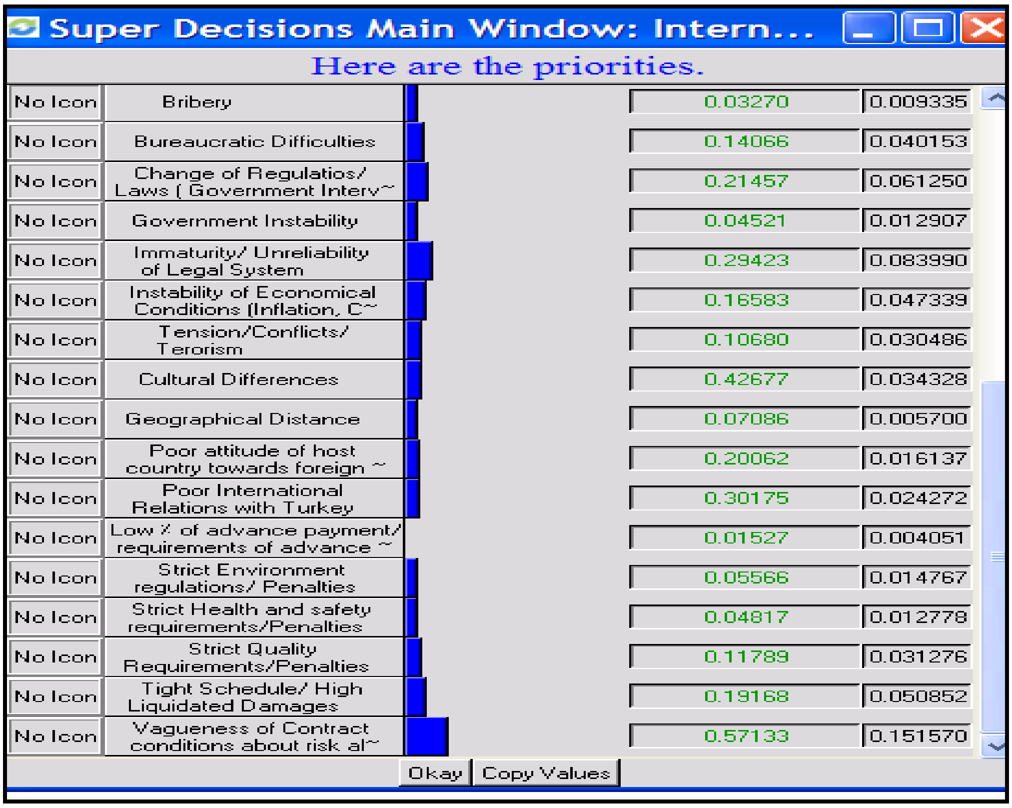


Figure 3.15b. The Priorities from the Limit Supermatrix

3.4.3.1.2 Cluster Comparisons

It was pointed out earlier that the weighted supermatrix is derived by multiplying all the elements in a component of the unweighted supermatrix by the corresponding cluster weight. Thus, to achieve the weighted supermatrix clusters are needed to be compared. Clusters are compared by taking each cluster in turn, as the parent, and pairwise compare all the clusters it connects to for importance with respect to their influence on it. The output of this process is the creation of the cluster matrix, which is shown in Figure 3.16. It is essential to recall that the overall goal for the ICRM model is the level of ICPR. In cluster comparisons, the comparison process is used to pairwise compare the clusters for influence to which the parent cluster connects.

When the cluster comparison process is disregarded, or in the case of equally important clusters and it is believed that it is not necessary to undertake cluster comparisons, the cluster weights are set to 1/n in the cluster matrix. In this case, the value of "n" is equal to the number of nonzero components beneath each component across the top of the unweighted supermatrix. Yet, the clusters in a network may not be equally important. Thus, the weights in cluster matrix need to be established by conducting cluster comparisons. The process of weighting all the elements in each unweighted supermatrix component by the corresponding cluster matrix value, either the default value of 1/n, or the resultant values of cluster comparisons, leads the matrix to become column stochastic (i.e. each column sums to one).

The concept of comparing the clusters is fundamental in real life practice. One needs to identify the importance of the categories under which the elements were classified since the final priorities depend on that. The local priorities of the elements under each cluster are modified for the overall network according to the influence of the cluster within which the elements are contained on the main goal.

Super Decisions Main Window: Internatio...

Cluster Node Labels	1 The Goal	2 Project Team	3 Construction	4 Country	5 Inter-Country	6 Contractua
1 The Goal	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2 Project Team	0.105450	0.059713	0.169976	0.224841	0.327812	0.240405
3 Constructio n	0.176648	0.163275	0.077951	0.159082	0.297430	0.210801
4 Country	0.389713	0.393627	0.381633	0.116292	0.189243	0.363335
5 Inter-Countr y	0.071987	0.099164	0.109014	0.067629	0.075397	0.097949
6 Contractual	0.256202	0.284222	0.261426	0.432156	0.110118	0.087510

Done

Figure 3.16. The Cluster Matrix for ICRM

Through the very last sections of this chapter, a comprehensive description for both the ANP technique and the ICRM was given. Figure 3.15a and complemented with Figure 3.15b represents the intended output required from developing the ICRM. Thus, the main objective from utilizing the ANP technique in this thesis, besides demonstrating its effective use in counting for dependence and feedback in a complex structure, was to derive relative priorities for the identified risk factors. That is why no alternatives were proposed, since the main objective was not to derive a case specific model that cannot be used practically, yet it was believed to be more meaningful to develop a general model which forms a foundation for the aimed comprehensive methodology. Accordingly, the output of this ANP model is to be utilized to develop a decision support tool, which a decision maker can use to compare between any available international construction projects alternatives. This tool will be the subject of discussion in the next chapter.

CHAPTER 4

THE INTERNATIONAL CONSTRUCTION PROJECT RISK RATING SOFTWARE APPLICATION

Chapter 3 has included a comprehensive discussion for the international construction risk model (ICRM) which was developed with the help of the analytic network process (ANP) software, *SUPERDECISIONS*. The aim of this chapter, on the other hand, is to test the output of the proposed ANP model by using the derived priorities to develop a decision support tool that provides a risk rating for a given international construction project which shall be conducted by a Turkish contractor.

An international construction project risk rating (ICPRR) software application was developed to serve this scope. The obtained relative priorities were incorporated into the ICPRR software application and a risk rating formula was developed to calculate the level of risk for a given international construction project. Thus, the proposed application can act as a decision support tool which provides a reliable risk rating; consequently, decision making process in the organization will be enhanced. Moreover, the application can also build a database for post-projects risk information. It was mentioned out earlier that it is common in the construction business that previous projects data are often absent. Further, it is believed that the main reason behind the shortage of previous data is the imperfection in the project closure process in most of the organizations. However, an organization should benefits from its previous experience in order to improve its performance and learns from its mistakes. Yet, most of the organizations lack of effective approaches of learning from completed projects to enhance their performance in the forth coming projects. Consequently, it is essential for a construction organization to perform post-projects reviews to identify and documents risk-related data in order to be utilized in future projects.

4.1 The Structure of the International Construction Project Risk Rating Software Application

The ICPRR software application was built with "Oracle Forms". It was protected with a username and a password to give more security for the user, as it will protect any saved information from intruders. Thus, when it is desired to be entered, the user will be introduced to the screen in Figure 4.1; which asks for the username and password to log into the ICPRR application. After completing this step, the user will manage to enter to the ICPRR application, and the screen depicted in Figure 4.2 will appear. This is the main window of the ICPRR application which consists of three main components, namely**:** File, Project Information, and Help.

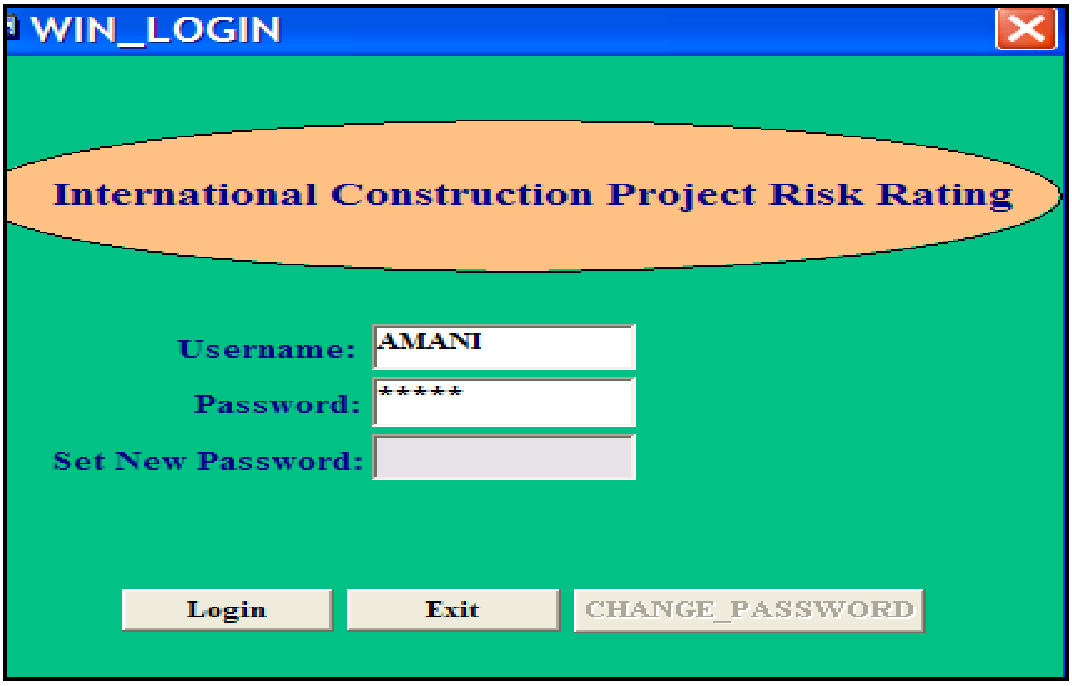


Figure 4.1. The Logon Screen to the International Construction Project Risk Rating Software Application

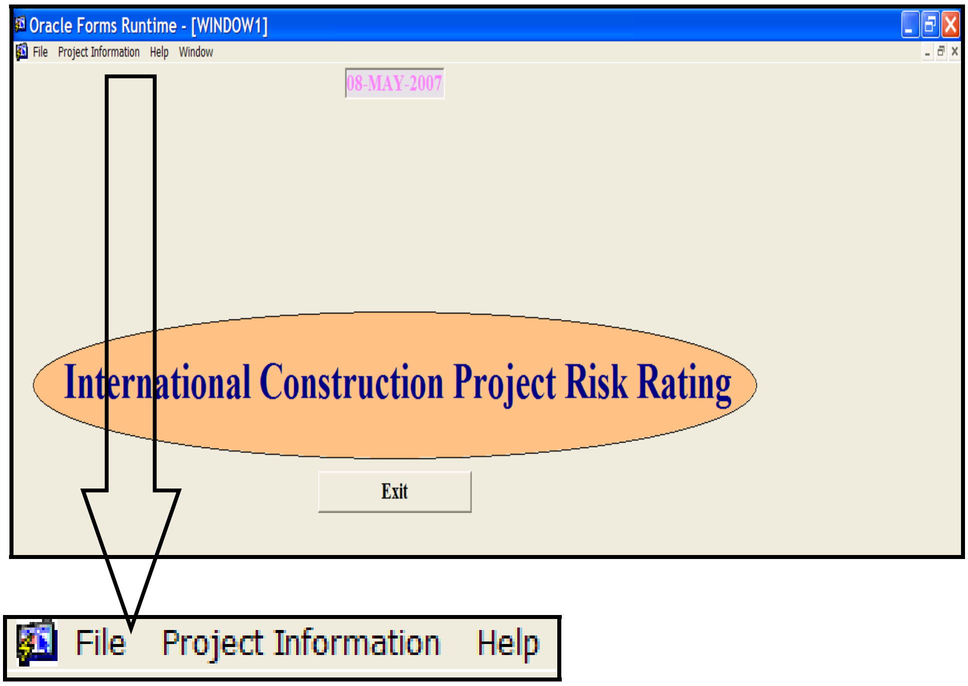


Figure 4.2. The Main Components of the ICPRR Software Application

4.1.1 Project Information

When "Project Information" is chosen, the screen shown in Figure 4.3 will show up. Within this screen the decision maker can enter new project, update, and delete existing projects. There are several fields that need to be filled which will assist in understanding the project under consideration, and facilitate future utilization. Among the information that will be inquired is: project name and title, project size, the country into which the project will be/was conducted, project type, and contract type. The software allows the decision maker to introduce new country, project type, or contract type if it is not found within the drop down menu for each of these entries. Then, and after the project information is being completed, project information component will lead to another component which is depicted in Figure 4.4.

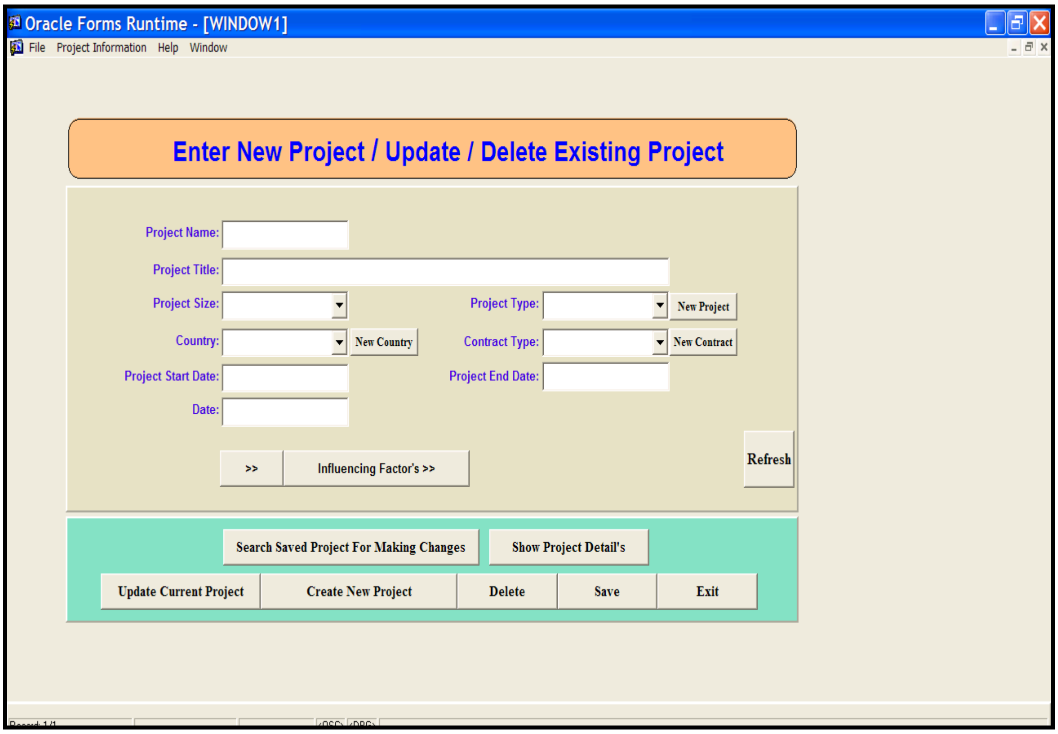


Figure 4.3. Project Information Form

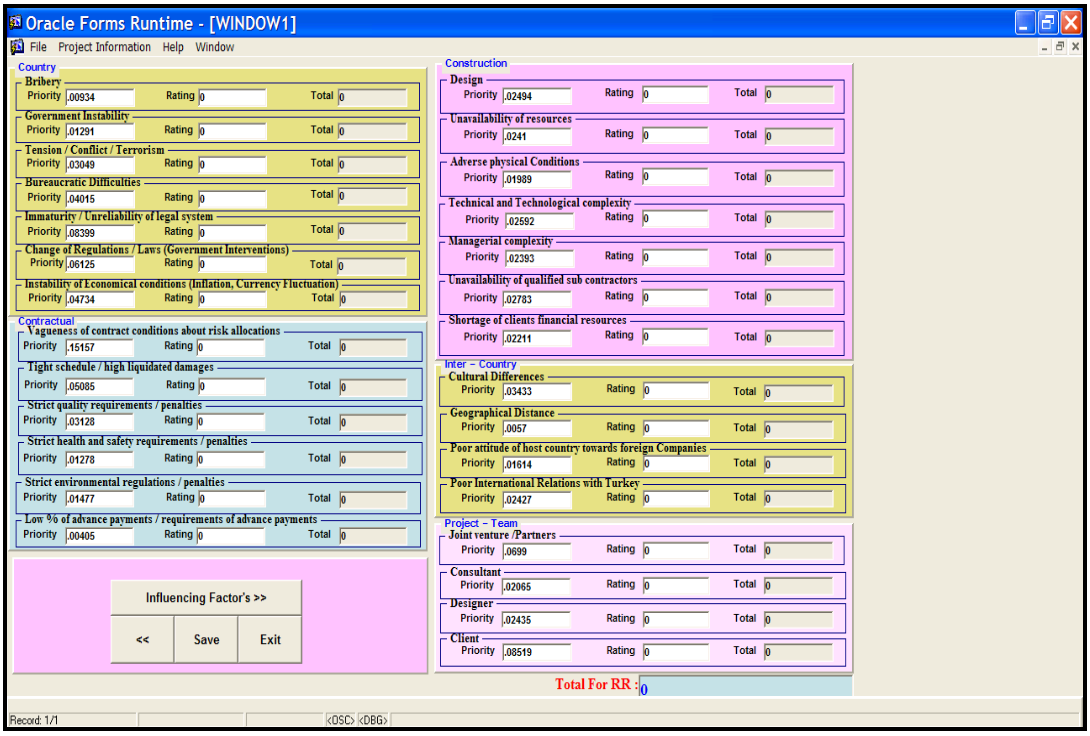


Figure 4.4. The Risk Rating Entry Screen

The component shown in Figure 4.4 allows the decision maker to assign performance rating for each risk factor according to the specific conditions of the international construction project under consideration; this will derive the total initial risk rating (RR). As it can be seen the priorities derived from the ANP model, the ICRM, is set as the default priorities. Yet, it is not compulsory to use the predefined relative priorities. If the decision maker believes that it needs to be modified, the software allows setting any desired priority, yet, to maintain accuracy the new priorities need to be in the normalized form (sum-up to unity). However, for the context of this thesis, one of the key motivators to develop the ICPRR software application is to validate the derived priorities of the risk factors from the ANP model, thus the default priorities will be used and validated through several post-projects which will be handled as case studies.

4.1.1.1 Adjusting International Construction Project Risk Rating

In the process of developing the ICRM several assumptions were accepted to facilitate the development process. Among these assumptions, it was assumed that normal construction conditions exist, that is sufficient amount of data will be available from the beginning, and the contractor will have enough experience capabilities (i.e. experience in similar projects, and experience in the country/similar countries) to conduct the project. Moreover, during the assessment process (i.e. while filling in the comparison matrices) the project delivery system and the contract type were disregarded. These assumptions were made since it was not simple to incorporate these factors into the ANP model. Consequently, the derived risk rating from the obtained relative priorities of the risk factors may not reflect adequately the project circumstances when different conditions are encountered. Thus, in some occasions, the risk for an international construction project could be found as an average project according to the derived priorities, yet, it could inherent considerable amount of risk that stems from the variation of the ideal assumptions while deriving the risk factors priorities.

Therefore, it was anticipated that for a construction project which its risk rating found to be average under the initially considered conditions (i.e. the contractor has adequate experience to conduct it, and fair project data was available at the outset), the risk rating could be influenced by several influencing factors which would increase the risk level of the project. These factors include: different state of the company's experience (i.e. experience of the company is Low), contract type (CT), the amount of the available project data from the beginning (DA), and project delivery system (PDS). Figure 4.5 explains the influencing factors. It is shown in the figure that the obtained risk rating is influenced by several influencing factors; these factors may increase the risk level of the project. Thus, the obtained international construction project risk rating should be adjusted to reflect the influence of such factors.

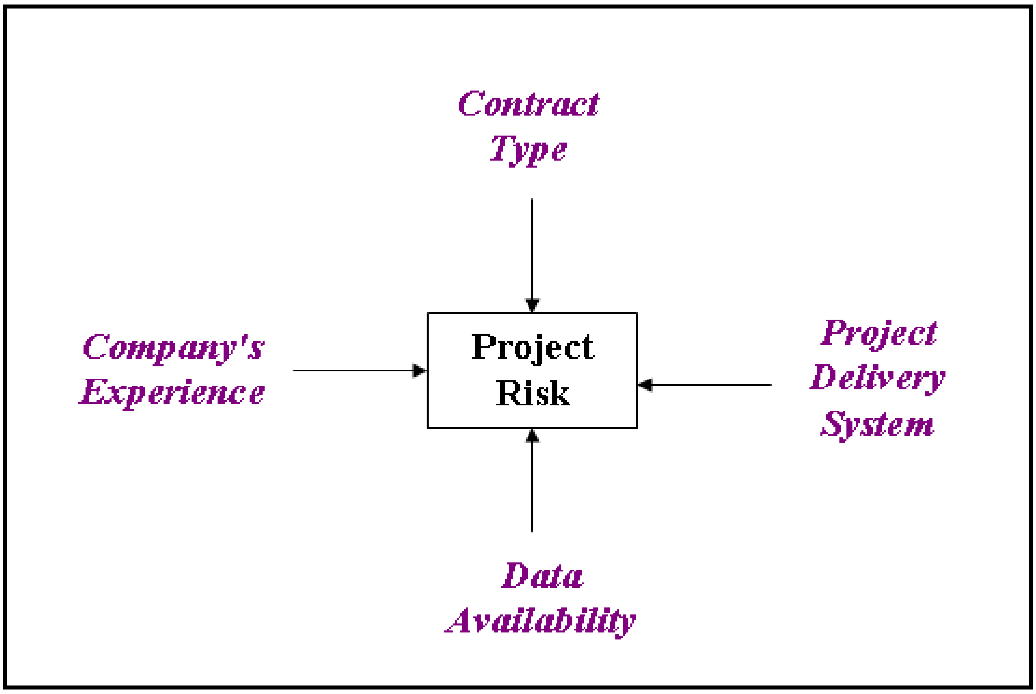


Figure 4.5. Influencing Factors on International Construction Project Risk

Moreover, it is expected that the importance captured by each risk factor is highly influenced by the company state. Therefore, the company's experience in the country/similar countries; and its experience in similar projects have great influence on the level of risk. Further, it is projected that if the contractor has experience in the country or other countries that carry similar characteristics then his ability to manage risk would increases. This will lead to reduce the level of risk retained by the contractor with adequate experience when compared with another contractor who has no or little experience (Dikmen et al., 2007a). In the same way; if the contractor has experience regarding the type of the project or the required technology then the level of risk associated with constructing the project would considerably be reduced. Moreover, it is assumed that company's experience influence depends on the level of risk; since risky projects may require more experience to handle when compared with normal projects. Therefore, adjusting the derived risk rating for a given project with respect to the company's experience should be done by adding to the project risk certain percentage from the initially obtained risk rating.

However, for the remaining factors (i.e. CT, DA, and PDS) it is believed that their influence is independent from the level of risk, that is, their influence should be reflected by adjusting the level of risk with certain amount regardless of the project risk.

According to the previous justification, after deriving the initial RR by assigning performance ratings to the prioritized risk factors, there shall be 2 types of adjustments; the first with regard to the company experience and is expressed with % from the initial risk rating, while the second is with regard to the CT, DA, and PDS influencing factors and is reflected through predicting what should be the risk rating of an average project if certain combination of these three factors exists. Figure 4.6 depicts the risk rating adjustment methodology.

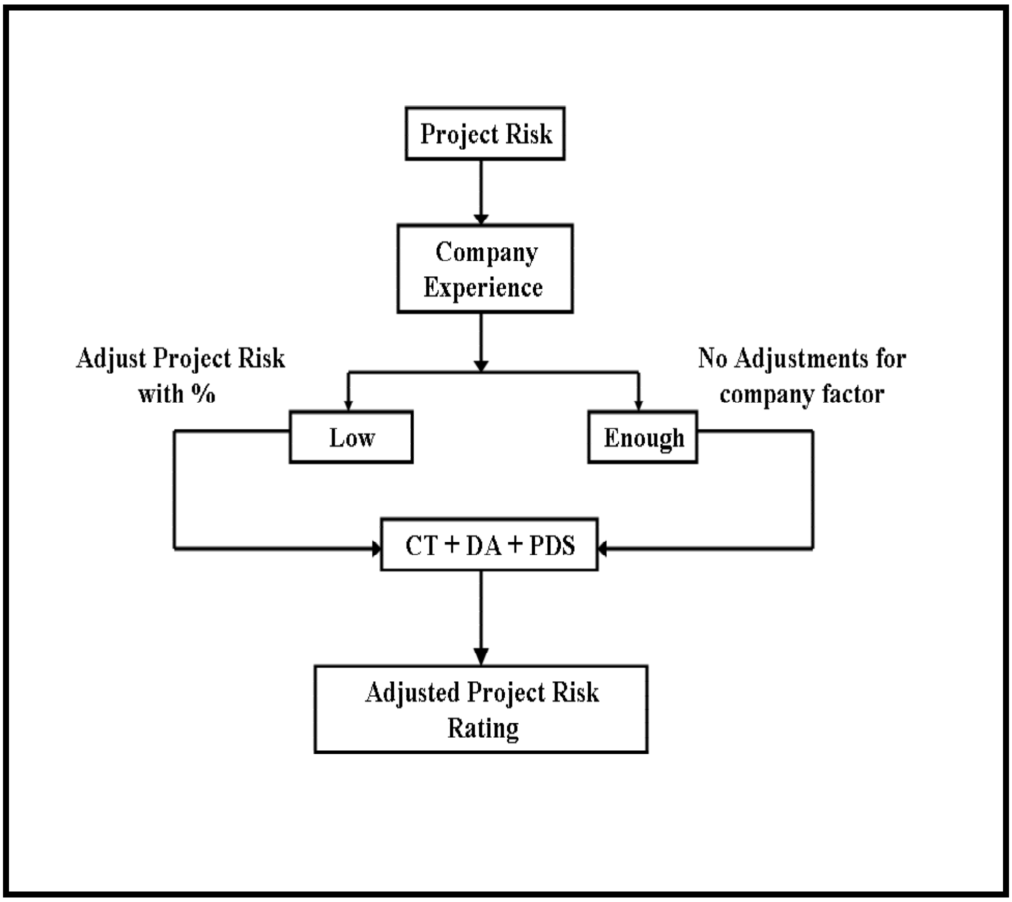


Figure 4.6. Risk Rating Adjustment Methodology

The need for adjusting the risk rating of a construction project for the PDS, CT, and DA is essential, since with different contractual relationships the contractor will gain different advantages and also diverse disadvantages will exist. There are various contractual approaches, which an owner can adopts to develop the design and construction team (Barrie and Paulson, 1992). This study highlights two widely used approaches, which are the design-bid-build (DBB) (some times referred as the traditional approach) and the design-build (DB). The previous approaches can be implemented using several types of contracts, including lump-sum, cost plus a fixed fee, and unit price.

The Design-Bid-Build Approach

Barrie and Paulson (1992) have elucidated this approach; they have stated that when implementing this type of contractual association, the owner employs a designer who initially prepares the plans and specifications, and later during the construction phase the designer may undertake inspection, monitoring, or control. Figure 4.7 explains this approach. For the construction process, the owner establishes a contract with a single general contractor who carries out the responsibility of constructing the project. However, the general contractor usually subcontracts the immense amount of the work to individual subcontractors. Yet, the legal contractual relationships of the subcontractors are directly with the general contractor. Thus, the general contractor is responsible to the owner for all the work, including the subcontracted works. The design-bid-build approach can be implemented using lump-sum contract, a unit price contract, or a cost-plus-fee contract. In some construction projects combinations of these contracts may be utilized.

The Design-Build Approach

In the design-build approach, all the project phases from inception through design and construction are assigned to one organization. Through this type of contractual relationship, the constructor is a general contractor with single firm control of all subcontractors. Usually, under design-build contracts, construction can readily be performed under a phased construction program to minimize project duration. This approach can be used under various types of contracts, including lump-sum, and cost-plus-fee contract. Figure 4.8 explains this approach. As a summary, the design-build approach involves the existence of a single organization that is responsible for both design and construction, together with specialty subcontractors, and can be implemented with lump-sum, cost-plus-fee, or sometimes unit price design-construction contract.

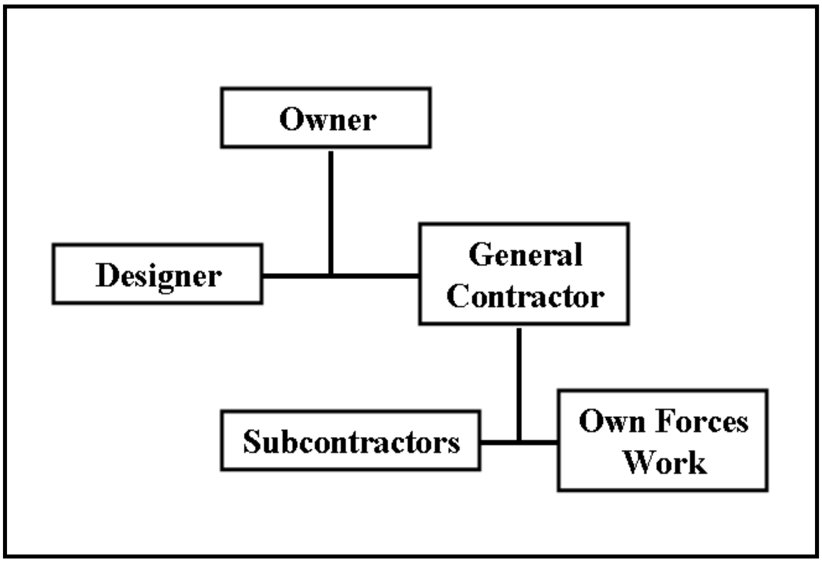


Figure 4.7. Design-Bid-Build Approach (Barrie and Paulson, 1992)

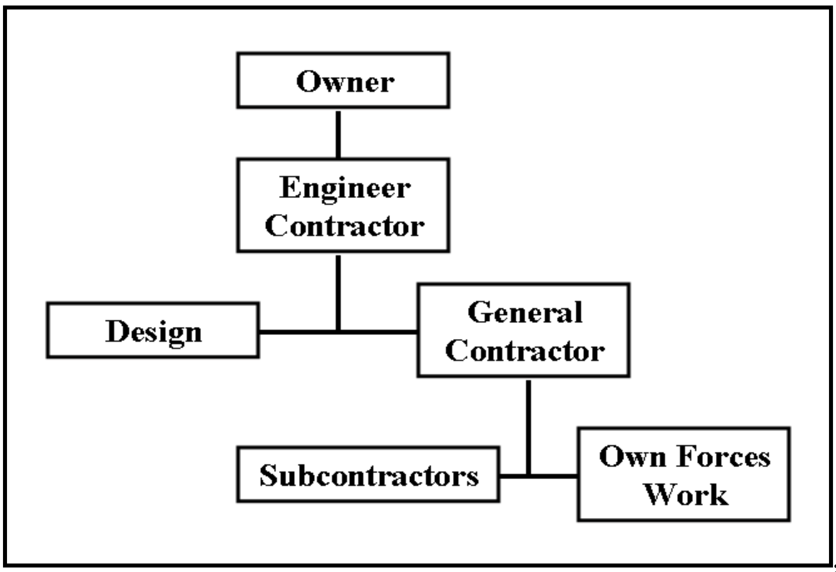


Figure 4.8. Design-Build Approach (Barrie and Paulson, 1992)

It has been revealed that there are several types of contracts that can be used with both contractual approaches. For the context of the ICPRR software application, three types of contracts will be encountered within the adjustment process, namely: lump-sum, unit price, and cost-plus-fee contracts.

Lump-Sum Contracts

In lump-sum contracts, the contractor agrees to perform the work for a predetermined price that includes his profit. This type of contracts has long been used in the competitively bid, and sometimes negotiated, general contract. Under this contract generally the general contractor subcontracts most of the work to specialty contractors under lump-sum subcontracts. The subcontracts incorporate the plans, specifications, and conditions from the general contract. Barrie and Paulson (1992) have listed the disadvantages of this type of contract from the contractor's perspective which have included:

- To be competitive the contractor must often use marginal subcontractors who may have problems performing the work.
- On many contracts too many bidders may make it difficult to obtain the work for a fair price.
- The owner controls the funding on disputed extra work or changed conditions, and the contractor must often resort to expensive arbitration or litigation with no assurance that it will recover for the additional costs.
- The contractor usually bears the economic risk of unusual weather conditions, strikes, or other external factors that influence a contractor's cost but which may not be directly under its control.
- Last minute quotations may contribute to misunderstandings with material suppliers and subcontractors.

Unit Price Contracts

Unit price contracts are similar to lump-sum, yet in this type of contracts the prices of the specified units of work are fixed, and the total cost to the owner will vary with the actual quantities of units put in place. Unit price contracts are best applied where the details and general character of the work are known but the quantities are subject to change within reasonable limits. Certain disadvantages listed under the lump-sum contracts can also be applied to this type as well (Barrie and Paulson, 1992).

Cost-Plus-Fee Contracts

Under this type of contracts, the contractor agrees to perform the work for a fixed or variable fee covering profit and home office costs, and all field costs will be measured at actual costs. Moreover, considered fees are often dependent on the size and complexity of the project. The disadvantages of this type of contracts from contractor's perspective (Barrie and Paulson, 1992):

- Fees may be minimal in comparison to profit potential in areas of known performance with favorable risk/reward ratio.
- Contractor supervision and management may resent major decisions being made or questioned by the owner in areas where they would be normally have full responsibility.
- The contractor reputation may suffer in the event of significant delays, cost overruns, or compatibility or personnel clashes with owner personnel.

To end with, adjusting the risk rating of a construction project according to the contractual agreement is dependent on the risk inherent with each approach. To visualize the degree of risk for the three different contract types, Figure 4.9 compares the different contract types according to their risk level for both the owner and the contractor. The figure shows that, the most risky contract type for the contractor to work with is the lump-sum contract. This is because under this type of contracts the contractor agrees to perform the work which will be conducted in the future with a price that is fixed in the present time. Yet, the construction process is involved with many variables that may have great influence on the construction cost. On the other hand, the least risky contract type is cost-plus-fee; where the contractor has eliminated the risk expected in fixed price contracting as a trade-off for a lower guaranteed fee.

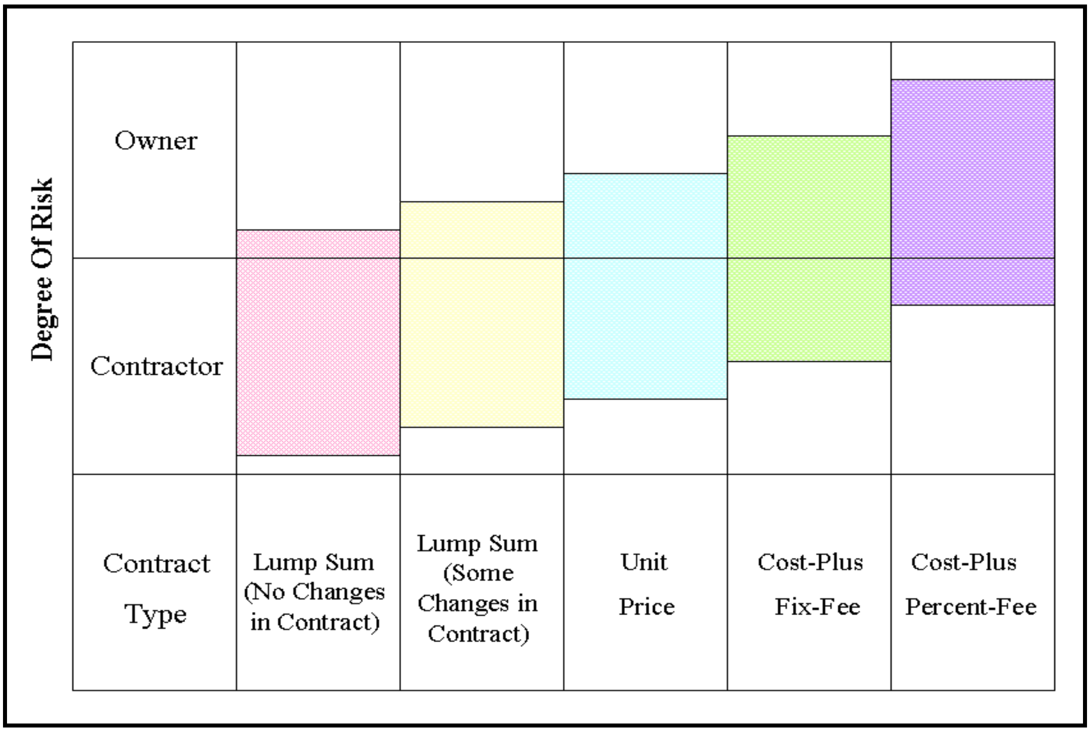


Figure 4.9. The Degree of Risk Associated with the Different Contract Types (Schuette and Liska, 1994)

A questionnaire was prepared to investigate the values according to which the RR should be adjusted, when counting for the influencing factors. In the questionnaire, initially the concept of the influencing factors was explained combined with the Figures 4.5 and 4.6. Then questions were set in a way that best captures the expert's judgment while suggesting the adjustment values. The part of the questionnaire that included the questions has basically two portions. The first asks the experts to give their opinion on the % to which an international construction project RR should be adjusted when the company's experience is regarded. While the other part included the questions concerning the different available combinations of the influencing factors. Thus, the questionnaire included the following question with reference to company's experience: According to your own judgment, with what percentage (%) from the overall risk rating should the project risk be adjusted if the contractor has no sufficient experience to conduct the project?

On the other hand, and with respect to the CT, DA, and PDS; a total of 11 different combinations of the influencing factors were found, an example of the questions, which were included in this part of the questionnaire for adjusting the risk rating of an average international construction project when a certain combinations exists, is: According to your own judgment, give the overall risk rating that the project should have if the following state of influencing factors exists. Since the initial RR was assumed to be average, the threshold value for the risk rating was given as "3", on a Likert (1 - 5) scale. Delphi method was used to fill in the questionnaire. In the first round, the questionnaire was sent to three diverse experts in the area of international construction. The analysis of the first round responses revealed a considerable divergence between the experts' judgments. Thus, a second round questionnaire was prepared and transmitted to the experts combined with the results of the first round. At the end of the second round convergence was achieved and the process stopped. This is complying with the general trend in utilizing Delphi method, since it is believed that the most changes in the Delphi method occurs in the first two rounds and not much is gained by iterating more than twice (Gunhan and Arditi, 2005a). The average of the experts' judgments in the second round was used as risk rating adjusting values. Table 4.1 contains the results of the questionnaire.

Table 4.1 Risk Rating Adjusting Values

State of the Influencing Factors			Risk Adjusting Value
CT	**DA**	**PDS**	
LS	Yes	DBB	0.2
LS	No	DB	1.0
UP	Yes	DBB	0.0
UP	No	DBB	0.0
UP	No	DB	0.1
CF	Yes	DBB	0.0
CF	No	DBB	0.0
CF	No	DB	0.0
LS	Yes	DB	0.5
UP	Yes	DB	0.0
CF	Yes	DB	0.0

Where, with respect to contract type CT, LS = Lump-Sum, UP = Unit Price, and CF = Cost-Plus-Fee. Where as, with regard to project delivery system PDS, DBB= Design-Bid-Build, and DB= Design-Build. Finally, concerning data availability DA, Yes = Sufficient Data Available, and No = No Sufficient Data Available.

The results of the questionnaire, as were obtained from the three experts, have shown that for an international construction project, the risk rating should be adjusted when the performing organization has no sufficient experience to accomplish it, by increasing the initially derived RR value with 15%. However, when adjusting for the several available combinations of the other influencing factors which are CT, DA, and PDS only four combinations were found to have a considerable influence on the RR. The most risky combination was found to be the case when contract type is lump-sum, the data are not available from the beginning, and the project delivery system is design-build.

The experts have suggested that even when the risk assessment process results in an average project this specific combination would shift the project from the average risk category to the high risk. According to the experts the RR should be increased by a value of 1 on a Likert scale (1-5); for this risky combination of the influencing factors, thus, the hypothetically assumed average project with a RR of 3 will have an adjusted risk rating of 4 when counting for this specific combination of the influencing factors. Moreover, the experts have revealed that, when the same contract type and project delivery system are implemented, yet the data are available when first starting the project, then the degree of the influence would slightly decreases. That is, the risk rating adjusting value would become 0.5 rather than 1. Further, the two other cases that to some extent would have an influence on the initial RR would be the cases when the following combinations exist (LS, Yes, DBB) and (UP, No, DB). The values that were suggested by the experts for adjusting the RR were shown in Table 4.1. The ICPRR software has included a component to count for the risk rating influencing factors, its task is to allow the decision maker to define the state of the influencing factors to enable the software to calculate the overall adjusted RR. Figure 4.10 shows the "Influencing Factors" component.

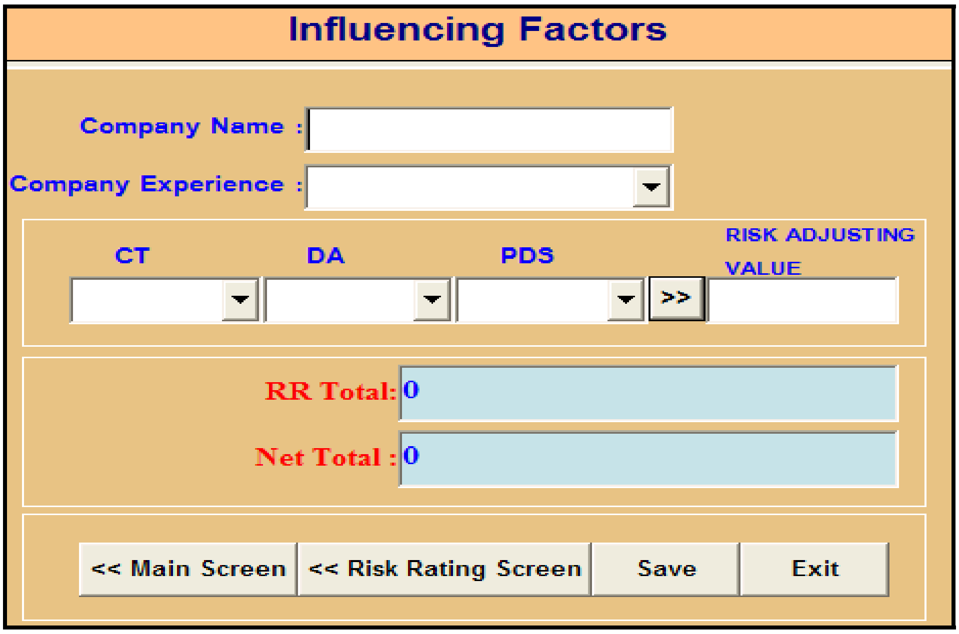


Figure 4.10 Influencing Factors Screen

4.1.2 The Components of the Help Menu in the ICPRR Application

To facilitate the utilization of the ICPRR application an inclusive Help menu was incorporated within the software. The main objective of including the Help menu is to explain the different components that build up the software. Thus, and referring to Figure 4.11, this part of the software has included the following components: project description, influencing factors descriptions, explaining risk factors, explaining influencing factors, and the ANP model.

<u>Project Description</u>

This component of the "Help" menu describes how the "Project Information" and "File" menu can be used. In other words, it explains how the ICPRR application is designed and the most appropriate way to be applied. Figure 4.12 shows the "Project Description" Screen.

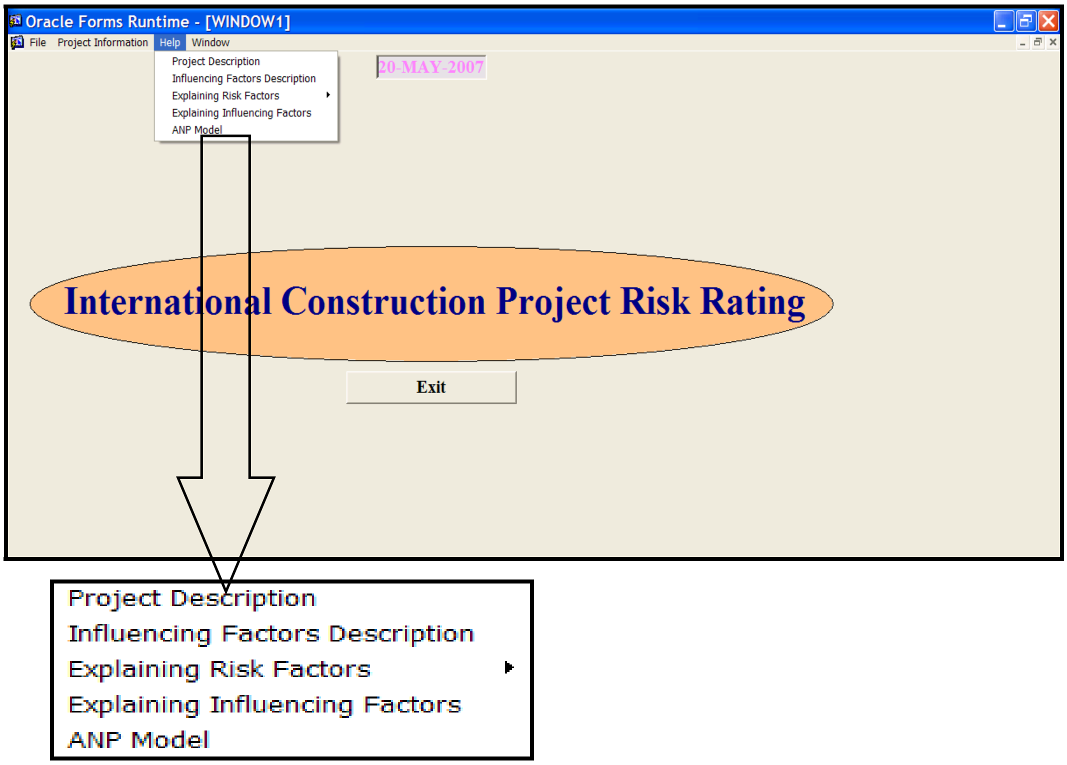


Figure 4.11 The Key Components of the Help Menu in the ICPRR Application

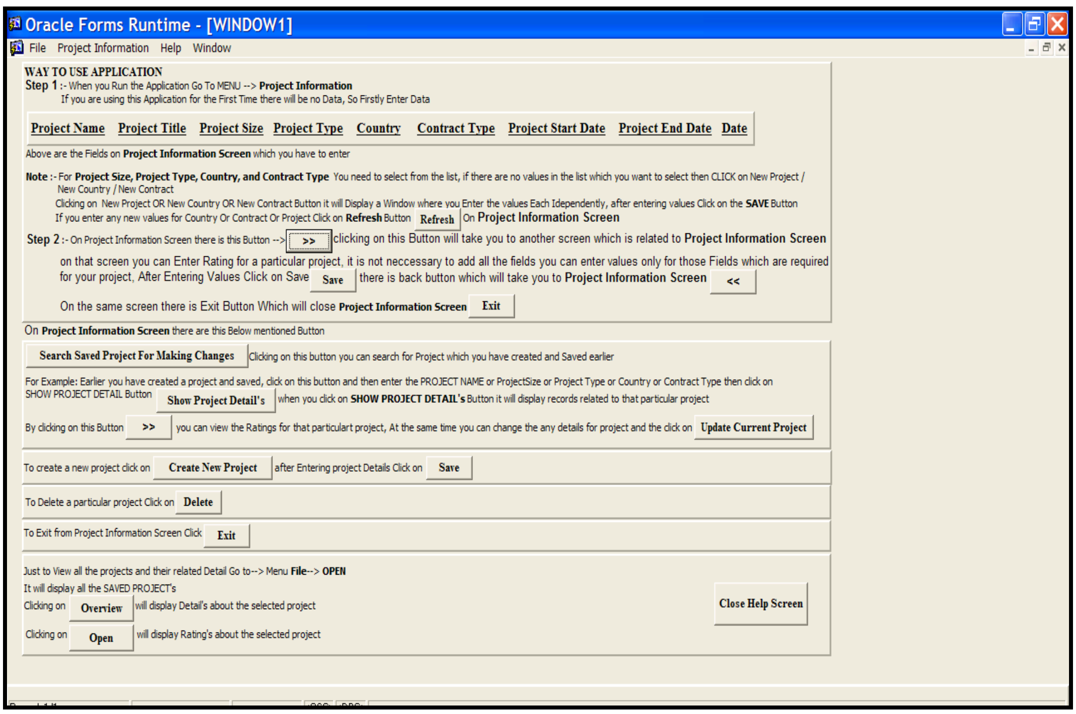


Figure 4.12 The Project Description Component in the Help Menu

Influencing Factors Descriptions

This component describes how to use the "Influencing Factors" interactive screen. It is also mentioned within this component that, although the application has included the default risk rating adjusting values for the influencing factors, yet it is not compulsory to use these values. The software allows the decision maker to assign any preferable adjusting values, and the procedures to do so is explained through this help component.

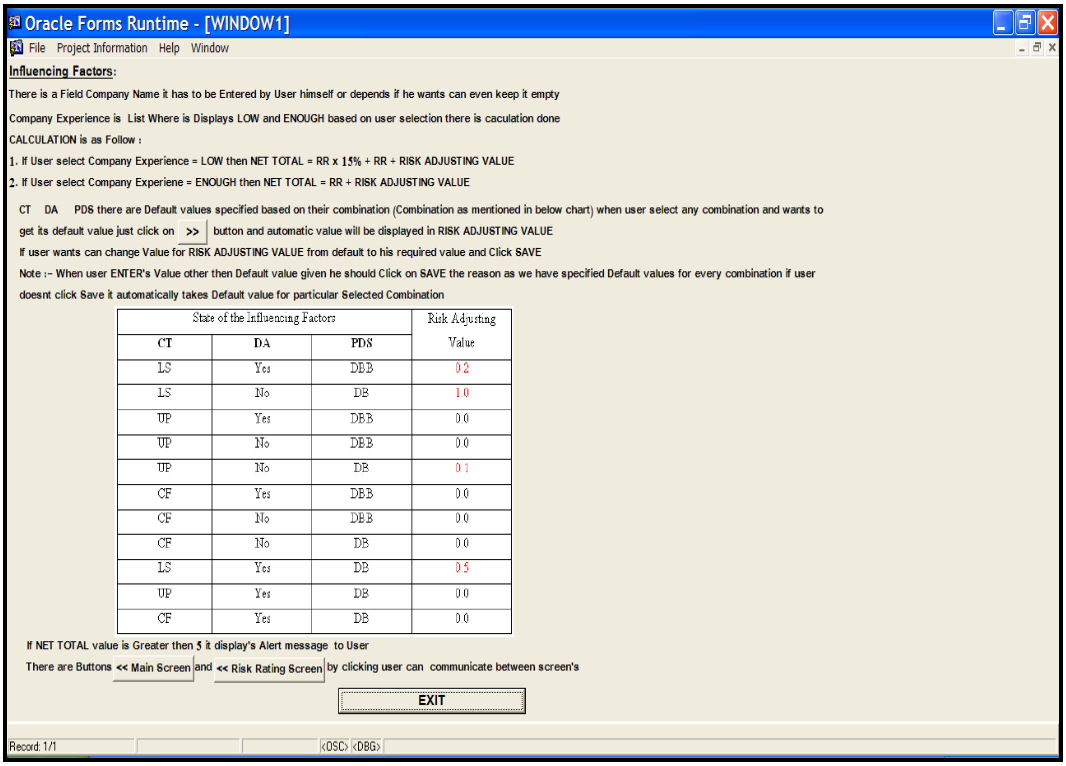
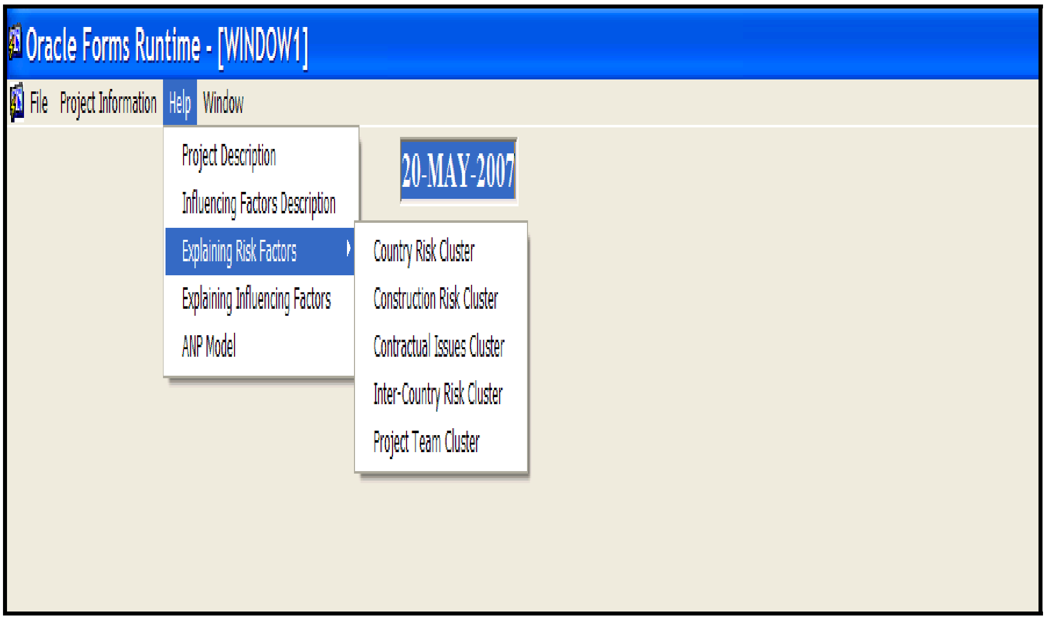


Figure 4.13. The Influencing Factors Description Component

Explaining Risk Factors

It was shown while explaining the "Project Information" component that the risk rating screen allows the decision maker to assign performance rating for each risk factor according to the specific conditions of the international construction project under consideration; which will derive the total initial risk rating (RR). However, in order to assign an adequate rating the decision maker needs to comprehensively understand the presented risk sources and know exactly what is meant by each risk category and precisely each risk factor. Thus, this element in the "Help" menu provides the required assistance in this field. When "Explaining Risk Factors" component is chosen, a drop down menu will appear allowing the decision maker to choose among several elements, each of which represents a separate cluster that was included in the risk model. Figures 4.14, reveals the dropdown menu of this element, which include the risk categories considered in the ANP model, ICRM. Each of these risk categories encompasses a concise description of the risk factors included.



4.14 The Dropdown Menu of "Explaining Risk Factors" Component

Explaining Influencing Factors

To understand the methodology used to adjust the initially derived RR and how the proposed adjusted value was derived, the user needs to be introduced to the methodology in an adequate manner. Thus, sufficient level of explanation to the adjusting methodology was included into the "Help" menu. This component of the "Help" menu included a description of the influencing factors that may have considerable effect on the derived RR together with the risk rating adjustment methodology and the values according to which the initial RR is adjusted. Figure 4.15 reveals part of this component. The Figure shows the values used for adjusting the RR.

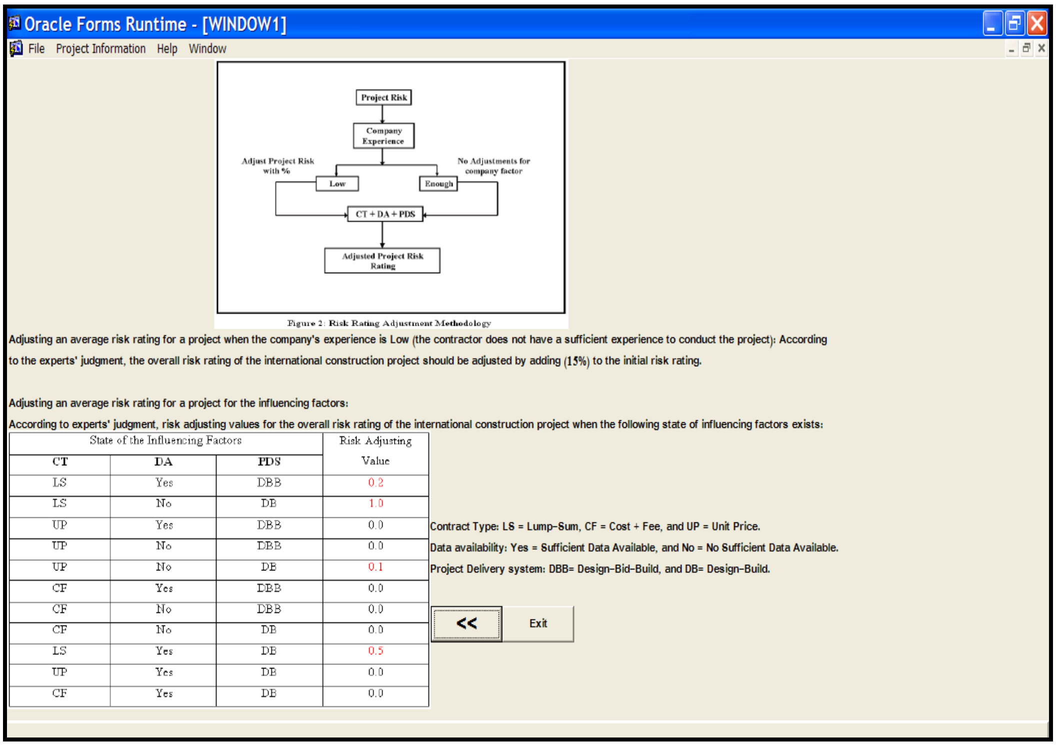


Figure 4.15. Explaining the Influencing Factors and the Risk Rating Adjustment Methodology

ANP Model

Since the priorities used for the risk factors are derived from the ANP model, depicting the model for the user was believed to provide sufficient understanding of how the relationships within the model were built. Figure 4.16 give a picture of the ANP as was included into the "Help" menu.

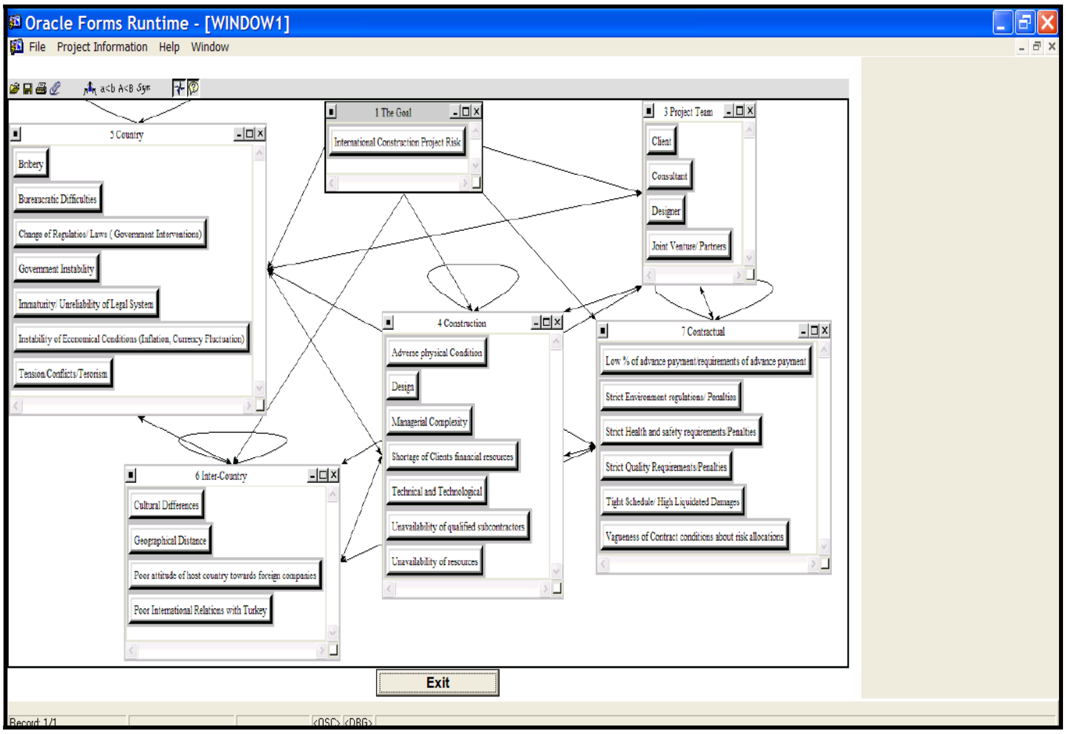


Figure 4.16 The Analytic Network Process Model Included in the Help Menu

4.1.3 The Components of the File Menu in the ICPRR Application

The key component of the File menu is the "Open" command. The "Open" represents the screen shown in Figure 4.17, which provides a list of the previously entered projects data. The decision maker is allowed to choose any project from the list and view the information associated with each chosen project. However, and in order to avoid loosing any saved information, the screen corresponding to the saved data are protected against any potential changes, and if the data are meant to be modified it can be modified from the "Project Information" screen. The "Open" component in the "File" menu incorporates two essential subcomponents which are: overview, and open. The "Overview" subcomponent is shown in Figure 4.18, which provides project details that represent the basic information previously entered in the "Project Information" screen. While the "Open" subcomponent is shown in Figure 4.19, that provides the performance rating of the risk factors for the opened project. Through the "Open" subcomponent the decision maker can portray the expected situation for a given construction project by reviewing the available post-project information that capture some similarities with the present project.

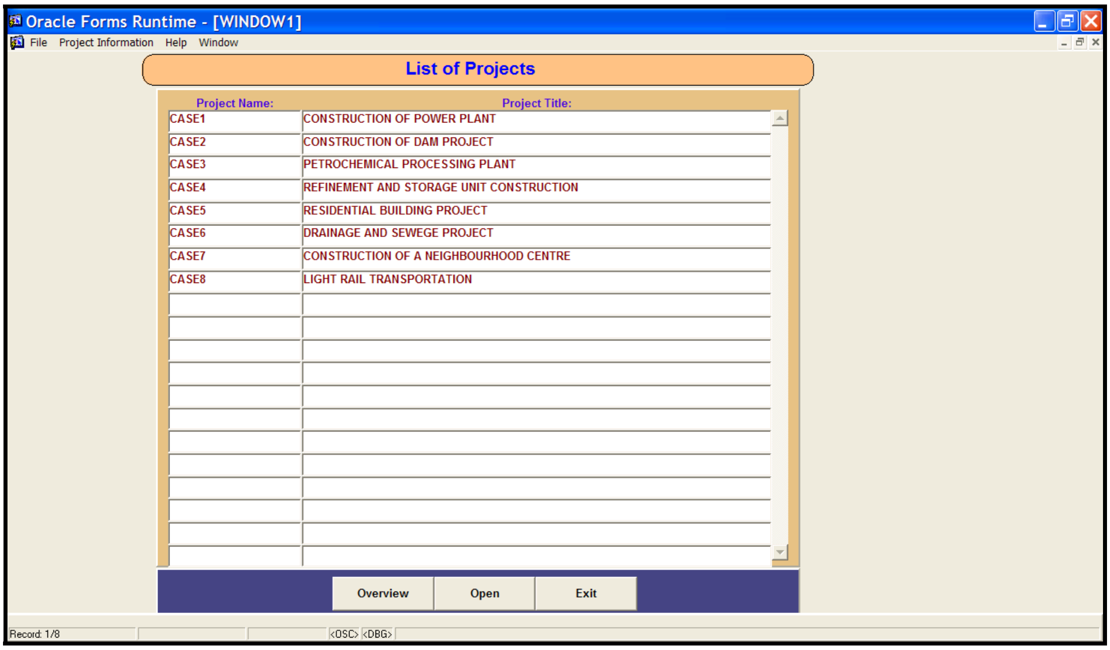


Figure 4.17 The List of the Saved Projects into the Application

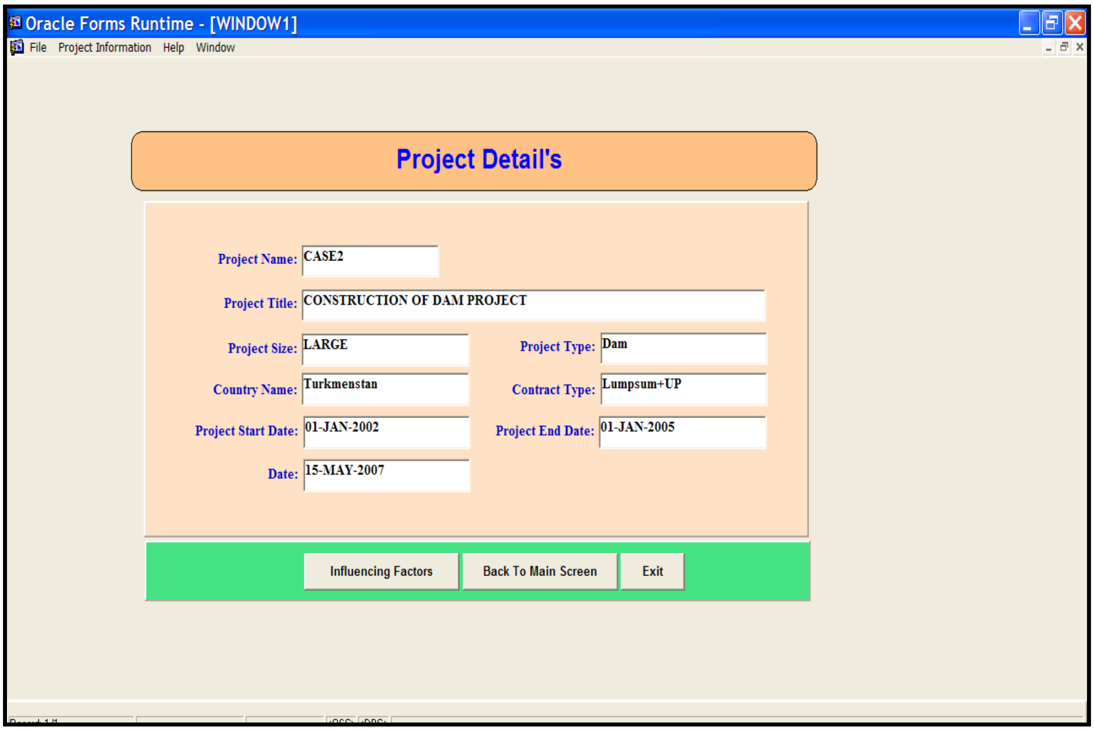


Figure 4.18. The Project Details of a Saved Project

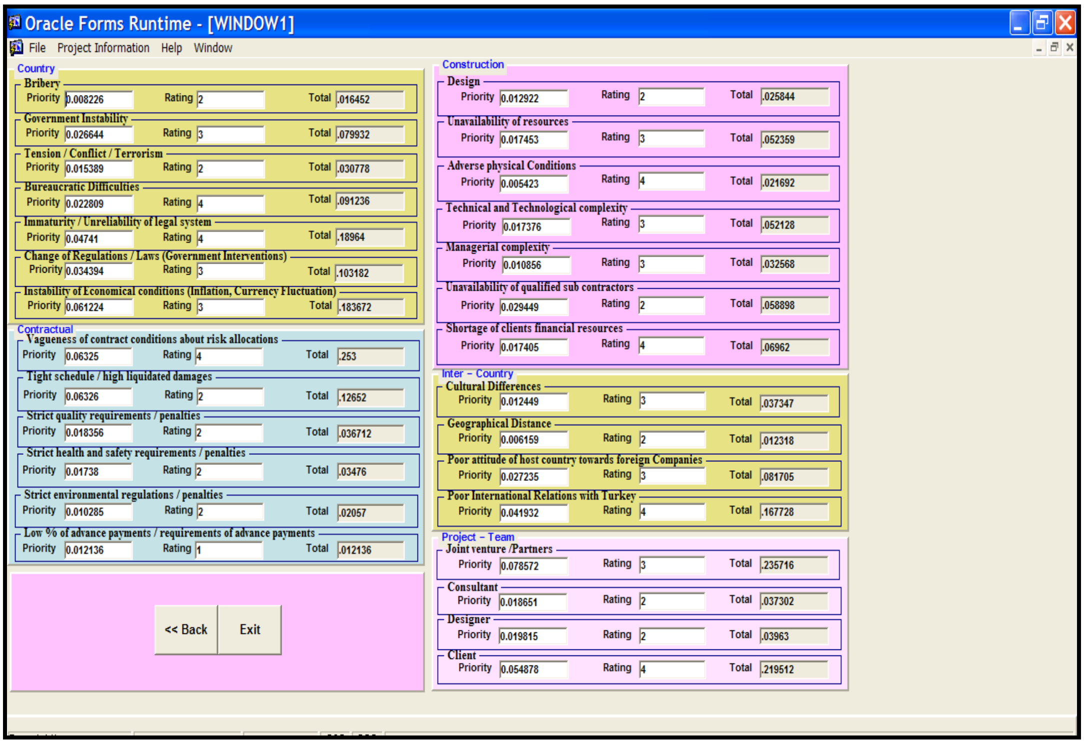


Figure 4.19. The Risk Rating of a Saved Project

The ICPRR software application was developed to serve two key objectives, to validate the derived priorities of the risk factors from the ANP model and to provide a tool that support organizational learning (OL). This part of the application was built-in to facilitate the second objective. OL can be defined as an intentional and unintentional organizational process, which enables the acquisition of, access to, and revision of organizational memory (OM) and finally guides organizational action (Ozorhon et al., 2005). Where, OM is defined as the means by which knowledge from the past is brought to bear on present activities (Ozorhon et al., 2005). Ozorhon et al. (2005) have further explained that OM assists learning from previous experience*,* and they have added that "OM can become an organization asset by capturing, organizing, disseminating, and reusing the knowledge created by its employees". An essential advantage which can be gained from OM is connecting decision making from previous situations and present ones, which will have direct influence on the decision making performance within the organization (Ozorhon et al., 2005).

In consequence of the unique nature of the construction industry, where it is known to be project-based, developed from divers, dispersed, and discontinues activities, it is believed that implementing OL within the construction organization is not an easy task. Thus, construction organizations need to implement the required assistance to facilitate adequate OM formation and effective utilization (Ozorhon et al., 2005). The developed ICPRR application provides an effective tool to enhance the OM formation, since it is structured to develop a reliable database for post-projects risk information. Thus, when a new project is available the decision maker can not only derive the expected risk associated with the project but can also check for potential problems by viewing post-projects information which where previously entered.

4.2 Validating the Analytic Network Process Model Outcomes

One of the main drivers behind developing the ICPRR application, besides presenting an organizational memory tool, is to validate the derived relative priorities of the risk factors from the ANP model as was built in the *SUPERDECISIONS* software.

Thus, the incorporated priorities within the ICPRR was planned to be tested by collecting risk data of post-projects to check the reliability of the derived priorities of the risk factors to predict the risk rating. A total of 8 post-projects data was collected. The ICPRR application was used to calculate the risk rating for the case studies to compare the derived values with the ones obtained from the experts' judgments.

The priorities of the risk factors as was obtained from the ICRM were depicted earlier in Figures 3.15a and 3.15b. Since the ICRM has accounted for the dependencies between the risk factors, it should be emphasized that the derived values are relative rather than absolute. The results show that the risk of vague contract conditions about risk allocation is the most critical risk source that may be encountered in the international market. Mutual understanding of the parties to the contract conditions and the adequate allocation of risk is an essential asset for successful projects. Client represents another critical source of risk, as the client is involved with many aspects of the project, many experts in the area of construction projects believe that the client related factors has a significant influence on construction time performance (Chan et al., 2004). Moreover, immaturity of legal system, the characteristic of the joint venture (JV), government intervention, tight schedule/high liquidated damages, and instability of economical conditions are another risk sources which were considered among the significant sources. On the other hand, factors such as low % of advance payment, geographical distance, and bribery were assumed according to the experts' judgments that are relatively insignificant; which confirm the findings of previous risk assessment models (Gunhan and Arditi, 2005a; Dikmen et al., 2007b).

However, it should be reminded that these priorities were derived while considering the normal project conditions and disregarding the project type and project delivery system. Thus, a risk rating adjustment methodology was proposed to adjust the risk rating of a given project when the initially assumed project conditions are changed. Accordingly, the software application has included a risk rating adjusting values to count for the potential influencing factors that may increase the project risk level.

The case studies were collected from different sources to give more credibility for the results of the testing process. As was mentioned earlier risk data for 8 post-projects were entered one at a time into the ICPRR application to evaluate the risk level of each project. Table 4.2 shows brief description of these projects. In each case, the expert was asked to assign a performance rating to the risk factors; while using a Likert (1-5) scale. Table 4.3 represents the linguistic values correspondents with each number on the scale. Thus, the experts were asked to assign numerical value that corresponds to the linguistic value that best describes their judgment.

Table 4.2 General Information about the Case Studies

Case	Project Type	Country	Size
CASE1	Power Plant	Jordan	Large
CASE2	Dam	Turkmenistan	Large
CASE3	Petrochemical Processing Plant	Saudi Arabia	Large
CASE4	Refinement and Storage Unit	Turkmenistan	Medium
CASE5	Residential Building	Iraq	Large
CASE6	Drainage and Sewage	UAE	Large
CASE7	Neighborhood Centre	Kuwait	Medium
CASE8	Light Rail Transportation	Poland	Large

Table 4.3 Rating Scale and Linguistic Values

Numerical Value	Linguistic Value
1	Very Low
2	Low
3	Neutral
4	High
5	Very High

Then experts' evaluations of the projects risk level were compared with the values obtained from the ICPRR application. The result of these processes is summarized in Table 4.4. However, Appendix C has included an example of the results obtained from the case studies risk assessment.

The results show that within the 8 cases most of the cases have a % error which is less than 10%. The results were discussed with the experts who have provided the initial risk rating of the post-projects, where they have approved the deviations from their judgments as they have mentioned that the risk rating derived from ICPRR is acceptable from their point of view.

Table 4.4 Summary of the Post-Projects Risk Assessment

Case	Expert Judgment	ICPRR Risk Value	% Error
CASE1	4.0	3.998	0.05%
CASE2	4.0	4.1403	3.50%
CASE3	3.5	3.010	14.01%
CASE4	3.0	3.255	8.49%
CASE5	4.5	4.904	8.98%
CASE6	3.5	3.526	0.743%
CASE7	4.0	3.701	7.475%
CASE8	3.8	3.807	0.184%

The only case which has resulted in an error exceeding 10% was CASE3; this result was discussed with the expert, who has provided the judgment for the risk rating that this case should capture, to stand on the reasons behind this result. The expert has referred this error to the different approaches of evaluating the project risk; he further stated that even with the relatively high % of error he would accept the result obtained from the ICPRR.

However, it should be perceived that the relative priorities which were derived from the ICRM and the risk rating adjusting values incorporated into the ICPRR application are resulted from experts' judgments and are subject to change if another group of experts are to be interviewed. Yet, these specific derived values have proven to be acceptable according to the results revealed in Table 4.4. Yet again, to consider the application as a reliable decision support tool it should be further tested with more post-project risk data, since the low number of the data collected can not justify the reliability of the application even when the results obtained were accepted by the experts. However, it can be argued that systematic approach in assessing risk associated with international construction projects would reduce the subjectivity inherent within decision making which are influenced by the risk level of the project such as bidding decisions (bid mark up and bid/no bid decisions).

CHAPTER 5

CONCLUSION

Through this research, an innovative approach of implementing the analytic network process (ANP) technique to assess risk associated with international construction projects, which are conducted by Turkish construction organizations, was proposed. Moreover, this thesis was aimed to achieve two fundamental objectives. At the start, the target was to develop a risk assessment model for international construction projects using the ANP technique to derive the relative priorities of the risk factors associated with international construction projects performed by Turkish construction organizations. Then, an organizational learning (OL) tool was to be presented through developing a software application that facilitate the formation of the organizational memory (OM) by developing a database for post-project risk information, this software application is expected to enhance the decision making process within a construction organization. Besides, the developed software was meant to validate the priorities of the risk factors which will be found from the ANP model. The development process of the ANP model has contained the acceptance of several essential assumptions which were assumed to smooth the progress of implementing the ANP technique. Thus, the ANP model was structured with assuming that the construction organization has adequate experience capabilities to conduct the project abroad and sufficient amount of project data will be available at the outset. What is more, during the assessment process of the 28 risk factors which were included in the ANP model, it was assumed that the contract type and the project delivery system influence on the importance of the risk factors can be ignored throughout the assessment process. That is, the derived priorities were obtained while disregarding these two factors.

Another essential fact that should be revealed is that the risk assessment model developed with the assistance of the ANP technique was proposed to provide a general framework for the assessment of risk associated with international construction projects conducted by Turkish contractors. Thus, even though the ANP technique can best handle the situations where several alternatives exist and the aim is to synthesize the alternatives to choose the best suitable one. Yet, for the context of this thesis, the ANP model was never meant to include alternatives, but it was built to derive general relative priorities of the risk factors which can be applied to any international construction project.

A questionnaire was prepared and performed in several brainstorming sessions with three Turkish experts in international construction projects. The main component of the questionnaire was structured from the comparison matrices obtained from the ANP model which was developed with the *SUPERDECISIONS* software. The findings of the questionnaire, as were entered into the ANP model, revealed that for Turkish contractors who perform construction activities abroad the most significant risk source they may face would be the "vagueness of contract conditions about risk allocation", it has achieved the highest relative priority with a value of (0.1516). The importance of this factor stems from the critical need to reach mutual understanding between the contracting parties of risk responsibility and accountability. The absence of identical understanding of risk accountability between the parties will results in negligence of risk event; since parties will assume that the risk event or its consequence is out of their responsibility coverage. The second most important risk is the "client" with a relative priority of (0.0852). Moreover, immaturity of legal system, the characteristic of the joint venture (JV), government intervention, tight schedule/high liquidated damages, and instability of economical conditions are another risk sources which were considered among the significant sources. On the other hand, factors such as low % of advance payment, geographical distance, and bribery were assumed according to the experts' judgments that are relatively insignificant. The priorities of the risk factors as obtained from the ANP model was revealed in Chapter 3.

The development process of the risk assessment model together with the discussion sessions which were conducted with international construction experts, have resulted in the succeeding facts;

- The ANP technique is a very handy tool for the situations where several attributes exist and the decision needs to be taken while counting for all these elements and their complex interrelated nature. However, as the number of elements and their relations to other elements in the system increase, the problem becomes more complicated; since the number and the size of comparison matrices would increase accordingly. Thus, before deciding to implement the ANP technique the problem under consideration should be adequately analyzed and made sure that it can not be best handled with analytic hierarchy process (AHP) or any other less complicated techniques. Moreover, when it is decided to utilize the ANP technique it is crucial to accurately define the relationships between the elements that structure the model, since the nature of the network will have direct influence on the derived results, and different outcomes will result from different networks.
- The assumptions which have been made through the steps that were undertaken to structure the ANP model required that the outputs must be further adjusted for the several available influencing factors that would increase the risk level of the project; yet it could not be incorporated into the ANP model effectively.
- The proposed risk assessment methodology has regarded risk, yet it did not consider opportunities or the issue of competitiveness in the aimed market. Thus, the proposed risk rating should be further evaluated while considering opportunities and competitiveness in order to decide on the most attractive project and the optimum risk markup.

- The risk assessment methodology is structured to derive a risk rating value that indicates the level of risk level of a given international project. Thus, the result of the assessment process can not provide the value of risk markup; nevertheless it can assist the decision maker in choosing the most appropriate one.

To increase the trustworthiness of the derived risk rating a risk rating adjustment methodology was incorporated into the ICPRR application were a risk rating adjustment value is assigned to each different state of the influencing factors. However, it should be perceived that the default relative priorities which were derived from the risk assessment model (ICRM) and the risk rating adjusting values incorporated into the ICPRR application are resulted from experts' judgments and are subject to change if another group of experts are to be interviewed.

On the other hand, the proposed risk assessment methodology represented in the developed ICRM risk assessment model together with the ICPRR software application, would provide two key advantages when implemented for the bidding decision process (i.e. bid/no bid and bid markup decisions) which is related to international construction, these advantages can be stated as;

- The subjectivity associated with decision making related to bidding process will be reduced, since the decision maker will be provided with a depiction on the level of risk that may be incorporated with the examined project. The results obtained from the case studies have indicated that the ICPRR application has provided acceptable risk rating value.
- The ICPRR application represents an effective organizational learning tool, as it will enhance organizational memory formation. The application can be used to store risk information for several projects and then these information can be referred when needed.

Thus, a database for previous projects risk information can be developed which may be used in visualizing the expected risks in the forthcoming projects. The information provided when entering new project will facilitate future utilization, since the decision maker can look into the stored projects to locate a project that encompass several similarities with the project under consideration.

This study has demonstrated that the ANP technique can be used to assess risk associated with international construction projects efficiently. Nevertheless, it has also revealed that there are several influencing factors which are expected to have an influence on the level of a construction project risk such as; the level of company's experience, the amount of the available project data from the beginning, project delivery system, and contract type. But these factors could not be incorporated into the ANP model effectively. Accordingly, a risk rating adjustment methodology was needed. However, after conducting a questionnaire among construction experts it was found that, and according to the experts' opinion, the influencing factors will only have a considerable influence when they occur in certain combinations.

To close with, the conducted research aimed to provide a reliable risk assessment methodology that overcomes the independence assumption between the risk factors associated with an international construction project. Within this context, the ANP technique was utilized to demonstrate its applicability to handle the complex nature of the risk assessment model. Then, a software application was developed which allows the decision maker to assign a performance rating to each risk source to obtain the overall risk rating after counting for the risk influencing factors. The acceptable results obtained from this application when the case studies were tested revealed that the performance of the application is satisfactory. However, due to the low number of case studies, the application should be further tested with cases that provide different project conditions to be recognized as an effective risk assessment tool. Further, when this application is adopted within an organization it can be customized to best facilitate the organization needs. Yet, it can be said that one of the shortcomings of this study is that the tool's ability to facilitate OL could not be tested.

The tool should never be considered as a generic tool. Similarly, the information fed into the software should be treated as subjective information that may change with respect to different decision makers.

Thus, the conceptual risk breakdown structure may be revised to include other risk sources, the application could also be adjusted to include more risk information which can be used to generate a post-project evaluation report that includes the information about risk events encountered within the project, the consequences of the risk events, and the implemented response strategies and their level of success.

Finally, the incorporated risk factors' priorities are subject to change according to the decision maker preferences as long as they are normalized to maintain accuracy in the mathematical calculations, even the default risk rating adjusting values are not fixed they can be changed to reflect the specific requirements of a given organization. Thus, this study has proposed a general framework for an effective risk assessment methodology, where the mainstream of the development process can be followed by a construction organization to build a risk assessment model that best reflects its objectives.

REFERENCES

Ahmed, I. (1990), "Decision-Support System for Modeling Bid/No-Bid Decision Problems", ASCE Journal of Construction Engineering and Management, 116(4), pp. 595-608.

Arditi, D. (2007), "The Delphi Method" [online]. Illinois Institute of Technology, Department of Civil and Architectural Engineering, [cited 28 April 2007]. Available from: http://www.iit.edu/~it/delphi.html.

Ashley, D.B., and Bonner, J.J. (1987), "Political Risks in International Construction", ASCE Journal of Construction Engineering and Management, 113(3), pp. 447-467.

Baker, S., Ponniah, D., and Smith, S. (1999), "Survey of Risk Management in Major U.K. Companies", ASCE Journal of Professional Issues in Engineering Education and Practice, 125(3), pp. 94-102.

Barrie, D.S., and Paulson, B.C. (1992), "Professional Construction Management", 3rd Edition, International Edition, McGraw-Hill, Inc.

Bing, L., and Tiong, R.L.K. (1999), "Risk Management Model for International Construction Joint Ventures", ASCE Journal of Construction Engineering and Management, 125(5), pp. 377-384.

Bu-Qammaz, A.S., Dikmen, I., and Birgonul, M.T. (2006), "Cultural Risk Assessment in Construction Projects", Proceedings of the Joint International Conference on Construction Culture, Innovation and Management (CCIM), 26-29 November, The British University of Dubai, UAE, pp.157-167.

Chan, A.P.C., Scott, D., and Chan, A.P.L. (2004), "Factors Affecting the Success of a Construction Project", ASCE Journal of Construction Engineering and Management, 130(1), pp. 153-155.

Chance, D.M. (2004), "Teaching Note 96-03: Monte Carlo Simulation", Louisiana State University, E.J. Ourso College of Business, Finance Department.

Cheng, E.W.L., and Li, H. (2005), "Analytic Network Process Applied to Project Selection", ASCE Journal of Construction Engineering and Management, 131(4), pp. 459-466.

Dikmen, I., and Birgonul, M.T. (2004), "Neural Network Model to Support International Market Entry Decisions", ASCE Journal of Construction Engineering and Management, 130(1), pp. 59-66.

Dikmen, I., and Birgonul, M.T. (2006), "An Analytic Hierarchy Process based model for risk and opportunity assessment of international construction projects", Canadian Journal of Civil Engineering, 33 (1), pp. 58-68.

Dikmen, I., Birgonul, M.T., and Han, S. (2007a), "Using Fuzzy Risk Assessment to Rate Cost Overrun Risk in International Construction Projects", International Journal of Project Management, 25(5), pp. 494-505.

Dikmen, I., Birgonul, M.T., and Gur, A.K. (2007b), "A Case-Based Decision Support Tool for Bid Mark-up Estimation of International Construction Projects", Automation in Construction (accepted and waitlisted for publication).

Dozzi, S.P., AbouRizk, S.M., and Schroeder, S.L. (1996), "Utility-Theory Model for Bid Markup Decisions", ASCE Journal of Construction Engineering and Management, 122(2), pp. 119-124.

Erb, C.B., Harvey, C.R., and Viskanta, T.E. (1996), "Political Risk, Economic Risk, and Financial Risk", Financial Analysis Journal, 52(6), pp. 28-46.

Farlex, Inc. (2007), "The Free Dictionary" [online]. [cited 22 February 2007]. Available from: http://www.thefreedictionary.com.

Fellow, R., and Liu, A. (2006), "Culture as a Category of Risk in Construction", Proceedings of the Joint International Conference on Construction Culture, Innovation and Management (CCIM), 26-29 November, The British University of Dubai, UAE, pp. 138-147.

Gunhan, S., and Arditi, D. (2005a), "Factors affecting international construction", ASCE Journal of Construction Engineering and Management, 131(3), pp. 73-82.

Gunhan, S., and Arditi, D. (2005b), "International Expansion Decision for Construction Companies", ASCE Journal of Construction Engineering and Management, 131(8), pp. 928-937.

Han, S.H, and Diekmann, J.E. (2001) "Approaches for Making Risk-Based Go/No-Go Decision for International Projects", ASCE Journal of Construction Engineering and Management, 127(4), pp. 300-308.

Han, S.H., Diekmann, J.E., Lee, Y., and Ock, J.H. (2004), "Multicriteria Financial Portfolio Risk Management for International Projects", ASCE Journal of Construction Engineering and Management, 130 (3), pp. 346-356.

Han, S.H., Diekmann, J.E., and Ock, J.H. (2005), "Contractor's Risk Attitudes in the Selection of International Construction Projects", ASCE Journal of Construction Engineering and Management, 131(3), pp. 283-292.

Hastak, M., and Shaked, A. (2000), "ICRAM-1: Model for international construction risk assessment", ASCE Journal of Management in Engineering, 16 (1), pp. 59-69.

Hillson, D. (2002), "What Is Risk? Towards a Common Definition", InfoRM, Journal of the U.K. Institute of Risk Management, pp. 11-12.

Hillson, D. (2003), "Using a Risk Breakdown Structure in Project Management", Journal of Facilities Management, 2(1), pp. 85-97.

Hillson, D., and Hulett, D. (2004), "Assessing Risk Probability: Alternative Approaches", PMI Global Congress Proceedings – Prague, Czech Republic.

Hillson, D. (2005), "When Is a Risk Not a Risk?", IPMA Project Management Practice, 1, pp. 6-7.

Hillson, D. (2006), "The Risk Management Universe – A Guided Tour", BSI Publication.

Hillson, D., and Murray-Webster, R. (2006), "Managing Risk Attitude using Emotional Literacy", Proceedings of the PMI Global Congress EMEA, Madrid, Spain.

Hillson, D., and Murray-Webster, R. (2007a), "Understanding and Managing Risk Attitude", Gower Publishing.

Hillson, D., and Murray-Webster, R. (2007b), "Risk Attitude" [online]. [cited 25 April 2007] .Available from: http://www.risk-attitude.com.

Hitchings, J., and Wilson, S. (2002), "Risk Management", The Institute of Civil Engineers, ICE Management Board and Commercial Management Board, Briefing Paper.

Hulett, D., and Hillson, D. (2006), "Branching Out: Decision Trees Offer a Realistic Approach to Risk Analysis", PM Network, Project Management Institute, 20(5), pp.34-38.

Institute of Civil Engineers (ICE), Faculty of Actuaries, and Institute of Actuaries (2007), "Risk Analysis and Management for Projects (RAMP)" [online]. [cited 25 April 2007] .Available from: www.ramprisk.com.

Institute of Risk Management (IRM), Association of Insurance and Risk Managers (AIRMIC), and National Forum for Risk Management in the Public Sector (ALARM). (2002), "A Risk Management standard", Published by AIRMIC, ALARM, IRM.

Isacsson, I, Kullberg, T., and Lasson, R. (2004), "Motives for Choosing a Currency in International Business", Bachelor Degree Dissertation at the International Business Programme, the Kristianstad Business School, Sweden.

Jaafari, A. (2001), "Management of Risks, Uncertainties, and Opportunities on Projects: Time for a Fundamental Shift", International Journal of Project Management, 19, 89-101.

Kapila, P., and Hendrickson, C. (2001), "Exchange Rate Risk Management in International Construction Ventures", ASCE Journal of Management in Engineering, 17(4), pp.186-191.

Kartam, N.A., and Kartam, S.A. (2001), "Risk and its Management in the Kuwaiti Construction Industry: a Contractors' Perspective", International Journal of Project Management, 19, pp. 325-335.

Ling, F.Y.Y., and Lim, S.S.Y. (2006), "Cross-Cultural Encounters When Managing Projects in China", Proceedings of the Joint International Conference on Construction Culture, Innovation and Management (CCIM), 26-29 November, The British University of Dubai, UAE, pp. 885-893.

Mahalingam, A., and Levitt, R. (2005) "Understanding and Mitigating Challenges on Global Projects: the Role of the Freelance Expatriate", ASCE Construction Research Congress, 5-7 April, San Diego, CA.

Mohamed, S. (2003), "Performance in International Construction Joint Ventures: Modeling Perspective", ASCE Journal of Construction Engineering and Management, 129(6), pp. 619-626.

Nasir, D., McCabe, B., and Hartono, L. (2003), "Evaluating Risk in Construction-Schedule Model (ERIC-S): Construction Schedule Risk Model", ASCE Journal of Construction Engineering and Management, 129(5), pp.518-527.

Olatuanji, O.A. (2006), "Assessing Client's Confidence and Satisfaction in Construction Professionals in Nigeria" Proceedings of the Joint International Conference on Construction Culture, Innovation and Management (CCIM), 26-29 November, The British University of Dubai, UAE, pp.436-445.

Öz, Ö. (2001), "Sources of Competitive Advantage of Turkish Construction Companies in International Markets", Construction Management and Economics, 19, pp.135-144.

Ozorhon, B., Dikmen, I., and Birgonul, M.T. (2005), "Organizational Memory Formation and its Use in Construction", Building Research and Information, 33(1), pp. 67-79.

Project Management Institute (PMI). (1996), "A Guide to the Project Management Body of Knowledge (PMBOK® Guide)", Project Management Institute Publishing Division, Four Campus Boulevard, Newton Square, PA, USA.

Project Management Institute (PMI). (2004), "A Guide to the Project Management Body of Knowledge (PMBOK® Guide)", Third Edition, Project Management Institute Publishing Division, Four Campus Boulevard, Newton Square, PA, USA.

Raz, T., and Hillson, D. (2005), "A Comparative Review of Risk Management Standards", Risk Management: An International Journal, 8(1), pp.61-76.

Saaty, R.W. (2003), "Decision Making in Complex Environments, the Analytic Hierarchy Process (AHP) for Decision Making and the Analytic Network Process (ANP) for Decision Making with Dependence and Feedback", The Creative Decisions Foundation, 4922 Ellsworth Avenue, Pittsburgh, USA.

Saaty, T. L. (2005), "Theory and Applications of the Analytic Network Process: Decision Making with Benefits, Opportunities, Costs, and Risks", USA: RWS Publications.

Saaty, T.L., and Niemira, M.P. (2006), "A Framework for Making Better Decisions", Research Review, 13(1), pp. 44-48.

Schuette, S.D., and Liska, R.W. (1994), "Building Construction Estimation", McGraw-Hill, Inc.

Smith, G.R., and Bohn C.M. (1999), "Small to Medium Contractor Contingency and Assumption of Risk", ASCE Journal of Construction Engineering and Management, 125 (2), pp. 101-108.

Tah, J.H., and Carr, V. (2000), "Information Modeling for A Construction Project Management System", Engineering, Construction and Architecture Management 7(2), pp. 107-119.

Wang, S.Q., Dulaimi, M.F., and Aguria, M.Y. (2004), "Risk Management Framework for Construction Project in Developing Countries", Construction Management and Economics, 22(3), pp. 237-252.

Yu, R., and Tzeng, G.H. (2006), "A Soft Computing Method for Multi-Criteria Decision Making with Dependence and Feedback", Applied Mathematics and Computation, Elsevier Inc., 180(1), pp. 63-75.

APPENDIX A

SAMPLE OF THE ANP MODEL QUESTIONNAIRE

- For each comparison matrix the control criterion (sub-criterion) and the parent node will be introduced together with the child nodes (Risk factors listed in the comparison matrices) regarding this parent node, the child nodes are assumed to be influenced by the parent node.
- The comparisons should use the fundamental scale for making Judgments Proposed by Saaty which uses 1-9 scale, the linguistic values for each number on this scale is represented in Table A.1.
- In the next presented comparison matrices the shaded fields do not need to be filled.

Table A.1 The Fundamental Scale of Making Judgments

Numerical Value	Linguistic Value
1	Equal
2	Between Equal and Moderate
3	Moderate
4	Between Moderate and Strong
5	Strong
6	Between Strong and Very Strong
7	Very Strong
8	Between Very Strong and Extreme
9	Extreme

SECTION A

NODE COMPARISONS

1. Comparison Matrices with Respect to "*Client*" Factor in "*Project Team*" Cluster

1.1 Compare risk factors in "***Project Team***" cluster, which factor is likely to have more influence on the level of "***Project Team Risk***" if the ***"Client"*** is assumed to be source of risk to the contractor?

	Designer	**Joint Venture/ Partner**
Consultant		
Designer		

1.2 Compare risk factors in "***Construction***" cluster, which factor is likely to have more influence on the level of "***Construction Risk***" if the **"Client"** is assumed to be source of risk to the contractor?

	Managerial Complexity	**Shortage of Client's Financial Resources**	**Unavailability of Subcontractors**	**Unavailability of Resources**
Adverse Physical Conditions				
Managerial Complexity				
Shortage of Client Financial Resources				
Unavailability of Subcontractors				

1.3 Compare risk factors in "***Country***" cluster, which factor is likely to have more influence on the level of "***Country Risk***" if the ***"Client"*** is assumed to be source of risk to the contractor?

	Bureaucratic Difficulties	**Immaturity/ Unreliability of Legal System**	**Instability of Economical Conditions**	**Tension/ Conflict/ Terrorism**
Bribery				
Bureaucratic Difficulties				
Immaturity/ Unreliability of Legal System				
Instability of Econ. Condit.				

1.4 Compare risk factors in "***Inter-Country***" cluster, which factor is likely to have more influence on the level of "***Inter-Country Risk***" if the ***"Client"*** is assumed to be source of risk to the contractor?

	Poor Attitude of Host Country Towards Foreign Companies	**Poor International Relations With Turkey**
Cultural Differences		
Poor Attitude of Host Country Towards Foreign Companies		

1.5 Compare risk factors in "***Contractual***" cluster, which factor is likely to have more influence on the level of "***Contractual Risk***" if the ***"Client"*** is assumed to be source of risk to the contractor?

	Tight Schedule/ High Liquidated Damages	**Vagueness of Contract Conditions about Risk Allocation**
Strict Quality Requirements/Penalties		
Tight Schedule/ High Liquidated Damages		

SECTION B

CLUSTER COMPARISONS

1. Comparison with respect to The Goal (i.e. International Construction Project Risk)

Compare the clusters in the following matrix according to their influence on the level of the international construction project risk (ICPR)

	Project Team	**Construction**	**Country**	**Inter-Country**	**Contractual**
Company					
Project Team					
Construction					
Country					
Inter-Country					

APPENDIX B

SAMPLE OF THE RISK RATING ADJUSTMENT METHODOLOGY QUISTIONNAIRE

For a construction project which its risk rating found to be ***average*** under the normal conditions (i.e. the contractor has enough experience to conduct it, and fair project data was available at the outset), it is assumed that the risk rating is influenced by several influencing factors that would increase the risk level of the project. These factors are: different state of company's experience (i.e. experience of the company is ***Low***), Contract Type (CT), No Sufficient Data is Available from the beginning (DA), and Project Delivery System (PDS). Figure B.1 explains the influencing factors.

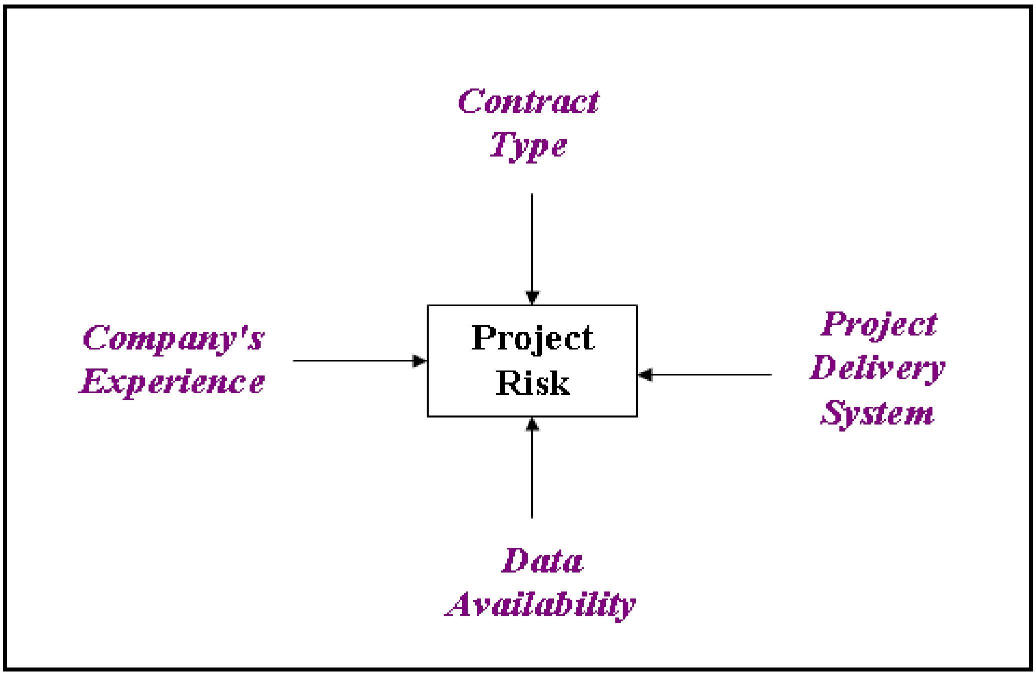


Figure B.1. Influencing Factors on International Construction Project Risk

On the other hand, it is assumed that company's experience influence depends on the level of risk; therefore adjusting the risk rating for a given project with respect to the company's experience should be with adding to project risk certain percentage from the risk rating.

However, for the remaining factors it is believed that their influence is independent from the level of risk that is their influence is reflected by adjusting the level of risk by certain amount regardless of the project risk level.
According to the previous explanation, there shall be 2 types of adjustments; the first with regard to the company experience and is expressed with % from the risk rating, while the second is with regard to the CT, DA, and PDS influencing factors and is reflected by predicting what should be the risk rating of an average project if certain combination of these three factors exists. Figure B.2 Depicts the Risk Rating Adjustment Methodology.

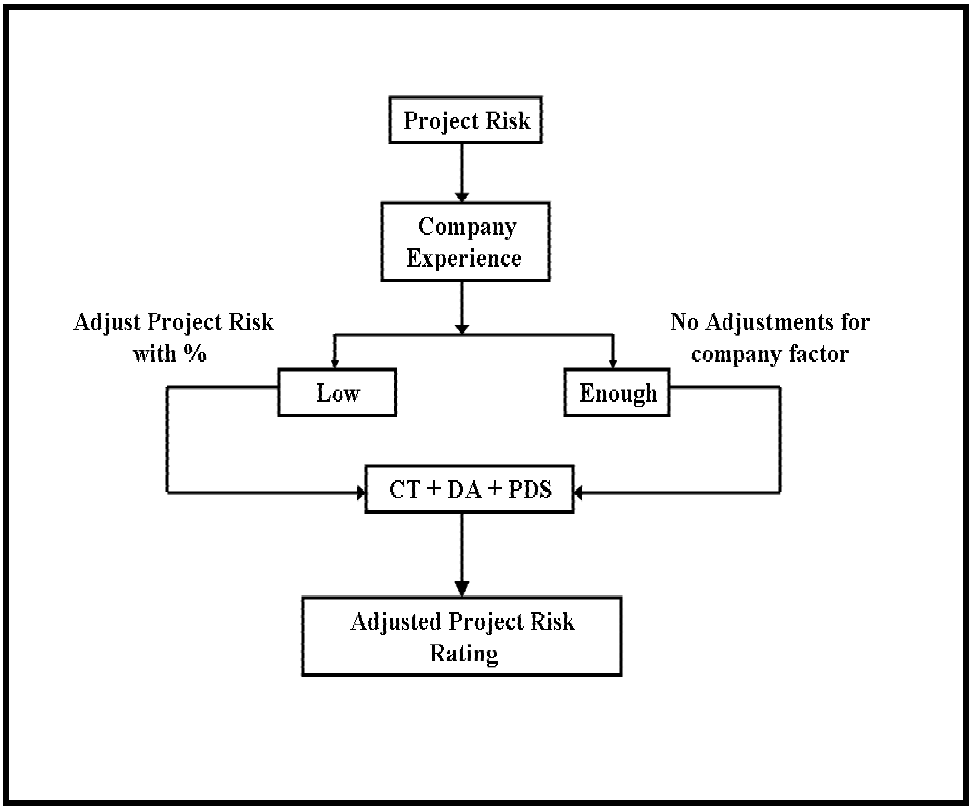


Figure B.2: Risk Rating Adjustment Methodology

☒ Adjusting an ***average*** risk rating for a project when the company's experience is ***Low*** (the contractor does not have a sufficient experience to conduct the project)

- According to your own judgment, with what percentage (%) from the overall risk rating should the project risk be adjusted if the contractor has no sufficient experience to conduct the project? (..............................%)

☒ Adjusting an ***average*** risk rating for a project when the following combinations exist:

- According to your own judgment, give the overall risk rating that the project should have if the following state of influencing factors exists (Please write the total risk rating that you believe an average project should have in the empty box)

CT	LS	
DA	Yes	
PDS	DBB	

LS = Lump-Sum, Yes = Sufficient Data Available, and DBB= Design-Bid-Build

- According to your own judgment, give the overall risk rating that the project should have if the following state of influencing factors exists (Please write the total risk rating that you believe an average project should have in the empty box)

CT	LS	
DA	No	
PDS	DB	

No = No Sufficient Data Available, and DB= Design-Build

APPENDIX C

SAMPLE FROM THE RISK RATING RESULTS OF THE CASE STUDIES

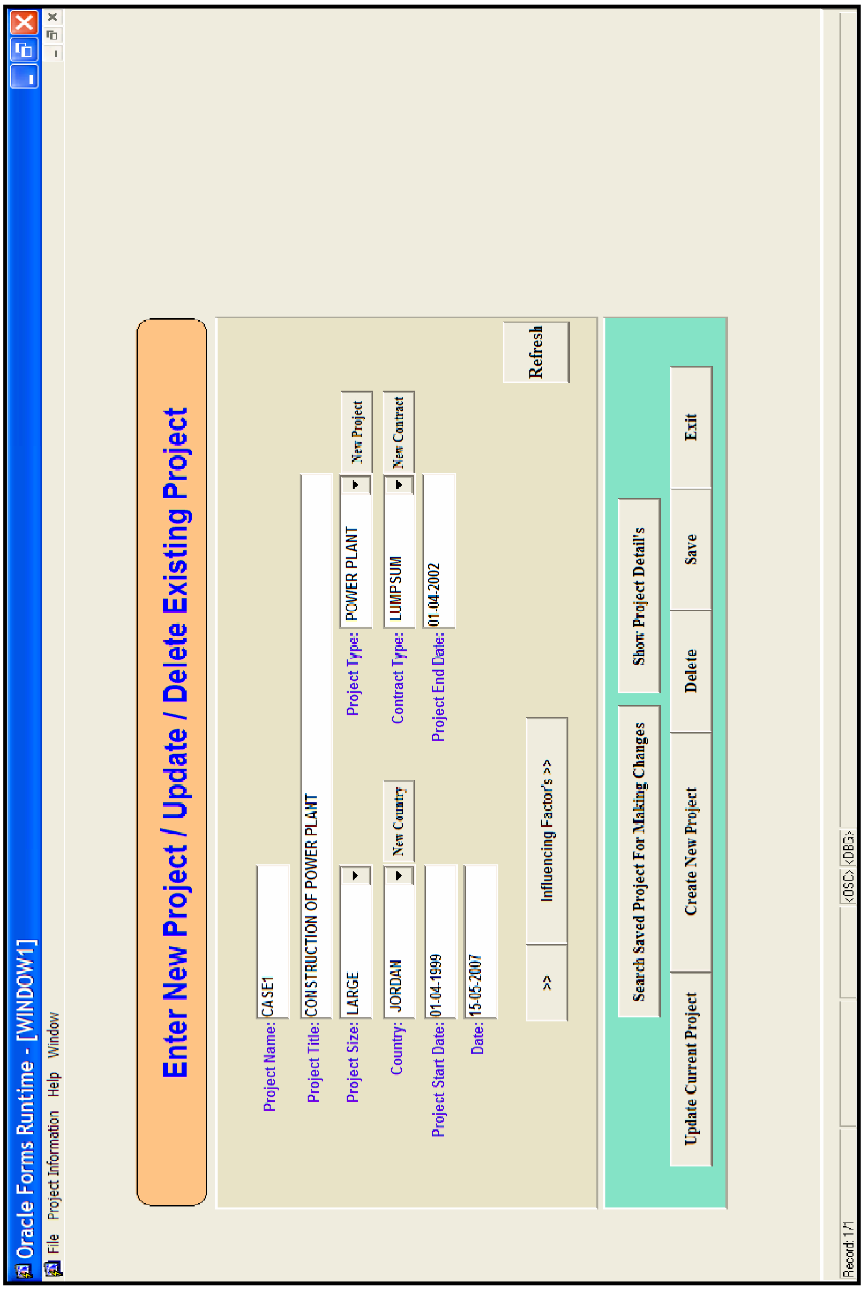


Figure C.1. CASE1 Project Information

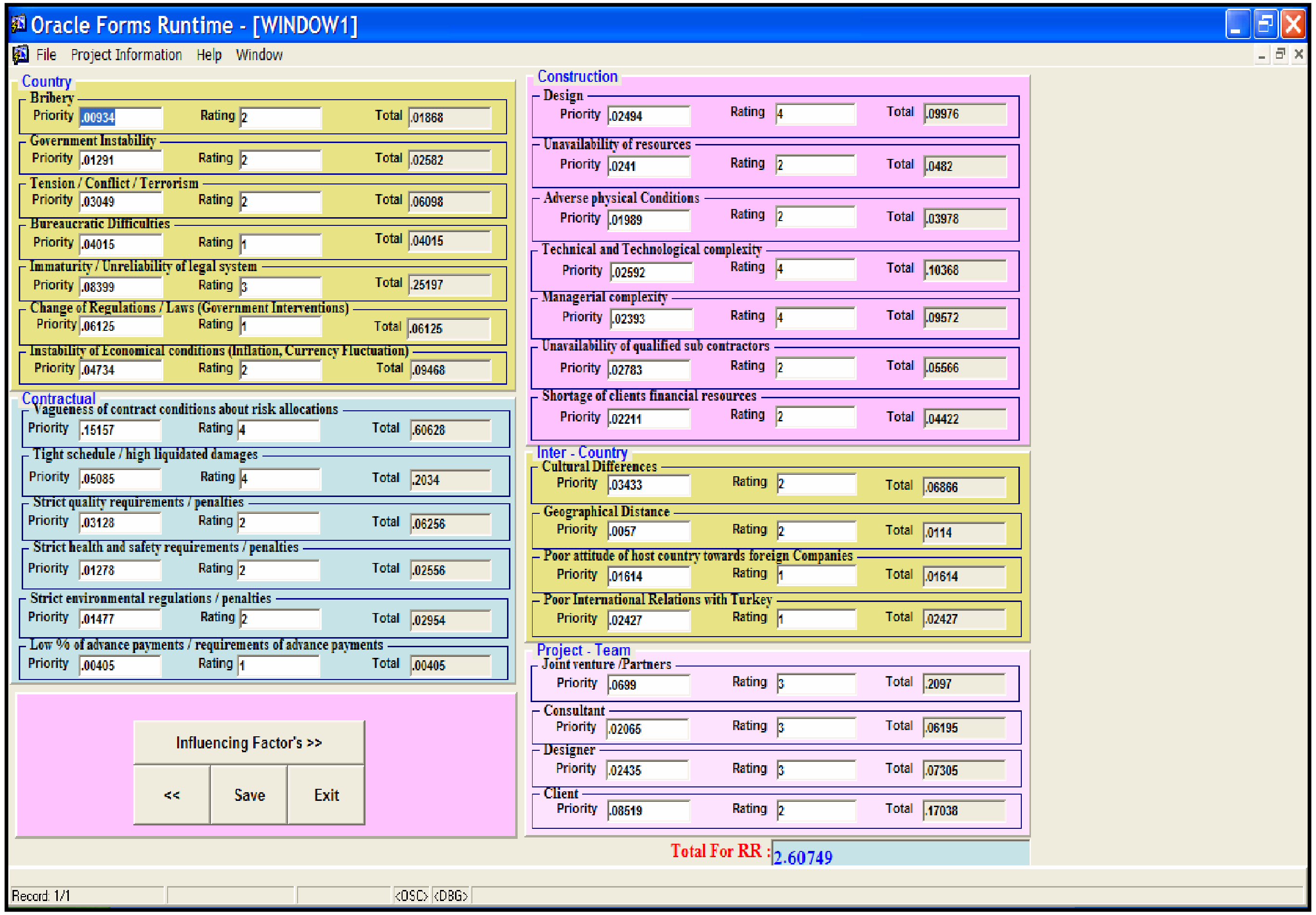


Figure C.2. CASE1 Initial Risk Rating

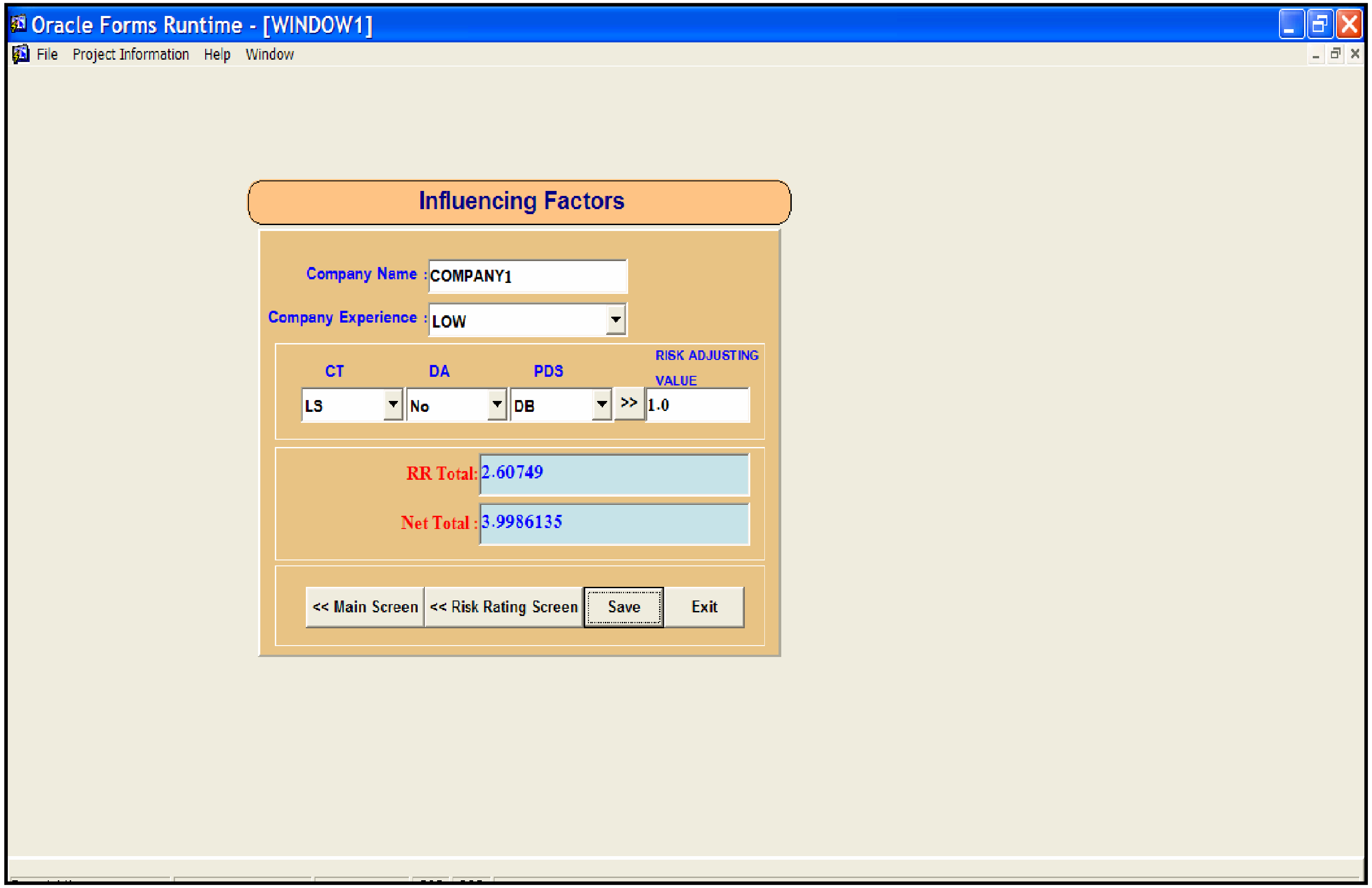


Figure C.3. CASE1 Adjusted Risk Rating for Influencing Factors