Defining Supply Chain Risk Management in Iranian Construction Industry

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ABSTRACT

The journey of supply chain management throughout the last twenty years has been considerable in numerous aspects. Its effect on the way corporate associations strategy business, relation between suppliers and clients, and manage the entire process of satisfying demand has had a significant impact on an organization's capability to compete and produce benefit. However, it is the way in which it has influenced all our lives dramatically, from our desires of client service, low price with high quality goods and instant accessibility that is maybe, the most remarkable part of this revolutionary practice in management. Supply Chain Management has increased in popularity due to some causes such as technological innovation, trend of reducing costs and global competition. Many high technology firms have begun to hire experts who can generate sustainable supply chain. Nevertheless, in developing countries, criteria are completely different. Iranian construction industry in terms of supply chain management involves the complex challenges of moving goods, on time and on budget, to ensure they arrive when and where they should. They cope with risk as unstructured and ill defined. Process performance is unpredictable. Client satisfaction is seriously low.

The purpose of this research is investigating potential risks on Iranian construction supply chain management. Totally, thirty-two risks were identified and categorized by risk breakdown structure. Probability and impact matrix was chosen to analyze and prioritize identified risks. The obstacles were found to be lack of awareness of supply chain management and risk management both sides, academic and practice and also political issues resulted in tough sanctions, which make significant problems to knowledge and technology exchange.

Keywords: Iranian construction industry, PIM, Supply chain management, Supply chain risk process.

ÖZ

Son yirmi yıldır Tedarik Zinciri Yönetiminin gelişimi dikkate alınan önemsenen bir husustur. Kurumsal ortaklıkların işletme stratejilerindeki tedarikçileri ve müşterileri ile aralarındaki ilişkinin kurulmasında, bu sürecin yönetilmesinde, organizasyonun kar elde etme ve rekabet edebilmesi konularında çok önemli etkilere sahiptir. Bununla birlikte, hepimizin hayatını etkileyen, müşteri servislerinden arzuladığımız iyi kalite ürünü düşük fiyata almak ve ürüne anında erişebilme devrim niteliğindeki bu yönetim biçiminin en hatırısayılır kısmıdır. Tedarik Zinciri Yönetimi, teknolojik yenilikler, maliyeti azaltma trentleri ve küresel rekabet gibi nedenlerle popülaritesini artırmaktadır. Birçok yüksek teknoloji firmaları sürdürülebilir tedarik zinciri yaratmada uzman isimleri kiralamaya başlamıştır.

Tüm bunlara ragmen, gelişmekte olan ülkelerde kriterler tamamen değişiktir. İran İnşaat Sektörü Tedarik Zinciri Yönetimi açısından ürünleri bir yerden biryere zamanında ve beklenen bütçe ile taşımada kompleks ve zorlu bir yapıya sahiptir. Bu nedenle, sektördekiler hedeflenen yapıları inşa edememe veya sağlıksız yapılar inşa etme gibi durumlarla başa çıkmak zorunda kalmaktadır. Süreç performansı kestirilemeyecek noktalara gelmekte ve müşteri memnuniyeti oldukça düşük seviyelerde olmaktadır.

Bu çalışmanın amacı, İran İnşaat sektöründeki Tedarik Zinciri Yönetimi ile ilgili zorlukları araştırmaktır. Toplam 32 risk tanımlanmış ve risk ayrışım yapısına göre kategorize edilmiştir. Tanımlanan riskleri analiz edip öncelik sıralarını belirlemede Olasılık ve Etki .matrisi kullanılmıştır. İki tarafında tedarik zinciri yönetimi ve risk

yönetimi konusundaki farkındalık eksikliklerini iyileştirmeye yönelik teknolojik değişimi destekleyen akademik, pratik ve hatta politik faaliyetler sert tepkiler alabilmektedir.

Anahtar Kelimeler: İran İnşaat Sektörü, PIM,Tedarik Zinciri Yönetimi, Tedarik Zinciri Risk Prosesi.

This research project is dedicated to my lovely parents Mr. Habibollah Abedini, Mrs. Mehri Khazaei.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

FMEA	Failure Mode Effects Analysis
FTA	Fault Tree Analysis
PIM	Probability and Impact Matrix
RBS	Risk Breakdown Structure
SCM	Supply Chain Management
SCRM	Supply Chain Risk Management

Chapter 1

INTRODUCTION

1.1 Background Information

The manufacturers could reduce their production costs because of mass production in the 1950s and 1960s. Negligible product or process flexibility were the main problems caused by new products which were created per in house capacity and technology. Within 1970s, the concepts of new material management were presented in order to develop performance and prevent negative impact of huge work on quality, cost and delay in delivery time.

With the growth of trade in 1980s, the manufacturers had to provide high level of quality, high level of flexibility and lower costs, which applied just in time and some management creativity. The result of this attached methodology was the awareness of the potential profits, cooperative relationship between client-supplier and significance of techniques. Therefore, manufacturers started to amplify positive performances and reduced negative activities to experts in these business sectors. According to Tan (2001), the strategy of supply chain management applied specific process by merging of integrated logistics definition and relationship between client and supplier.

In 1990s, improvement of supply chain management was categorized into three stages by Werner (2008):

- Incorporation of capacities of an interior supply chain, which causes an inner methodology and data stream consisting of buying, delivery, technology, funds and creation.
- Companies began to amplify their data exchange among clients and supplier due to using modern IT. More suitable business applications were used and also responsibilities were shifted on the logistics.
- Some planning techniques were implemented such as advanced planning and scheduling.

Besides, supply chain management applied network to connect participants. Exchange of data in real time was stated by García, D., et al. (2003).

The manufacturing industry has developed the concept of supply chain management in the past decades. According to Shingo (1988), the first signals of supply chain management were observed by Toyota manufacturing process. Harland et al. (1999) emphasized that globalization in business industry developed supply chain management (SCM). Also global inflation between 80s and 90s compelled organizations to change plan at practical level, which were added value and reduced costs.

Therefore, many authors and researchers emphasized on adding value and minimizing cost are significant targets in SCM. Saad et al. (2001) mentioned that the methodology of SCM to construction sector needs a huge attempt. It requires developing combination in design, manufacture process and functions to connect the process in a chain attention increasing opportunities to add value and reduce costs.

Changing attitude of participants towards cooperation, mutual profits and teamwork are very important.

Existing risks in supply chain management have several conceptualizations, the character of which is difficult to understand. The literature on risk management suggests some clear explanations (Chiles and Mcmackin, 1996; Holton, 2004). Waters (2007) stated that risk sometimes might happen as a danger to interrupt typical events and prevent certain plan as arranged.

This study has focused on Iranian construction projects as a case. Iran is known as a developing country and many construction projects face variety of threats such as technical, management, organizational, financial and environmental. This study was aimed to survey participants' opinions about how Iranian companies deal with risks on supply chain management.

1.2 Objectives

The purpose of this study is to develop the implementation of supply chain risk management into Iranian construction industry. To do so, the main aims and objectives have been categorized into following items:

- To recognize most fundamental risks and threats which are related to supply chain management systems.
- To prioritize all identified risks by using qualitative methods.
- To propose most important responses and strategies in order to mitigate adverse effects on project goals.

The research question also formulated below in order to acquire these objectives:

i. What is the status of supply chain management on Iranian construction companies?
ii. What are the top supply chain risks, which are highly negative on Iranian construction projects?
iii. What are the main problems and solutions of supply chain management?

1.3 Research Methodology

According to this research, in order to collect data, questionnaire survey was designed and written based on the knowledge of Iranian construction companies as a case study.

This thesis was designed into 2 main subjects. At first, literature review, the chosen case study and preparation of the survey was explained in details. In the second part, questionnaire was distributed among top Iranian construction companies and further on data analysis and discussion are also proposed.

1.4 Achievements

In order to acquire the main objectives, which are mentioned before, the achievements of this research are presented below:

- The most important supply chain risk within Iranian construction industry are divided into five factors; price fluctuation of construction materials, financing issue, tight project schedule, inadequate time scheduling and supplier bankruptcy.
- In order to categorize and prioritize identified risks, qualitative risk analysis was chosen. In this regard, probability and impact matrix was performed to assess and monitor all threats.

- The most important and common response was two main actions; mitigation by decreasing probability or influence of threat on construction project or take the responsibility of managing and controlling risks to third party like insurance or to experts judgment.

1.5 Thesis Outline

This thesis includes six chapters. First of all, introduction presents background information on supply chain risk management and research questions, objectives, works undertaken and achievement respectively.

In the second chapter, the theoretical overview and the past research on supply chain management and its application in construction industry will be explained.

In the third chapter, methodology will be explained and proper method to analyze supply chain risks and organizational performances of supply chain management will be discussed.

In the fourth chapter, all identified risk was prioritized and categorized according to their risk score, which results from questionnaire survey. In this regard, tables and figures were proposed in order to summarize data.

Results and discussions of the data analysis will be discussed in chapter five. Moreover, important notes found by questionnaire and interview will be discussed in details. The most suitable approaches to mitigate and monitor significant risks will finally be presented with regard to research survey.

Finally, chapter six will conclude the study and includes general accomplishments, final discussions and results. At the end, some recommendations for future studies will be presented. To sum up, Figure 1.1 shows the outline of the thesis.

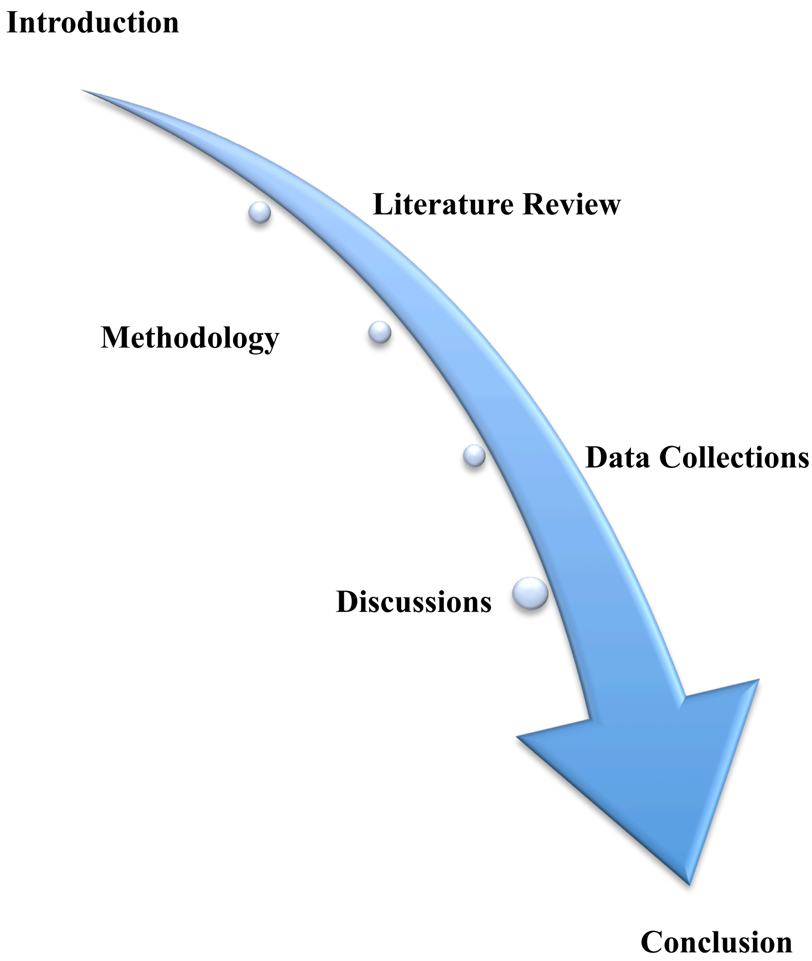

Figure 1.1: Thesis framework

Chapter 2

LITERATURE REVIEW

2.1 Introduction

Supply chain management is being one of the most crucial processes nowadays. Numerous definitions depict supply chain management as the chain linking every component of the manufacturing and supply process from raw materials to end clients, enveloping a few hierarchical limits. This is overall compressed by Christopher (1992). He characterized supply chain as: “The management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole”.

Supply chain management concentrates on how firms use their supplier's procedure, innovation and ability to raise competitive profit. It is a management logic that develops traditional intra-enterprise exercises by trading together with the same goal. Likewise Berry et al. (1994) stated that supply chain management points at building trust, exchanging data on business sector needs, creating new items, and decreasing the supplier base to a specific equipment producer to discharge management resources for creating compelling and long haul relationship.

The literature review utilized as a part of this study consists of three parts. First of all, the definition and the idea of supply chain are explained. The second part defines supply chain management in construction industry and also past research in that field. At long last, in the third part, the supply chain risk management process and steps are defined.

As such, the goal behind this chapter is compressed into these sections:

- Supply chain concepts and definitions
- Supply chain management in construction industry
- Supply chain risk management
- Supply chain risk process

2.2 Supply Chain Management Definitions

There are many supply chain definitions provided with different investigators. As Lysons (2006) stated that supply chain has no specific explanation. Tan (2001) described supply chain on the point of a comprehensive and tactical methodology to proceedings, logistics management and materials, and it has been defined as a management philosophy. According to Waters (2007), Supply chain management is the capacity responsible for storage of materials and transport on their movement from the main suppliers through midway operations to the last clients.

One definitions of SCM is offered by La Londe (1998) as "the delivery of enhanced customer and economic value through synchronized management of the flow of physical goods and associated information from sourcing through consumption". Johnston (1995) defined SCM as the procedure of strategically dealing with the movement and depot of materials, parts and completed bill of goods from suppliers, through the firm and to clients. Different definitions show that SCM recommends organizational reform, stretched out to the accomplishment of company-wide cooperative values. Rich and Hines (1997) mentioned that it supports a keen feeling of coordination of all exercises, the timing, controlling and harmony of material streams.

There are many similarities between supply chain and logistics. CSCMP (2012) offered a practical definition of logistics as: “The part of the supply chain that plans, implements, and controls the efficient, effective flow and storage of goods, services and related information from the point of origin to the point of consumption in order to meet customers’ requirements”.

It could be discussed that SCM differs from logistics meaning. SCM goes further and incorporates components that are not commonly included in a meaning of logistics; for example, data frameworks along with the coordination and combination of planning and monitoring activities. As logistics mainly copes with the streams to, in and out of companies, with an intra-organizational outlook, SCM is an advancement that copes with the inter-organizational vision of logistics beside the scale of intra-organizational.

Moreover, combination of Aberdeen Group (2006) and CSCMP (2012) mentioned a comprehensive definition of SCM which is: “encompasses the planning and management of all activities involved in sourcing and procurement, conversion, return, exchange, repair/refurbishment, remarketing, and disposition of products, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers”.

SCM systems have been effectively utilized in different industries; for instance, food and assembling for a long time. The supply chain in these industries incorporates all the exercises connected with processing from raw materials to finishing of the last product. This incorporates procurement, production planning, sequence processing, manage list of goods, transport, storage, client administration and all the essential supporting data frameworks. It is normally a progressing procedure centered upon particular items, which are frequently purchased or manufactured. Its management includes a fixed team of connecting partners with a common interest toward enhancing product quality and methodology. Harland (1996) categories SCM into four categories:

- Internal supply chain: This view of SCM is noticed by intra-organizational, which includes materials management.
- Double relationships with urgent suppliers.
- The chain of business management, which has no direct relationship.
- The network management of interconnected business which includes the final preparation of a product to last customers.

Independent and also non-profit organizations called the Supply Chain Council presents a maturity model that divided all supply chain level into five types (McCormack et al., 2004):

- Type 1- (Ad hoc): Totally unfamiliar with supply chain and its practices. The costs are high and satisfaction is poor.
- Type 2- (Defined): Basic supply chain practices are defined while the organizations act based on traditional methods. The costs are unacceptable and satisfaction is poor.

- Type 3- (Connected): There are connections between customer and organizations. The costs start reducing and also satisfaction improves significantly.
- Type 4- (Integrated): Well-defined supply chain management. All supply chain processes such as risk predictions and cooperation are applied. The costs are greatly decreased.
- Type 5- (Extended): The highest level of cooperation among organizations. There is real competition between organizations.

2.3 Supply Chain in Construction Industry

The movement of physical goods from one place to another is still biggest challenge. There are obvious examples in order to show how human being was concerned with materials movement to a construction site such as the Great Pyramids.

The application of SCM in the construction industry was the result of its accomplishment in other industrial areas (Akintoye et al., 2000; Briscoe et al., 2001; Saad et al., 2002) and began from the end of the 1980s (Vrijhoef and Koskela, 2000). Supply chains were currently been faced with the problem of unmatched ideas. This resulted in waste and different issues in steps of the supply chain, which led to an alternate step. The most significant failure at the beginning of supply chain management could be recognized as myopic control.

A construction project supply chain may include many firms such as subcontractors, contractors, material and equipment suppliers, engineering and plan firms, advising firms and so on. It remains divided and includes a lot of small and medium type subcontractors and suppliers. Most of the times, materials must be imported and supply chain gets worldwide and becomes tough to manage. Likewise, construction projects require a high rank of coordination around different stakeholders, who have contradictory concerns.

In the framework of the construction industry, SCM might be viewed as the procedure of strategic management of data stream, methods and activities, including different systems of associations and linkages which their name are “upstream” and “downstream”, all around a project life cycle. As far as the prior, the “upstream” tasks inside construction SCM, in connection to the position of a head contractor, including construction customers and design groups, comprises of the tasks and activities resulting in procurement for manufacture on site. The “downstream” includes tasks and activities in the transfer of the construction product including construction suppliers, subcontractors, and proficient contractors linked with the head contractor. In the construction business, especially on a bigger project, which includes an important number of independent supplying organizations, the unpredictability of the system can frequently be critical (Briscoe et al., 2001).

Jones and Saad (2003) stated that SCM has a key role in construction in order to correct whole performances, but stayed behind at the beginning of development. One of the crucial changes that the construction industry ought to cope with in its development into SCM organizations is cognition of the suitable grade of experts in a number of fields. Adding the standards of perfect production to construction should shift the key role of design from the relevant consultant to the most suitable supplier, subcontractor or team of both. Some researchers concentrated on supply chain network. For example, Harland (1996) claimed that supply chain management is the arrangement of a network of organizations that are included in the business process.

In the construction area, this network can regularly be greatly complicated, especially on large projects where the amount of independent supplying associations will run into hundreds, if not thousands. Figure 2.1 illustrates only the key members of a common construction supply chain network, with the head contractor at the center of chart. There are some links to the customer, supply agencies and expert services. The current interest is concerned on the supply relationship between material suppliers, head contractor and the production subcontractors.

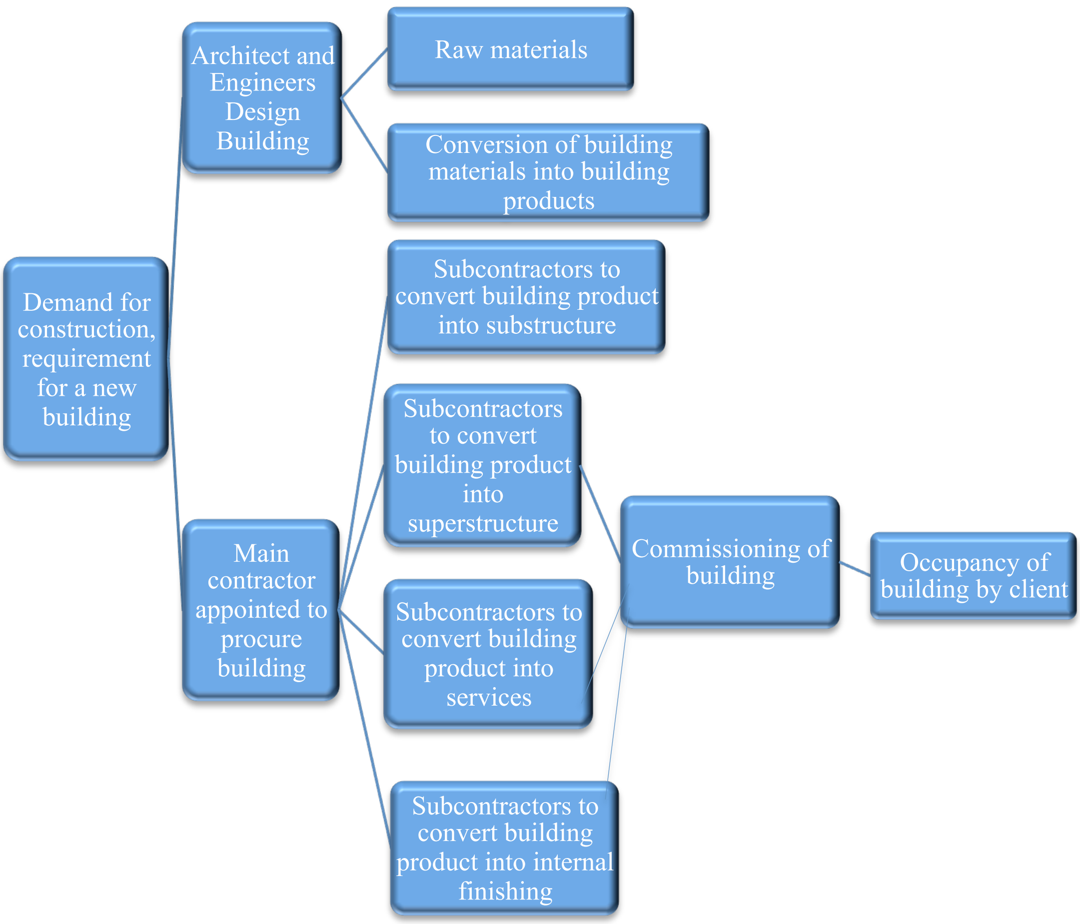

Figure 2.1: A common construction supply chain network (Shove, 1999)

It is distinguished that supply chain combination can collect many profits for businesses. In the construction industry, more contractors have a tendency to depend on the resource of suppliers and subcontractors; in the construction supply chain, it is vital for contractors to make collaborative connections with different partners. The construction supply chain identified with the information of designing, logistics, administration science and different parts of learning, needs connection among suppliers, managers, architects, contractors, subcontractors and different members. With this regard, this makes the management in construction supply chain getting to be more complex.

Different with other areas, the construction industry is moderately beginner in its methodology to the supply chain. As Egan (1998) stated, construction industry can acquire experiences from other industries. He also said that “Construction businesses are beginning to realize that their success is increasingly dependent on the organizations they supply to and buy from, and that for continued success, they need to cooperate and collaborate across customer/supplier interfaces”.

Many authors and researchers emphasized that adding value and minimizing cost are significant targets in SCM. Saad et al. (2001) mentioned that adopting the methodology of SCM to construction sector needs a huge attempt. It requires developing combination in design, manufacture process and functions to connect the process in a chain paying more attention to increasing opportunities to add value and reduce cost. As this method needs an important change attitude of participants towards cooperation, mutual profits and teamwork are very important.

The next parts report the supply chain risk management from different explanations and view of supply chain, explained with several specialists. Diverse periods are characterized based on observations in each stage. Hence, particular stages are introduced in following part. Consequently, one method is picked for supply chain risk assessment.

2.4 Supply Chain Risk Management

There are different conceptualizations of existing risks in supply chain management. It is difficult to understand the character of risks. Previous risk studies suggest some rich explanations (Chiles, 1996; Holton, 2004). As stated by Rao (2009), explaining risk characterization is the most difficult challenge among researchers. According to them, the studies on supply chain risk management are large scale. However, there is not consent on the sources of the risk. As similar ideas, Sodhi et al. (2012) prepared a table which distinguished the different sources of risks in supply chain. Table 2.1 illustrates the variety of views in many studies on supply chain.

Table 2.1: Diversity of supply chain risk view (Sodhi et al. (2012))

Author	Scope of risks
Jüttner, Peck and Christopher (2003)	Environmental sources, network sources, and organizational sources
Spekman and Davis (2004)	(1) inbound supply, (2) information flow, (3) financial flow, (4) the security of a firm's internal information system, (5) relationship with partners, and (6) corporate social responsibility
Cavinato (2004)	(1) physical, (2) financial, (3) informational, (4) relational, and (5) innovational sources
Chopra and Sodhi (2004)	Categorise supply chain risks at a high level as disruptions or delays. These risks pertain to (1) systems, (2) forecasts, (3) intellectual property, (4) receivables, (5) inventories and (6) capacity
Christopher and Peck (2004)	(1) process, (2) control, (3) demand, (4) supply, and (5) the environmental
Kleindorfer and Saad (2005)	Risks sources and vulnerabilities from (1) operational contingencies, (2) natural hazards, and (3) terrorism and political instability
Bogataj and Bogataj (2007)	(1) supply risks, (2) process risks, (3) demand risks, and (4) control risks
Sodhi and Lee (2007)	(1) supply, (2) demand, and (3) contextual risks requiring both strategic and operational decisions
Tang and Tomlin (2008)	(1) supply, (2) process, and (3) demand risks, (4) intellectual property risks, (5) behavioural risks and (6) political/social risks
Manuj and Mentzer (2008a)	(1) supply, (2) operations, (3) demand, and (4) other risks including security and those related to currency
Manuj and Mentzer (2008b)	(1) supply, (2) operational, (3) demand, (4) security, (5) macro, (6) policy, (7) competitive, and (8) resource risks
Oke and Gopalakrishnan (2009)	Consider low-impact-high-frequency and high-impact-low-frequency risks in three major categories: (1) supply, (2) demand, and (3) miscellaneous
Rao and Goldsby (2009)	(1) framework, (2) problem-specific and (3) decision-making risk

Waters (2007) states that risk sometimes may happen as a danger to interrupt typical events and prevent certain plan as arranged. This aim is certainly the oldest one known as it was utilized for guaranteeing trader ships many years ago. As Christensen and Montgomery (1981) mentioned, risk is utilized to improve the rates of capital profit on enterprise and the flexibility of expected and pure profit. Also the strategic actions and relational risks are covered by literature (opportunism, cheating, stealing) (Bettis and Mahajan, 1985; Baird and Thomas, 1985; Manuj and Mentzer, 2008).

Basically, the literature on supply chain management describes risk absolutely negative and as resulting in undesired consequences (Manuj and Mentzer, 2008; Harland, Brenchley and Walker, 2003). Professionals and academicians describe risk in plenty of ways based on context and discipline. Paulsson (2004) mentioned that risk is an occasion with undesirable results or "the probability that a particular adverse event occurs during a stated period of time, or results from a particular challenge". According to the supply chain framework, resource uncertainty and unreliability leads to risk (Tang and Nurmaya, 2010). In all literature, risk is described as the possible event of a happening or disruption that prevents stable stream of material, consequently bringing on disconnection in the supply chain (Zsidisin, 2003; Waters, 2007; Tang and Nurmaya, 2010).

According to Norrman and Lindroth (2002), supply chain risk includes everything which influences shipping streamline between the main supplier and last client. Also Tang and Nurmaya (2011) argued that risk in each sides financial, physical and data could interrupt the routine processes.

Risks may be important if their effect on supply chain would interrupt the free stream of materials or data. Diekmann, Sewester and Tahen (1988) and Hetland (2003) viewed risks in terms of suggestive of an unclear event. Waters (2007) demonstrated the difference between the ideas and stated that risk happens because of future uncertainty. As he stated also, risk produces some calculable measures of future incidents which is the main differentiation, however uncertainty could not. Consequently, uncertainty implies unpredicted incidents. The incidents can be listed that may occur in the future, although there is no idea of what will really occur or of the relevant probability. The incidents might be happened in the future because of lack of knowledge. However they make no recommendation to whether the incidents are helpful or harmful. Many researchers stated that risk and uncertainty could not be clearly separated in literature on supply chain risk management (Tang and Nurmaya, 2010).

According to Paulsson (2004), the application of SCRM can be reliable for control threats in organizations, some events that decrease the outcomes, likelihood of undesired indecent or disruption. He also described it as taking “actions to shift the odds in your favor”.

The purpose of supply chain risk management is to classify the feasible sources of risk and taking proper actions to prevent supply chain vulnerability (Narasimhan and Talluri, 2009). The integrated supply chain risk management presents the chance to acquire added value and to reduce the risk to the customer. There are many risks and uncertainties included in construction. A part of these risks might be quite negative; for instance, an action being physically hazardous, some business nature harmful affected by risk event based on the individual’s position in the supply chain.

The supply chain risk has two segregated sides, external risk and internal risk. The external risk is about social, environmental, political and economic uncertainties. The internal risk is basically about internal conflict in supply chain. It is totally related to the uncertainties that affect quality, schedule and cost in the projects from main contractor to suppliers and subcontractors. The risk knowledge in the construction supply chain decreased mistakes gradually along main contractors, project managers, subcontractors and suppliers.

After comprehensive learning about risk knowledge, in the next step, the application of supply chain risk process must be studied; which is discussing how risk can be identified, analyzed and controlled. The following part will present supply chain risk process according to literature on risk process described by many researchers and authors.

2.5 Supply Chain Risk Process

There have been many attempts to categorize supply chain risk process into the main critical stages. However, there are some different categories described on literature. According to literature on SCRM, the process includes the recognition, calculation of possible threats, and their probable impact on functions. Lysons and Farrington (2006) stated that the beginning step is identifying risks, afterward recognizing possible risk sources at each important connection with each stage of supply chain process. In other words, the purpose of process is to identify the possible causes of risk and also prevent vulnerability with proper applications.

Sodhi et al. (2012) mentioned that supply chain management process takes action with two main keys, the first key is collaboration and the next one is coordination. Jüttner, Peck and Christopher (2003) stated that there are four main steps in supply chain risk management process:

- Analyze the risk sources
- Identify the exact meaning of risk
- Recognize the risk causes
- Apply methods to reduce risks

The others categories were mentioned by Kleindorfer and Saad (2005) as:

- Determining vulnerability and risk
- Evaluation
- Moderation

Sodhi et al. (2012) describe parallel categories as:

- Risk identification
- Risk Analysis
- Risk mitigation
- Risk control

Similar categories were stated by Hallikas et al. (2004) as:

- Identify risk
- Evaluate risk
- Action risk management
- Monitor risk

Current researchers have tendency to cluster global supply chain risk management such as Christopher et al. (2011) who categorized it into four groups: supply chain risk, demand chain risk, control risk and environmental risk.

Consequently, it is obvious that SCRM works like tactical administration, which is effective on exercise, economic action of companies and market (Narasimhan and Talluri, 2009). The figure 2.2 illustrates SCRM structure, which was proposed by Waters (2007). In this study, the framework of supply chain risk management which was introduced by Waters (2007) will be applied for analysis.

Figure 2.2: Supply chain risk management process (Waters, 2007)

2.5.1 Supply Chain Risk Identification

Identifying risk is the first stage of supply chain risk process. Waters (2007) remarked that a fundamental activity on whole supply chain process is identifying the risks. Nevertheless, it would be infeasible to prepare a list of each possible risk; identification can also merely support the important supply chain issues. This stage includes preparing a list of possible incidents that might damage and disrupt supply chain. Potential risk identification lets companies to apply models to control risks. Surely, this way is more beneficial than waiting to respond events when they happen.

According to the Wagner and Bode (2006), there are three risk categories to identify: supply direction, demand direction and catastrophic. Jüttner, Peck and Christopher (2003) and Mason-Jones and Towill (1998) stated that there are three risk types to identify:

1) Internal risks caused by the organizations.
2) External risks caused by organizations among supply chain process.
3) External risks caused by environment and participants.

The organizations apply some methods in terms of type and probability of risk happening. There are some strategies for identifying supply chain risks such as:

- Surveying historical problems: It can be a high level strategy because of its frequency.
- Supply chain mapping: It can show frame, necessities and drawbacks that can consist risk. Totally, there are two models in this category; (1) Supply-chain operations reference mapping and (2) Value Stream Mapping.
- Team of experts (brainstorming): In order to raise the knowledge sharing, experienced labor and knowledgeable people in different sections of organization make together and share their knowledge. Delphi method also works with expert interviews.
- Project visits: It is easy to collect detailed data on risks.
- Researching trends: Some organizations are looking to last development on risk issue.
- Surveying data: Information system audits can show problems and trends within the project. It can reveal poor efficiency in the past and probably poor performance in the future.
- Checklists: A list may complete with past research and experience.
- Cause and effect chart: A chart that traces the drivers and incidents.
- Gantt bar chart: It reveals the priority and timing of tasks.
- Identifying source risk.
- Deliver risk identification: The vision of clients develops capability to identify existing risks.
- Regression risk identification: Extreme returns can show risks at the beginning in the project.

The interesting identification was remarked by Waters (2007) which states that practical risks are connected with progress and movement of materials, economic risks are connected with the money stream, and organizational risks are a result of connections within supply chain members. Finally, data risks are connected with the framework and the data stream. Yang (2011) proposed that identifying risks in supply chain logistics could be categorized into three groups; practical risk, financial risk and technical risk.

There is another identifying model, which is called Risk Breakdown Structure (RBS). This model categorizes project risks into four main groups:

1) Organizational
2) Technical
3) External
4) Management

Although RBS shows risk type, group and sub group. There are different types of mentioned model because of the diversity of sources. Figure 2.3 illustrates RBS four main categories (Rajabi, 2011). RBS method will be applied to identify risks on this research because it surveys critical categories to find all risks that may occur in the project.

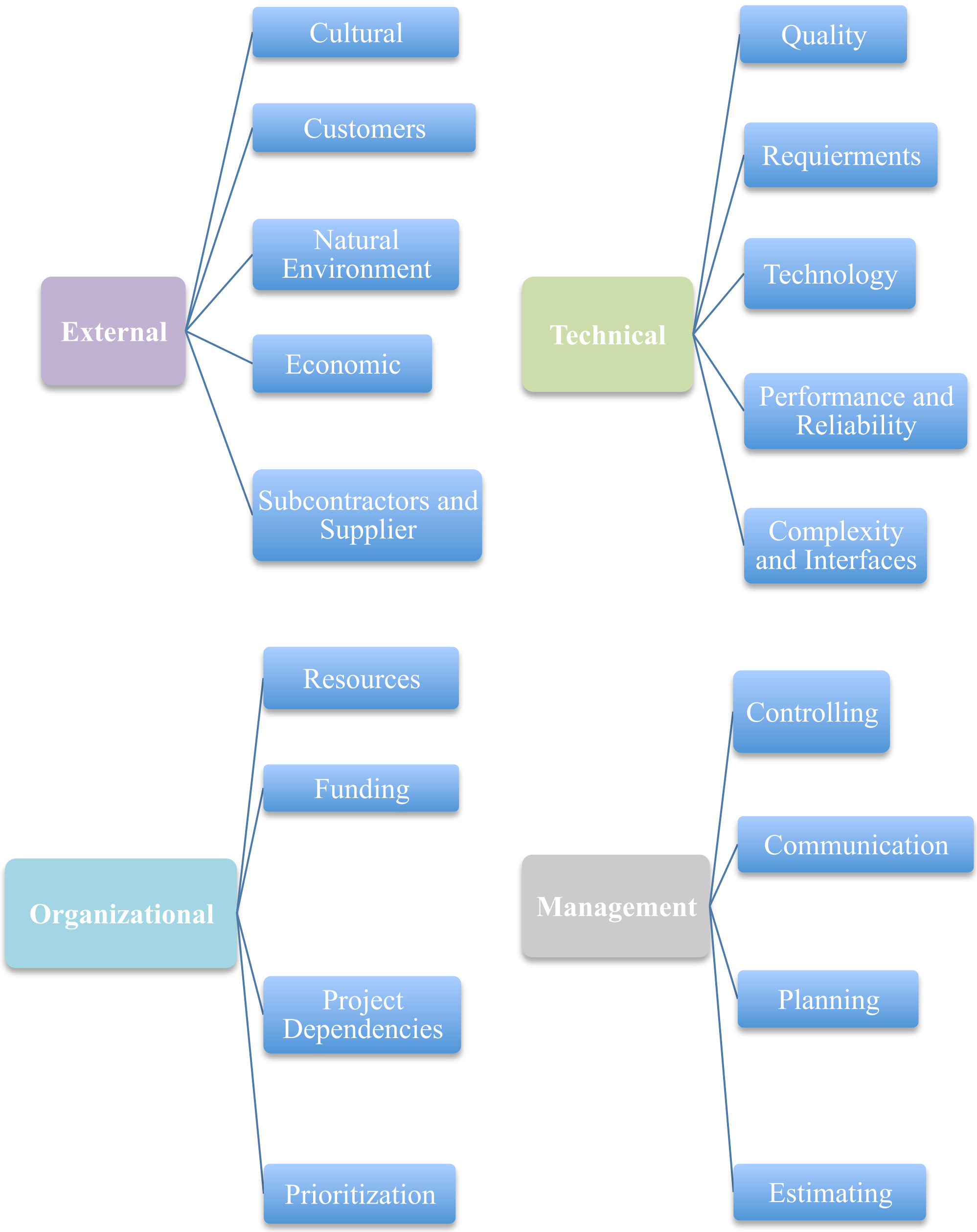

Figure 2.3: Sample of Risk Breakdown Structure List (Rajabi, 2011)

After risk surveying and identifying, the next step is assessing whole risks that how much they may be disruptive on supply chain stream. The following part will present some techniques to analyze risks.

2.5.2 Supply Chain Risk Analysis

The next step after risk identification is supply chain risk analysis. This step plays crucial role on every construction supply chain management process where whole collected data about potential risks are analyzed and assessed. In this case, every identified risk must be analyzed with regard to the probability of likelihood and impact.

Risk analysis process in supply chain management recognizes existing risks with their impact; and then prioritizes sources for risk mitigation. Risk analysis will contain explaining the risk nature, making clear situations that can lead to the incident, finding how frequently incidents have occurred or potential to occur and also possible impact of incidents on supply chain stream.

There are some methods to analyze identified risks on supply chain. The most commonly used method is risk probability and impact method. Basically, likelihood and impact are two measures of risk analysis. Likelihood evaluates the probability that the incident may happen. However, accurate probability can be tough to find unless there is historical information, which shows the frequency of the incident happening. Impact evaluates the risk consequences on the organizations when the incident happens.

Cooper et al. (2005) and PMBOK (2013) stated that this method evaluates the likelihood of any risk. Moreover, other critical components such as time, quality and cost must be evaluated for the possible influence on risk impact. For two modules, probability and impact, all identified risks should be investigated.

Some researcher remarked the measures of probability and impact. The numbers are assigned for very low, low, medium, high and very high. National Patient Safety Agency (2008) and Health Service Executive (2009) emphasized that according to service customer, financial loss and environmental must be concerned on scoring. Table 2.2 illustrates a framework to score both measures on supply chain project.

Table 2.2: Scoring framework (National Patient Safety Agency, 2008; Health Service Executive, 2009)

Probability Level	Probability Score	Detail
Very Low	1	Incident not supposed to happen
Low	2	Incident more probable than not to happen
Moderate	3	Incident can or can not happen
High	4	Incident more probable than medium level
Very High	5	Incident supposed to happen

In Table 2.3, scoring impact on critical project components are described based on PMBOK (2013), which defines relationship between numbers and major project areas. The specific qualities like very low to very high are related to each condition in different areas such as cost, time, scope and quality.

Table 2.3: Described impact score on project components (PMBOK, 2013)

Impact Level	Impact Score	Detail (Impact on Cost/Time/Quality)
Very low	1	Insignificant cost and time increase/Quality degradation barely noticeable
Low	2	< 10% cost increase/< 5% time increase/Only very demanding applications are affected
Moderate	3	10-20% cost increase/5-10% time increase/Quality reduction requires to sponsor approval
High	4	20-40% cost increase/10-20% time increase/Quality reduction unacceptable to sponsor
Very high	5	> 40% cost increase/>20 % time increase/Project end item is effectively useless

Probability and impact scores are two main keys of this method. Probability and impact matrix determines which risks need detailed risk response plans. Basically, the matrix used is a 3*3 matrix, which is low, medium and high or 5*5 matrix, which is very low, low, medium, high and very high ranking. Table 2.4 shows a sample of 5*5 matrix.

Table 2.4: A sample of Probability and Impact Matrix (5*5 matrix)

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

According to PMBOK (2013), each risk must be prioritized in terms of risk probability and risk impact within specific project. The application of matrix assists the project stakeholders to analyze the risks and then prioritize them based on their impact on project. This method calculates risk score for each risk by multiplying the risk probability and risk impact (Westland, 2006); besides, all risks can be prioritized based on risk score. Then, the risks can be assigned different colors on map or graph. Each color shows the severity of risk on project. Table 2.5 illustrates risk score for each identified risk with different colors.

Table 2.5: Risk scores based on probability and impact matrix (PMBOK, 2013; Tabanfar, 2014)

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

It is obvious that both opportunities and threats can be assessed with the same probability and impact score. According to PMBOK (2013), the matrix method is designed to show identified risk as very low, low, medium, high and very high, which combines the probability and consequence.

There are some other methods of risk analysis such as Failure Mode Effects Analysis (FMEA) and Fault Tree Analysis (FTA). Failure Mode and Effects Analysis is one of the most popular methods to assess identified risks. Hu et al. (2009) emphasized that this method, designed by NASA in 1963, can be used to survey, recognize, assess and control defeats on projects. According to Chen (2007), this technique is an analytical process for evaluating potential failures on projects. According to Van Leeuwen et al. (2009) Failure Mode and Effects Analysis is utilized to prioritize threats and control performances. Bluvband and Grabov (2009) mentioned that FMEA technique is influenced by uncertainty, poor characterization of some stages, and decision-making errors within project. However, there are some suffering disadvantages. In order to gain the necessary details, this method requires to a lot of time, cooperation and sources (Pillay and Wang, 2003; Hsu et al., 2011; Xiao et al., 2011). The literature on FMEA obviously shows that the researchers have tendency to address some of these disadvantages (Wang et al. 2009; Chen, 2007).

Other risk assessment method is Fault Tree Analysis (FTA), which is utilized to identify main drivers of risk incidents and evaluate their likelihood and consequences. Figure 2.4 shows a sample analysis of delay in procurement based on FTA method. This method is suitable for some risks arise from sources, where they happen as external type on project.

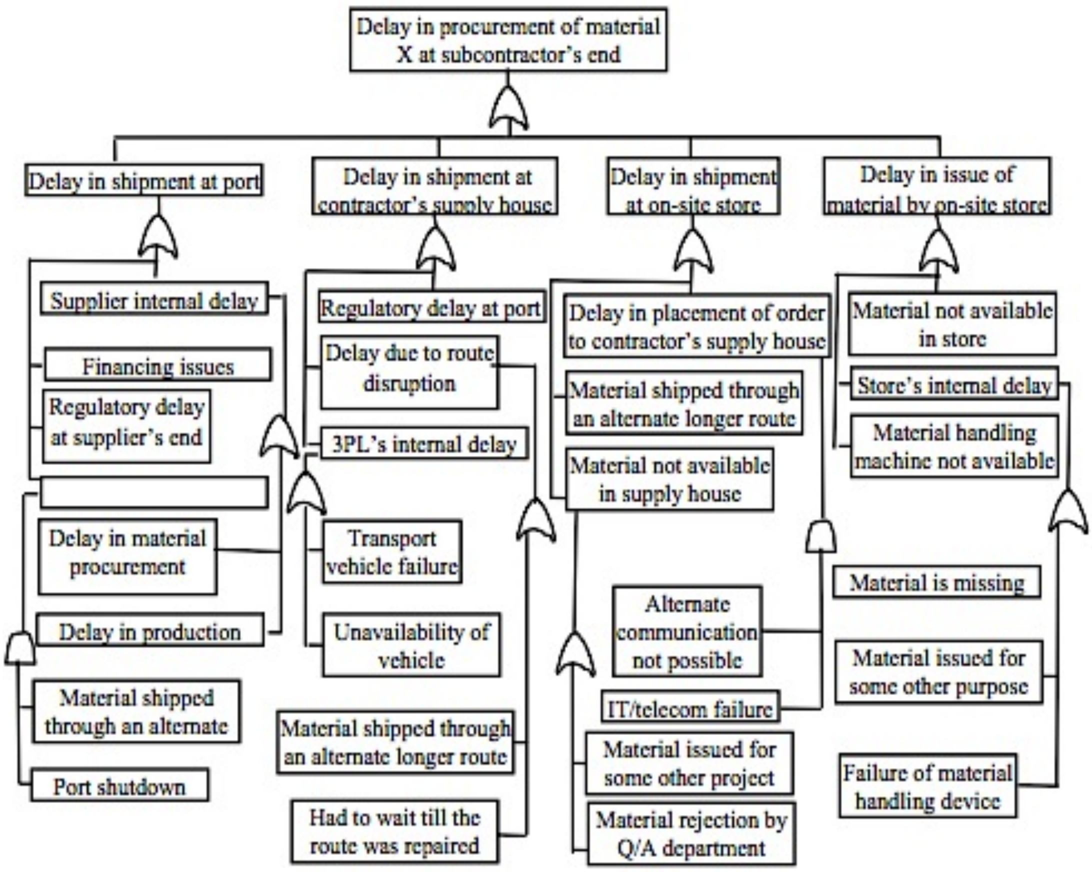

Figure 2.4: FTA assessment sample (Dainty et al., 2001)

2.5.3 Supply Chain Risk Response and Control

The last stage of supply chain risk process is response and control. According to Winch (2002) the third stage of process shows the performances, which must be done after identifying and analyzing the risks. PMBOK (2013) described risk response by way of “the process of developing options and determining actions to enhance opportunities and reduce threats to the project objectives”. Moreover, it states the stage of risk control includes risk response, identifying risk, monitoring and evaluating and analyzing new risks throughout the project stream.

According to Waters (2007), risk response is the main stage of supply chain process to addressing the risks. He described risk response as: “designing an appropriate response” which must be taken after risk analysis, particularly, the most suitable application of coping with the threats. In continue, he offered the activities in risk response including accept or ignore, mitigate the probability and consequence, limit, share, transfer, continue, move to another location, adapt and reverse.

Many researchers and authors tried to categorize the risks in terms of their severity. It can be divided by threats and opportunities. PMBOK (2013) described three techniques for threats or some risks that if happened, undoubtedly have unfavorable impact on the project; (1) mitigate, (2) avoid and (3) transfer. Whereas in case of opportunities, accept technique is used for favorable impact. Any of these response techniques differ by influence on the risk situation. These techniques must be selected in terms of the risk’s probability and impact. Appropriate techniques for risks that are crucial and have high impact are avoiding and mitigating. However, suitable techniques for risks with low impact are transferring and accepting.

Totally, the exact definitions of these four techniques are:

- **Avoid**: is performed to delete the risks or preserve the plan from risk's impact on project. Most of the times, project manager may change the project plan.
- **Mitigate**: is performed to decrease the probability of incidence and impact. Acting at the beginning of project to reduce risk impact are preferred by experts, since the repair of failure system needs much more money and time.
- **Transfer**: is performed to move impact of a risk to other organizations where it is not necessary to delete risk.
- **Accept**: is performed to continue with the current plan, until these risks happened. This technique is applied where it is not possible or cost effective to deal with a certain risk in other way.

Baker et al. (1999) remarked other suggestions to cluster risk response; unsatisfactory (avoid), unfavorable (avoid and mitigate), satisfactory (risk preservation), insignificant (no acting).

Acting risk response may be affected by the rate of the risk. In order to prepare response planning, PMBOK (2013) and WSDOT (2010) introduced the techniques for any rate of risk. Table 2.6 shows risk response matrix based on the risk probability and impact.

Table 2.6: Risk response matrix in terms of impact and probability (Tabanfar, 2014)

Probability	High	Transfer	Avoid
	Low	Accept	Mitigate
		Low	High
		Impact	

As Table 2.6 shows, high probability risks and high impact risks need strict actions. However, the green territories are used for transfer and accept techniques.

In conclusion, there are some important subjects on supply chain management, which must be investigated. First of all, who is in control of monitoring risks; then, which level of risk should be controlled and finally, which level of response performance should be applied. The Next chapter will present data collection on specific case study and selected method.

Chapter 3

METHODOLOGY

3.1 Introduction

During last decade, it was obvious that developing countries have attempted to eliminate traditional manners and improve decision-making based on latest technologies. In other words, these countries have tendency to generate appropriate structures to develop on different industries. Hence, in order to reduce great amount of losses, particularly in construction industry, the crucial techniques can be risk identification, risk assessment, risk response and control. This study focused on Iranian construction projects as a case study. Moreover, proper method was selected to analyze supply chain risks and organizational performances of supply chain management, which are applied in Iranian construction industry.

3.2 Proposed Method

The literature on construction supply chain risk management clarifies that many researchers applied theoretical frameworks to compare consequences. This comparison shows that relevant methods which prioritize risks are chosen among that construction project. There may be several risks in any construction project. Hence, after identifying the risks, most of project managers try to prioritize risks and also make a plan to control them. Selected method for this research is Probability and Impact Matrix, which is a method for the project group to support in prioritizing risks. Based on the size and unpredictability of the project under control, the risks may change. But, the projects have not enough time and money to waste. Therefore, it is important to figure out how to distinguish those basic risks which needs the most consideration from the project group.

According to this research, in order to collect data, questionnaire survey was designed and written based on the knowledge of Iranian construction companies. The questionnaires were filled out by people who had responsibilities on supply chain process. The next part will describe the trend of data collection.

3.3 Data Collection

First of all, the questionnaire was written based on the risk identification. Some risks that almost always happen within each project were distinguished by researchers. However, there are many risks depending on project type. In order to identify those risks, identifying risk process must be applied. Respondents identified all significant risks on supply chain management that may occur in Iranian construction. Furthermore, identified risks have more influence on Iranian construction projects based on respondents' opinions (Table 3.1) shows results. Particularly, 3 levels of RBS that were surveyed in the study were:

- Level 0: Project risk
- Level 1: 4 main categories
- Level 2: Sub-categories
- Level 3: Identified risks

It must be argued that some of identified risks could be categorized on the other sections. For example, inadequate program scheduling could be considered in both management and organizational.

Table 3.1: Identified supply chain risks based on RBS method

Level 0	Level 1	Level 2	Level 3
Project Risk	**Management**	Estimating	Inadequate cost estimate
			Inadequate program scheduling
		Planning	Inadequate time scheduling
			Tight project schedule
		Controlling	Increased transport cost
			Increased insurance cost
			Uncertain supply and demand
		Communication	Labor dispute
			Lack of cooperation between project team
	External	Natural Environment	Natural disasters Unpredictable incidents
			Supplier bankruptcy
		Cultural	Price fluctuation of construction materials
			Product recall
		Customers	Subcontractor failure
			Delayed materials deliveries
		Subcontractors and Supplier	Raising labor cost
			Row material scarcity
		Economic	Increased fuel cost
	Technical	Requirements	Lack of sufficient skilled workforce
			Inexperienced labors and staff
		Technology	Lack of access to modern technology
			Lack of access to appropriate materials
		Quality	Transport vehicle failure
		Performance and Reliability	Unavailability of proper vehicle
			Transport material safety
		Complexity and Interfaces	Unprioritized material procurement based on schedule
	Organizational	Project Dependencies	Lack of sufficient skilled manager
		Funding	Financing issue
		Resources	Delay in material procurement
			Delay in production
		Prioritization	Delay due to route disruption
			Ignoring geographical condition

Then, all identified risks were analyzed by scoring each risk from 1 to 5 according to their probability and impact on the construction project. Moreover, risk score was calculated by multiplying both score of probability and impact. Finally, the last stage was response and control. This stage used actions such as transfer, mitigate, accept and avoid in order to decreasing risks on the project. Within supply chain risk process, all risks were ranked and categorized based on their risk score.

The data were located by risk map in the probability and impact matrix. There are different areas such as very low to very high which show risk situation and condition. Consequently, in the following chapter percentage of all risks and average risk scores are shown in different matrices, graphs and tables. In order to figure out the respondents' knowledge about concept of supply chain risk management, some interviews were also performed (A sample of the interview can be see in Appendix D). It could be better recognized by interviews that which method is normally applied to respond and control existing risks.

3.4 Supply Chain Risk Analysis: Probability and Impact Matrix

As shown in chapter 2, Tables 2.2 and 2.3 illustrated the range of probability and consequence in which each range has different conditions in the project.

There are different techniques for explaining criterion situation for probability and consequence that some of them were presented in previous part. The selected technique shows specific amount of probability and impact for each category (Tables 3.2 and 3.3).

Table 3.2: Ranges of probability

Probability Level	Probability Score	Detail
Rare	1	(1-20)% Risk event not expected to happen-Every 5 years
Unlikely	2	(21-40)% Risk event may happen every 2-5 years
Moderate	3	(41-60)% Risk event may happen every 1-2 years
Likely	4	(61-80)% Risk event may happen monthly
Very Likely	5	(81-100)% Risk event expected to happen

This research defined all categories for both probability and impact to respondents. Particularly in impact range, respondents evaluated three main factors of cost, quality and time on project.

Table 3.3: Ranges of impact

Impact Level	Impact Score	Detail (Impact rate- Economic- Health and safety)
Trivial	1	Very low impact-Insignificant cost increase-No injury
Minor	2	Low impact- (5,000-15,000)$ cost increase-Emergency care
Moderate	3	Medium impact- (15,000-75,000)$ cost increase-Moderate injury
Major	4	High impact- (75,000-225,000)$ cost increase-Serious injury or death
Extreme	5	Very high- (More than 225,000)% cost increase- (High death frequently)

After determining ranges of probability and impact, next stage was calculating risk score. By multiplying the two measures, risk score was calculated. Table 3.4 presents probability and impact matrix (PIM).

Table 3.4: Probability and Impact Matrix Framework

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

As the Table 3.4 illustrates, all rates of identified risks are shown by several colors. The matrix shows the risk priority, calculated by probability and impact. As level of impact and probability increases, risk score is located on red and dark red area. It shows negative effects on project efficiency. However, as the ranges of probability and impact reduce, risk score will be located on green and yellow areas, which are considered as very low and low consequences on whole project. On the orange area, which is located at the middle of matrix, there are some risks with moderate consequence on the project. After all risks are located on map, and prioritized based on impact on project, risk response plan will be prepared as last process of supply chain risk management.

3.5 Supply Chain Risk Response

Following risk identification and risk analysis, risk response takes place to develop supply chain risk process on construction project. According to Choi and Liker (1995), Mullai (2008), Christopher and Peck (2003), and Elkins et al. (2005), there is a large body of literature determining supply chain risk response techniques. The intended risk response techniques can be different based on diverse condition on project. Totally, there are three main tools and strategies that assist the planning of risk responses process. Some strategies are assigned for threats or negative risks such as avoid, transfer, mitigate and accept. However, some strategies are designed for opportunities or positive risks such as exploit, share, enhance and accept.

According to the supply chain maturity model (McCormack et al., 2004), five levels of maturity reveal the performance characteristics toward supply chain process. Each level is affiliated with maturity stage as capability, control, predictability efficiency, and effectiveness. It can be argued that the Iranian construction industry has used supply chain management for years as ad hoc level. They coped with risk as unstructured and ill defined. Process performance is unpredictable. Client satisfaction is dramatically low. Mostly transfer strategies are selected together with finding another party who is willing to take responsibility for its management.

This research focused on threats or some risks having negative influence on projects. Hence, all respondents were asked to specify performances to decrease negative risks. Table 3.5 illustrates risk levels by different colors related to prioritization and actions.

Table 3.5: Risk response framework

Risk Level (Color zone)	Risk Ranking	Response Plan
Green	Very Low	Accept
Yellow	Low	Accept-Transfer
Orange	Medium	Transfer
Red	High	Mitigate
Dark Red	Very High	Avoid

In order to do a comprehensive research, it is necessary to mention that all respondents had experience on large-scale construction projects. Therefore, in accordance with their knowledge, this research provided a valuable data, which could be highly important.

The data was analyzed by IBM SPSS Statistics 20 software, which stands for Statistical Package for the Social Sciences. This software is a widely utilized program for statistical analysis in social sciences. General programs may prefer other procedures such as invoicing and accounting forms, although specialized programs are more appropriate for this purpose. SPSS is basically designed for analyzing statistical data, and as a result, it offers a great range of charts, methods and graphs. SPSS also provides more techniques of cleaning or screening the data in planning for further assessment. SPSS is designed to make certain that the output is kept separate from information itself. As a matter of fact, it saves all results in a separate file, which is different from the data. The following chapter will present data collection and analysis data.

Chapter 4

DATA COLLECTION AND ANALYSIS

4.1 Introduction

This part will present trend of collecting data. Data collection was performed by questionnaire survey. Questionnaire survey was selected because of its potential to collect reasonable amounts of data and also is a suitable method of data collection to gain proposed goals. Therefore, research survey is used to recognize the likelihood of each risk and their consequences on whole construction supply chain project.

The purpose of this chapter is to show the results of identified risks based on their type; then, prioritizing risks in accordance with their average risk scores. Finally, some tables and graphs will be presented to illustrate risk response based on probability and impact matrix method.

4.2 Research Survey

It is very significant to mention that questionnaire survey has some advantages such as practicality, collecting large amounts of data, easy analysis of the results with software and potential to compare the results with other studies. As presented earlier, the case study of this research is Iranian construction industry. Totally, supply chain risk exists at three levels including industry level, company level and project level. Research survey was done at company level. Unfortunately, the awareness of supply chain management is dramatically low among Iranian construction companies. Hence, in order to prepare high data accuracy, most of experienced engineers who worked as main responsible at large-scale projects, were selected. This survey was performed by face-to-face, telephone and through the email contact. Research survey was prepared and selected 27 of best construction companies were selected while 20 of them accepted to set a time to fill out questionnaire and answer some questions. In detail, 11 respondents were participated in interview and 9 respondents filled out via email and telephone. Table 4.1 shows details of research survey. A sample of questionnaire can be found in Appendices A, B, and C.

Table 4.1: Detail of research survey

Number of Questionnaires Distributed	27
Number of Questionnaires Used in Thesis	20
Percentage of Survey Response rate	74%
Average Respondent's Experience	16-17 years
Average Number of Annual Projects	5-8 (large scale)
Average Number of Workforce and Employee	150 permanent per project
Average Annual Financial Turnover	50-100 Million $

4.3 Supply Chain Risk Process

As mentioned before, supply chain risk management (SCRM) has three main stages: risk identification, risk analysis and risk response.

4.3.1 First Stage: Identifying Risks

This research implemented RBS method to identify existing risks in Iranian construction projects and questionnaire survey was prepared based on this method.

RBS classifies risks in accordance with four main categories namely, organizational, technical, external and management. Moreover, the majority of respondents stated that RBS is mostly similar to performances of Iranian construction companies because their companies operate based on these four main groups and it clarifies recognizing risk type on each different category. However, other respondents believed that checklist and brainstorming by experienced engineers could be proper way to identify risks.

4.3.2 Second Stage: Analyzing Risks

After risk identification, risk analysis takes place as second stage. Probability and impact method prioritizes identified risks based on calculated risk scores. As a result, average risk scores and percentage of each risk were calculated. All results were calculated by IBM SPSS Statistics 20. It should be mentioned that all figures were designed based on ascending order make them easy to understand. Tables (4.2), (4.3), (4.4) and (4.5) show risk scores of management, technical, organizational and external respectively.

Table 4.2: Management risk scores

Respondents		Risk Score A1	Risk Score A2	Risk Score A3	Risk Score A4	Risk Score A5	Risk Score A6	Risk Score A7	Risk Score A8	Risk Score A9
1		20.00	20.00	20.00	20.00	16.00	12.00	6.00	6.00	6.00
2		20.00	16.00	25.00	25.00	15.00	6.00	6.00	2.00	8.00
3		20.00	25.00	25.00	20.00	20.00	12.00	12.00	2.00	12.00
4		12.00	20.00	20.00	15.00	20.00	3.00	6.00	4.00	6.00
5		12.00	25.00	16.00	25.00	16.00	5.00	2.00	6.00	2.00
6		20.00	20.00	25.00	20.00	9.00	4.00	6.00	2.00	9.00
7		25.00	20.00	20.00	25.00	20.00	6.00	8.00	3.00	6.00
8		8.00	15.00	8.00	12.00	2.00	4.00	12.00	6.00	10.00
9		20.00	20.00	12.00	16.00	15.00	5.00	2.00	9.00	4.00
10		25.00	16.00	25.00	20.00	15.00	4.00	4.00	3.00	4.00
11		16.00	20.00	20.00	20.00	20.00	8.00	6.00	2.00	6.00
12		9.00	9.00	16.00	6.00	9.00	6.00	6.00	6.00	2.00
13		10.00	12.00	20.00	20.00	12.00	8.00	2.00	4.00	3.00
14		12.00	15.00	16.00	25.00	15.00	8.00	9.00	4.00	4.00
15		20.00	12.00	12.00	25.00	8.00	9.00	4.00	2.00	4.00
16		12.00	12.00	15.00	20.00	12.00	6.00	12.00	4.00	6.00
17		16.00	9.00	16.00	15.00	12.00	12.00	6.00	6.00	6.00
18		9.00	15.00	15.00	20.00	15.00	6.00	6.00	8.00	6.00
19		15.00	15.00	20.00	12.00	12.00	10.00	12.00	2.00	8.00
20		12.00	16.00	15.00	16.00	12.00	6.00	6.00	6.00	8.00
Total	Mean	15.6500	16.6000	18.0500	18.8500	13.7500	7.0000	6.6500	4.3500	6.0000
	Sum	313.00	332.00	361.00	377.00	275.00	140.00	133.00	87.00	120.00

Table 4.3: Technical risk scores

Respondents		Risk Score B1	Risk Score B2	Risk Score B3	Risk Score B4	Risk Score B5	Risk Score B6	Risk Score B7	Risk Score B8
1		12.00	6.00	20.00	16.00	12.00	25.00	15.00	16.00
2		8.00	8.00	16.00	20.00	15.00	20.00	15.00	12.00
3		12.00	12.00	20.00	16.00	16.00	16.00	20.00	12.00
4		9.00	6.00	16.00	16.00	12.00	6.00	16.00	6.00
5		9.00	6.00	8.00	12.00	8.00	12.00	9.00	4.00
6		8.00	6.00	15.00	12.00	12.00	16.00	8.00	3.00
7		8.00	9.00	20.00	16.00	16.00	20.00	12.00	20.00
8		15.00	8.00	20.00	15.00	2.00	2.00	8.00	6.00
9		8.00	6.00	10.00	15.00	6.00	12.00	8.00	4.00
10		9.00	8.00	6.00	12.00	8.00	12.00	9.00	4.00
11		9.00	4.00	16.00	16.00	6.00	12.00	12.00	8.00
12		16.00	4.00	9.00	12.00	9.00	9.00	9.00	6.00
13		9.00	9.00	16.00	6.00	9.00	20.00	12.00	8.00
14		8.00	8.00	20.00	6.00	6.00	12.00	20.00	6.00
15		9.00	9.00	12.00	12.00	16.00	9.00	12.00	9.00
16		6.00	8.00	8.00	15.00	12.00	8.00	12.00	16.00
17		20.00	4.00	6.00	6.00	6.00	20.00	8.00	8.00
18		4.00	9.00	8.00	6.00	4.00	12.00	10.00	15.00
19		8.00	6.00	10.00	6.00	8.00	10.00	8.00	8.00
20		9.00	4.00	15.00	6.00	9.00	16.00	8.00	15.00
Total	Mean	9.8000	7.0000	13.5500	12.0500	9.6000	13.4500	11.5500	9.3000
	Sum	196.00	140.00	271.00	241.00	192.00	269.00	231.00	186.00

Table 4.4: Organizational risk scores

Respondents		Risk Score C1	Risk Score C2	Risk Score C3	Risk Score C4	Risk Score C5	Risk Score C6
1		12.00	25.00	16.00	9.00	3.00	3.00
2		8.00	25.00	25.00	25.00	4.00	4.00
3		6.00	25.00	9.00	20.00	3.00	3.00
4		16.00	15.00	16.00	9.00	2.00	6.00
5		15.00	20.00	16.00	16.00	6.00	3.00
6		16.00	25.00	20.00	25.00	3.00	3.00
7		12.00	25.00	12.00	15.00	12.00	6.00
8		8.00	16.00	12.00	10.00	8.00	15.00
9		16.00	20.00	9.00	9.00	8.00	2.00
10		6.00	25.00	12.00	16.00	6.00	4.00
11		8.00	25.00	20.00	20.00	15.00	8.00
12		9.00	20.00	12.00	16.00	3.00	8.00
13		12.00	25.00	6.00	20.00	4.00	12.00
14		8.00	16.00	12.00	12.00	9.00	6.00
15		9.00	12.00	20.00	16.00	8.00	8.00
16		16.00	12.00	15.00	15.00	4.00	6.00
17		4.00	25.00	3.00	8.00	6.00	4.00
18		9.00	20.00	8.00	12.00	12.00	3.00
19		8.00	16.00	9.00	12.00	4.00	10.00
20		8.00	15.00	20.00	16.00	10.00	5.00
Total	Mean	10.3000	20.3500	13.6000	15.0500	6.5000	5.9500
	Sum	206.00	407.00	272.00	301.00	130.00	119.00

Table 4.5: External risk scores

Respondents		Risk Score D1	Risk Score D2	Risk Score D3	Risk Score D4	Risk Score D5	Risk Score D6	Risk Score D7	Risk Score D8	Risk Score D9
1		8.00	25.00	25.00	4.00	12.00	16.00	6.00	16.00	20.00
2		5.00	25.00	25.00	3.00	3.00	20.00	10.00	12.00	15.00
3		4.00	25.00	25.00	2.00	6.00	12.00	10.00	5.00	20.00
4		3.00	20.00	20.00	2.00	3.00	4.00	15.00	4.00	15.00
5		6.00	20.00	25.00	2.00	6.00	9.00	8.00	3.00	15.00
6		10.00	25.00	25.00	1.00	6.00	16.00	10.00	4.00	15.00
7		5.00	25.00	20.00	2.00	4.00	16.00	12.00	6.00	12.00
8		4.00	4.00	20.00	9.00	20.00	12.00	6.00	4.00	6.00
9		9.00	20.00	20.00	2.00	4.00	9.00	15.00	2.00	20.00
10		2.00	25.00	25.00	1.00	3.00	12.00	15.00	3.00	20.00
11		4.00	20.00	25.00	2.00	2.00	6.00	10.00	4.00	10.00
12		4.00	12.00	25.00	3.00	2.00	6.00	10.00	6.00	20.00
13		8.00	12.00	16.00	4.00	6.00	12.00	9.00	2.00	16.00
14		3.00	16.00	25.00	6.00	9.00	16.00	4.00	6.00	9.00
15		12.00	12.00	15.00	2.00	6.00	25.00	3.00	9.00	15.00
16		6.00	10.00	12.00	2.00	4.00	12.00	8.00	6.00	16.00
17		6.00	9.00	25.00	2.00	2.00	10.00	9.00	3.00	20.00
18		8.00	16.00	25.00	6.00	2.00	10.00	9.00	3.00	15.00
19		4.00	15.00	12.00	6.00	4.00	16.00	8.00	6.00	10.00
20		5.00	20.00	15.00	3.00	3.00	15.00	15.00	9.00	12.00
Total	Mean	5.8000	17.8000	21.2500	3.2000	5.3500	12.7000	9.6000	5.6500	15.0500
	Sum	116.00	356.00	425.00	64.00	107.00	254.00	192.00	113.00	301.00

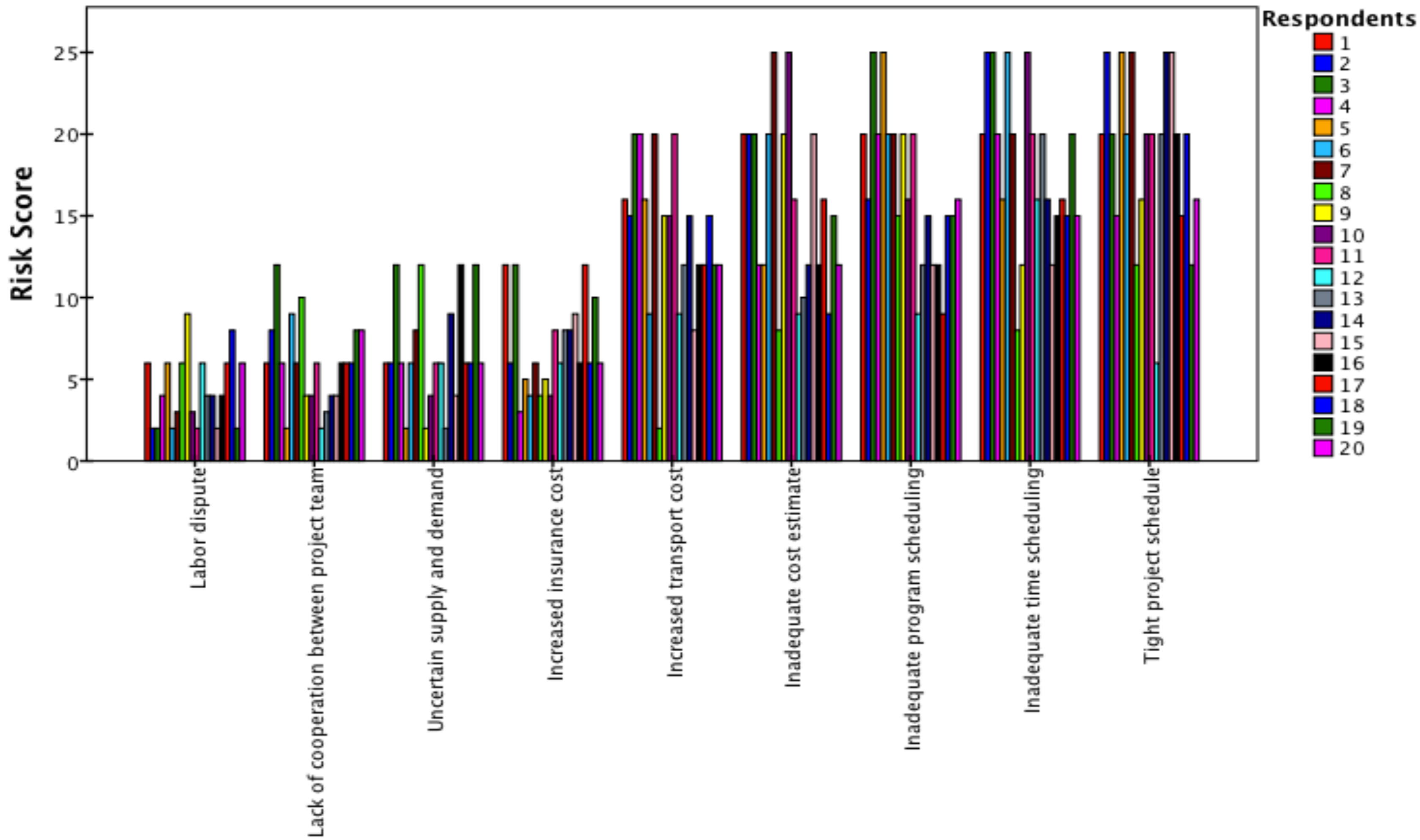

Figure 4.1: Risk scores of management category

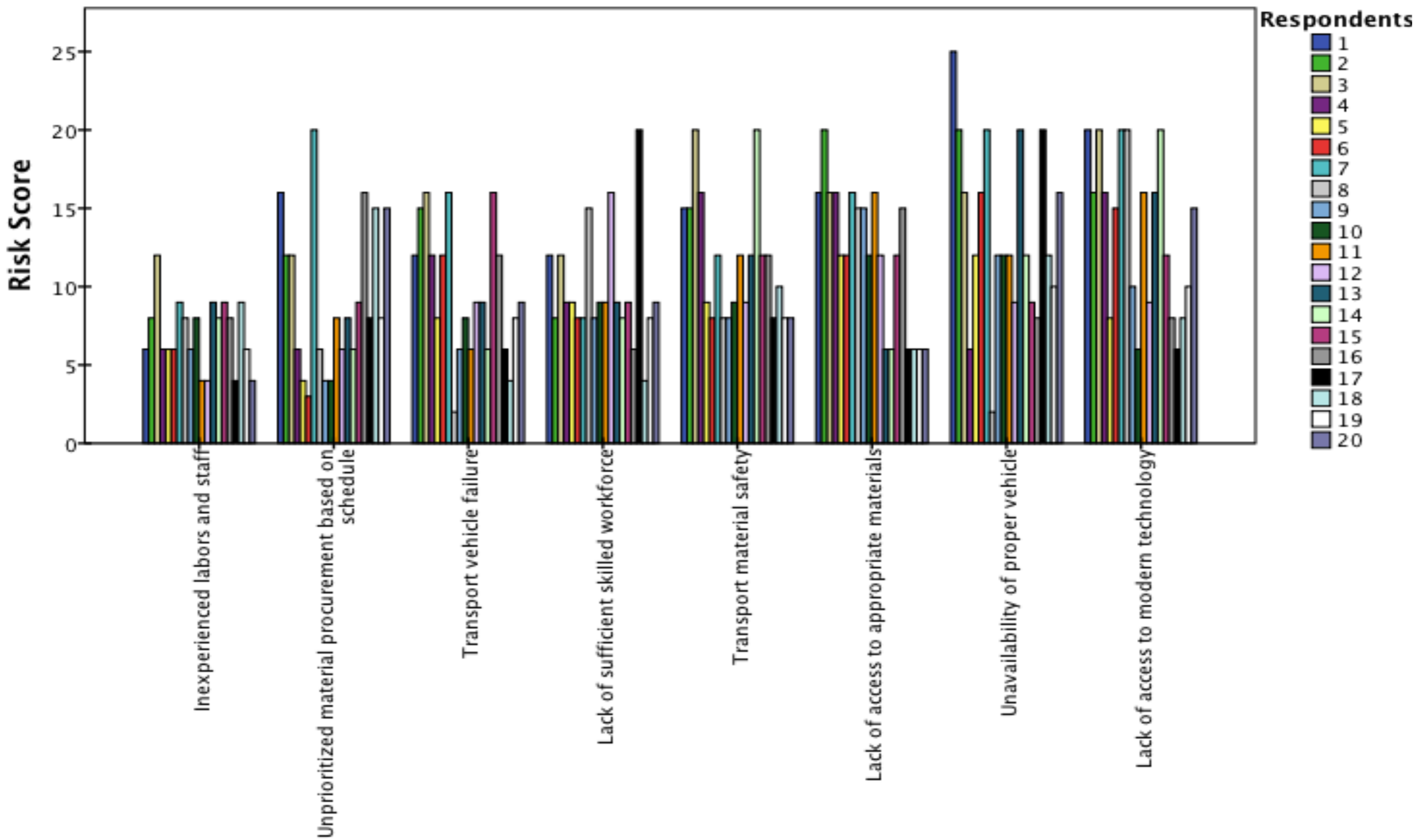

Figure 4.2: Risk scores of technical category

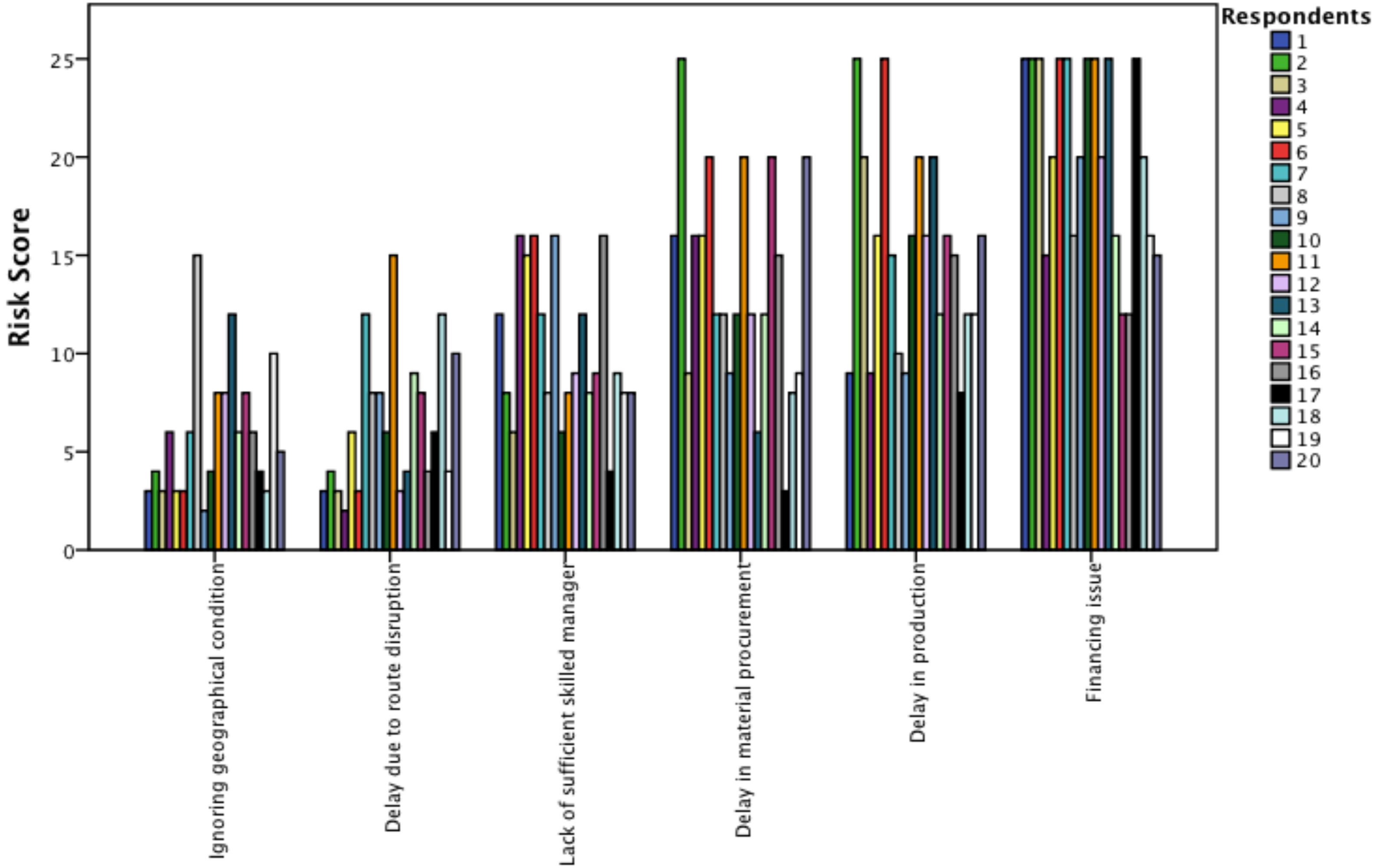

Figure 4.3: Risk scores of organizational category

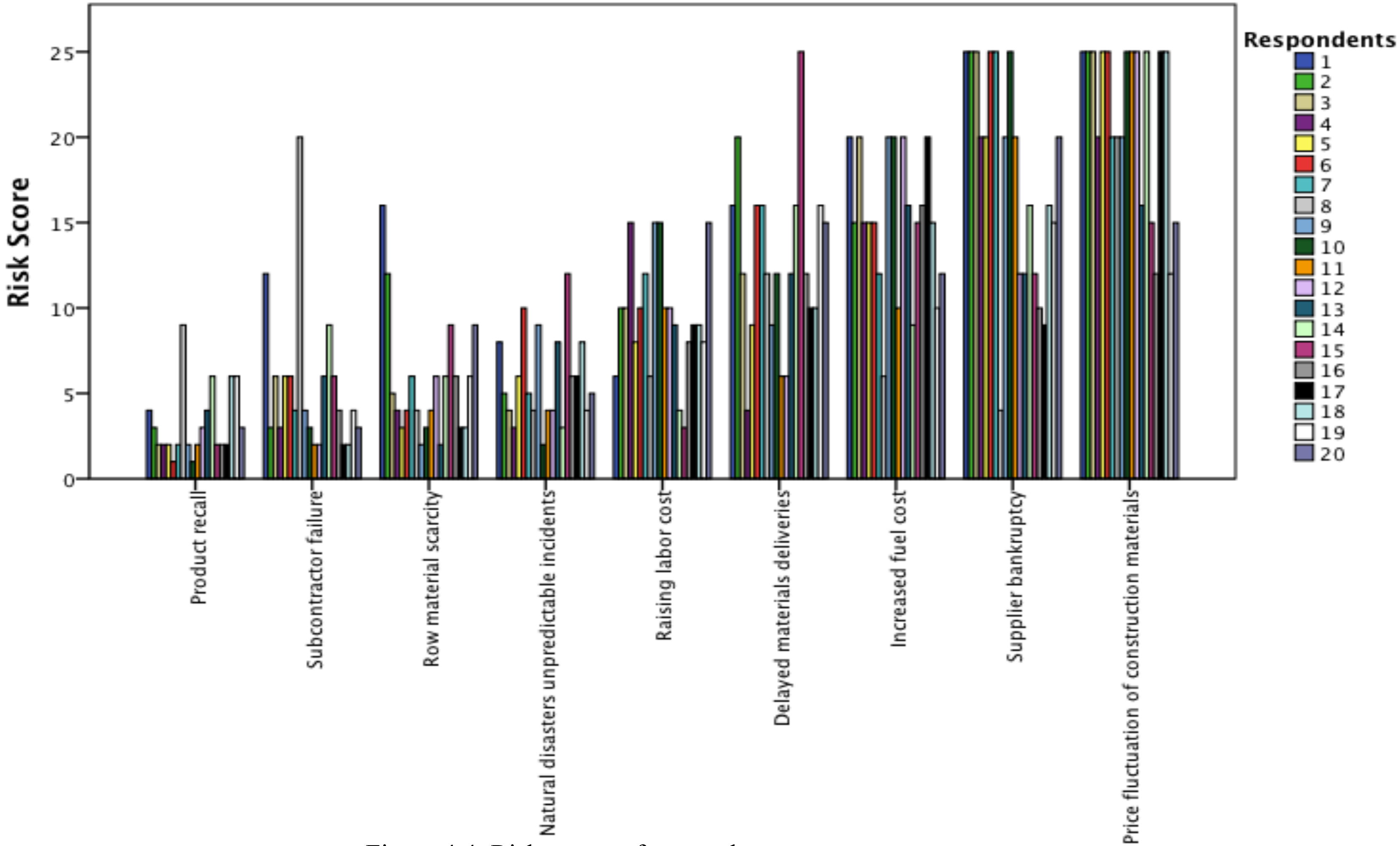

Figure 4.4: Risk scores of external category

Table 4.6: All identified risks with their average and percentage (Output by SPSS)

Risk Type	Mean Risk Score	Percentage %
Inadequate cost estimate	15.65	4.33
Inadequate program scheduling	16.60	4.59
Inadequate time scheduling	18.05	5.00
Tight project schedule	18.85	5.22
Increased transport cost	13.75	3.81
Increased insurance cost	7.00	1.94
Uncertain supply and demand	6.65	1.84
Labor dispute	4.35	1.20
Lack of cooperation between project	6.00	1.66
Lack of sufficient skilled workforce	9.80	2.71
Inexperienced labors and staff	7.00	1.94
Lack of access to modern technology	13.55	3.75
Lack of access to appropriate materials	12.05	3.33
Transport vehicle failure	9.60	2.66
Unavailability of proper vehicle	13.45	3.72
Transport material safety	11.55	3.20
Unprioritized material procurement based on schedule	9.30	2.57
Lack of sufficient skilled manager	10.30	2.85
Financing issue	20.35	5.63
Delay in material procurement	13.60	3.76
Delay in production	15.05	4.16
Delay due to route disruption	6.50	1.80
Ignoring geographical condition	5.95	1.65
Natural disasters unpredictable	5.80	1.61
Supplier bankruptcy	17.80	4.93
Price fluctuation of construction	21.25	5.88
Product recall	3.20	.89
Subcontractor failure	5.35	1.48
Delayed materials deliveries	12.70	3.51
Raising labor cost	9.60	2.66
Row material scarcity	5.65	1.56
Increased fuel cost	15.05	4.16

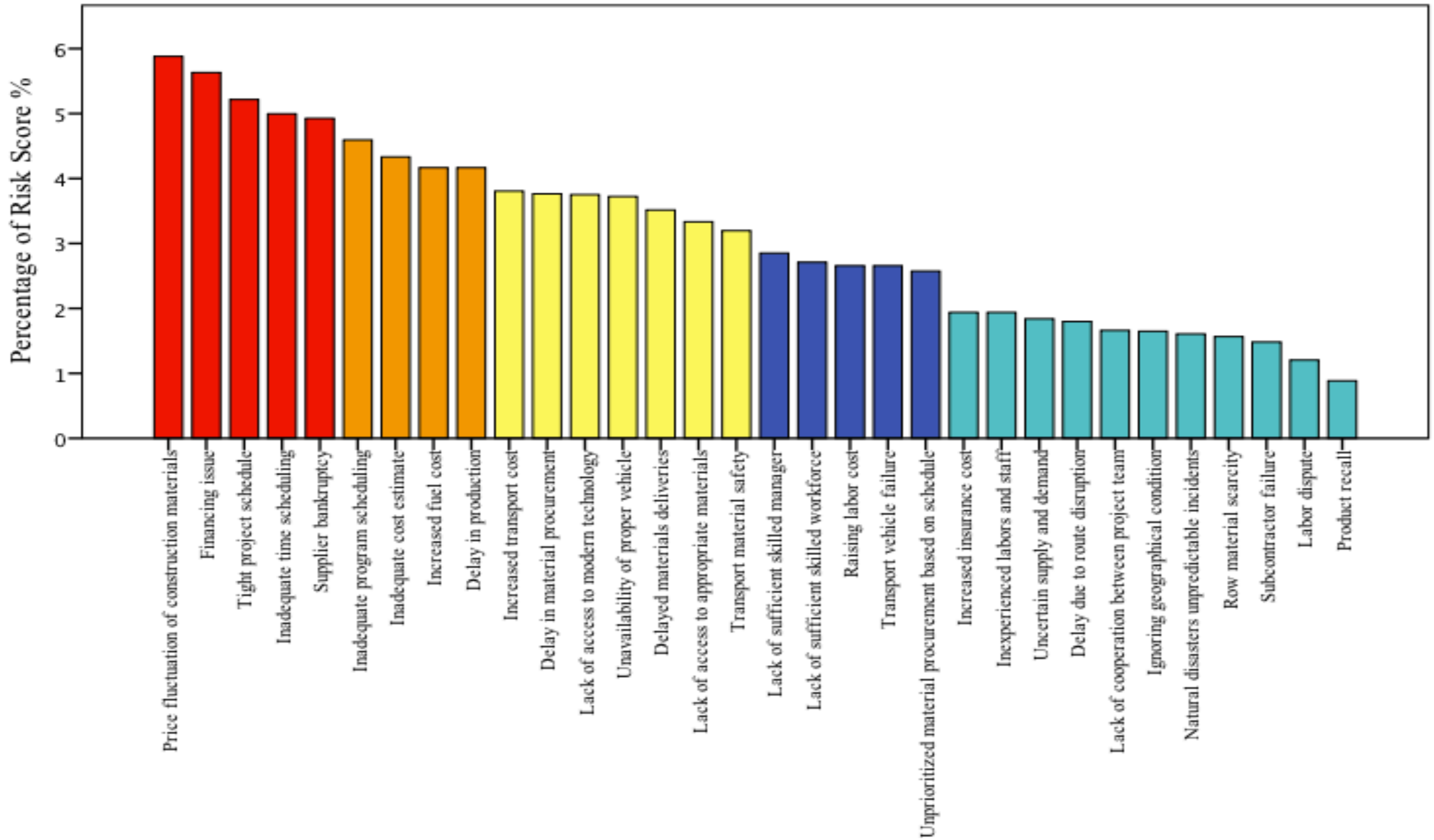

Figure 4.5: Prioritizing percentage of average risk scores

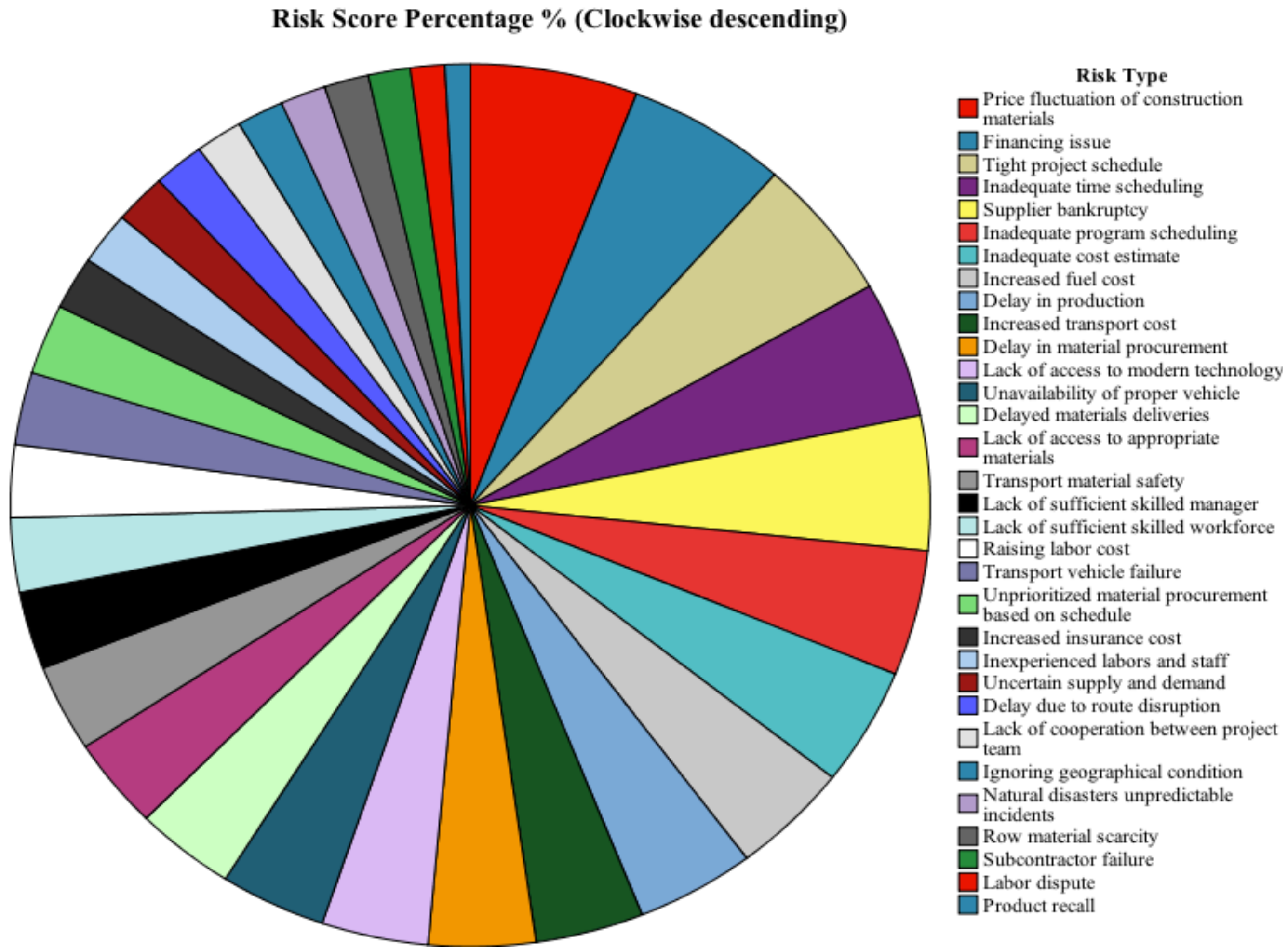

Figure 4.6: Prioritizing all risk scores

4.3.3 Third Stage: Responding to Risks

According to PMBOK (2013), the third stage of risk process is risk response, which is used to select appropriate strategies to control threats. Literature presents some of these strategies such as avoid, mitigate, transfer and accept. This research survey asked all respondents to specify suitable plan to control threats and also responsibilities assigned to who or which level of staff. Table 4.8 shows planning of risk responses based on different levels of risks.

Table 4.7: Risk response framework

Risk Type	Suitable Response	Assigned to	Detail
Very High	Avoid	Executive	Hire highly strict strategies-Change plan-Immediate protection
High	Mitigate	Upper Management	Hire highly strict strategies to decrease the probability of incidence and impact-Review by manager at the beginning of project
Medium	Transfer	Upper Management	No need to change plan-Move impact of a risk to another organizations-Review by manager
Low	Transfer-Accept	Middle Management	No need to change-Continue in monitoring-In some cases move to third party
Very Low	Accept	Intermediate	Continue with current monitoring

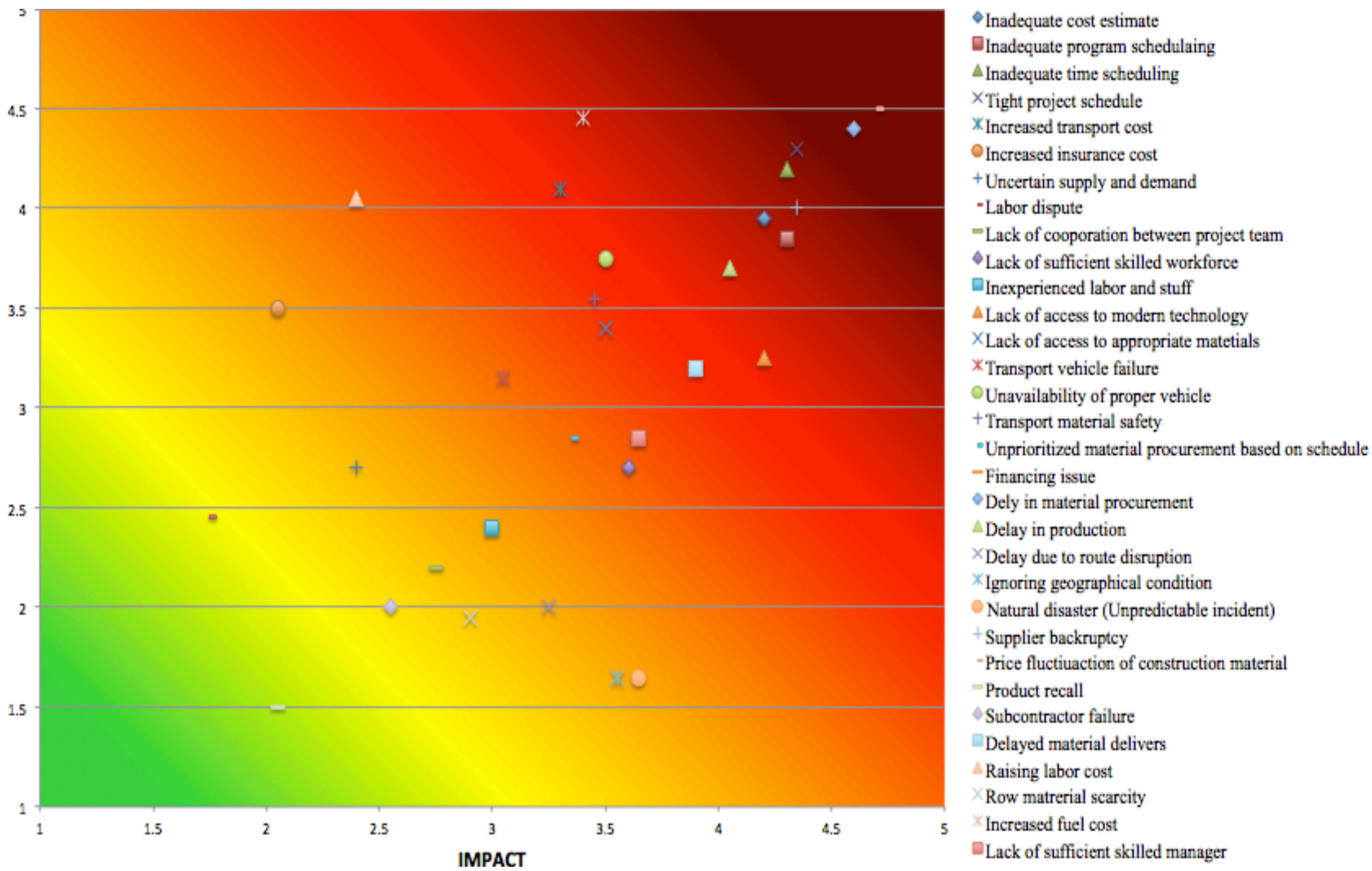

Figure 4.7: Mapping probability and impact matrix

Chapter 5

RESULTS AND DISCUSSIONS

5.1 Introduction

This chapter presents general accomplishments, and final discussions and results, which were extracted from, research survey. Moreover, it presents appropriate concept of supply chain risk realization and answers the research questions.

5.2 Results and Discussions

Supply chain risk management applies risk management process to deal with threats and uncertainties, which is as a result of resources or logistics operations. Each construction company implements different techniques and strategies to recognize the way to handle risks having negative influence on project.

5.2.1 Discussion on Risk Identification

As mentioned before, main stage of supply chain risk process is identification, which is used to create a list of potential threats that would be disruptive to any aspect of supply chain stream. There are some methods to identify risks on projects; most of which being presented earlier. This research used Risk Breakdown Structure (RBS), which categorizes risks into main responsibilities and areas. Table 3.1 shows three levels for identifying risks.

As discussed before, Iranian construction companies are located at first level of supply chain management where McCormack et al. (2004) called Ad hoc. They deal with risks as unstructured and ill defined. However, some of companies use methods to identify risks to prevent loss and damage. Most of the experienced experts apply checklist, brainstorming and also surveying historical data to recognize threats on projects.

5.2.2 Discussion on Risk Analysis

The main goal of analyzing risk is prioritizing risk based on negative impact on specific project. In management category, tight project schedule has more range in comparison with other risks. In organizational category, financial issue gained highest level of risk score, while ignoring geographical condition is lowest level in this category.

As observed in Figure 4.5, price fluctuation of construction had highest level among all potential risks. This risk can arise from many sources. The main significant factors can be availability of the product in the marketplace, fluctuation in Iranian currency and the price of raw construction materials, all mainly caused by political problems. The international community has generated highly strict sanctions on main Iranian industries, which leads to prevent importing specific construction materials and equipment.

There are some potential risks which have high rates in this study such as financing issue, tight project schedule, inadequate time scheduling and supplier bankruptcy. These risks have got high rate of probability and impact by respondents. There are some researchers who emphasize about importance of time. For instance, Lyons and Skitmore (2004) stated that one of the significant points about risk management is time loss. Other researchers determined different risks as highest rate with negative impact on project. For example, Gajewska (2011) mentioned “cheap solutions and not finding the right contractor” had maximum ranked among potential risks; while

Zou et al. (2006) stated that the most problem with high impact on project is tight project schedule.

Most of respondents emphasized that sanctions, traditional culture, inexperienced managers, lack of communications with high technology foreign companies are main problems in Iranian construction industry. Respondents in research survey emphasized that they have not been familiar with PIM or other methods. Basically, most of the experienced experts participate on meeting to survey filled checklist and then try to prioritize them based on negative influence on their project.

One of the respondents mentioned “The experienced experts consist of people who graduated minimum 10 years ago, so most of them just applied their traditional knowledge and do not have tendency to learn new subjects”

5.2.3 Discussion on Risk Response

In accordance with Perry (1986), there are three main strategies in order to respond threats on each construction projects, which can be summarized below:

- Mitigation
- Transference
- Avoidance

In order to takes proper actions, all respondents are believed that all identified risks must be separately performed according to their severity of influences on project goal. To do so, those risks which are located in dark red zones must be mitigate and also avoid in some specific situation. On the other hand those risks ,which are located in the middle of the matrix (red and orange zone) should also mitigate and transfer to others to take their responsibility.

For those risks that located in green and yellow zone (very low and low) should take both transference and acceptance since the severity of those risks is very low and by decreasing probability and impact we can accept them and proceed the project.

In overall, this research illustrate that most of the respondents were not familiar with supply chain risk management. Particularly, they had no idea about types of risk response based on strategic management. In some cases, after risk occurred, companies shift responsibilities to insurance to compensate loss, actually it can be transfer technique which is one of the main response techniques.

Nevertheless, some respondents mentioned that, experienced experts survey checklist and historical data and then try to prevent risk occurrence. This study makes clear that lack of knowledge brings it very difficult to determinate suitable response strategy.

In Iranian construction industry some of these mitigation strategies may be useful. For instance, having redundant suppliers can solve and prevent many potential risks. As supplier bankruptcy results in delay in production, delay in material delivery, lack of access to appropriate materials. Moreover, time loss and chaos in project schedule caused by delay in material delivery. Therefore, selecting reliable supplier and also having substitute supplier is one of the main mitigation strategies in this case.

5.3 Answering to Research Questions

As presented before, the questions are:

i. What is the status of supply chain management in Iranian construction companies?

ii. What are the top supply chain risks, which are highly negative on Iranian construction projects?

iii. What are the main problems and solutions of supply chain management?

As extracted by research survey and results, the answers can be:

i. According to the supply chain maturity model (McCormack et al. 2004), five levels of maturity reveal the performance characteristics toward supply chain process. Each level affiliated with maturity stage for instance, capability, control, predictability efficiency and effectiveness. It can be argued that the Iranian construction industry used supply chain management for years where is ad hoc level. They cope with risk as unstructured and ill defined. Process performance is unpredictable. Client satisfaction is dramatically low. Mostly transfer strategy is selected and finding another party who is willing to take responsibility for its management.

ii. The top 5 supply chain risks were found to be:

   1. Price fluctuation of construction materials
   2. Financing issue
   3. Tight project schedule
   4. Inadequate time scheduling
   5. Supplier bankruptcy

iii. Most of respondents emphasized that sanctions, traditional culture, inexperienced managers, and lack of communications with high technology foreign companies are main problems in Iranian construction industry. However, solutions would be elimination of the sanctions to allow Iranian industries use modern technologies and have proper relationship with high technology companies all around the world. Also, knowledge of managers and responsible staff in supply chain should become update with the latest technologies and applications.

Chapter 6

CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

This research was implemented through questionnaire and interviews, which were concerned with level of awareness of Iranian construction firms. The survey categorized all potential risks based on RBS method into four main groups of management, organizational, technical and external. Finally, some recommendations for future studies will be presented.

6.2 Conclusion

In this research probability and impact matrix was used to assess data, which shows results on a matrix table based on threat rate on project. This method is one of the suitable ways to analyze data in comparison to quantitative methods.

Based on the findings of the survey, level of Iranian construction companies in supply chain management was located at Ad hoc, which is determined as primary level. This level shows lack of knowledge about supply chain and its practices, the costs are high and satisfaction is poor. Iranian construction companies apply some techniques such as checklist, brainstorming and historical data in order to identify risks having negative influence on their project. In most cases, all respondents mentioned that their companies have tendency to wait until a threat occurs within construction project and when it is happened, they would cope with the threat based on to their skills, experience and brainstorming.

Furthermore, selecting appropriate risk analysis is highly important to find out rank of all potential risks. This selection must be related to project conditions. It was also found that most of the respondents have not been familiar with supply chain risk management. Particularly, they had no idea about types of risk responses based on supply chain risk management. In some cases, after risk occurred, companies shifted responsibilities to insurance companies to compensate loss; which actually can be transfer technique, which is one the main response techniques.

There are some factors, which interfere with deficiencies of supply chain risk management as follow:

- Absence of Knowledge
- Inexperienced managers
- Lack of communications with high technology foreign companies
- Sanctioning

This research has enabled that the author to develop his awareness of supply chain management and how to control risks in construction industry. Also this study has helped that the author to acquire knowledge and skills, which are significant to develop the construction supply chain risk management in current situations and future careers.

6.3 Recommendations for Future Studies

There are some recommendations for future studies:

- Due to lack of time, this study could not survey the drawbacks existing in current risk types and their cost effectiveness.

- Risk response and mitigation is very important on supply chain management. Future studies can focus on more novel techniques in order to speed up the process of risk response.
- Surveying impact of adverse risk events on organization members.
- Study on two main issues of supply chain risk management, cooperative and competition.
- Selecting reliable supplier and consider alternative supplier when disruption occurred.

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APPENDICES

Appendix A: Sample of Questionnaire (General Information)

Respondent Profile	
Company name	
Respondent name	
Work experience	
Field of work	
The average number of annual project	
The annual financial statement	
The number of workforce	

Appendix B: Sample of Questionnaire (Management, Technical)

General Information		Respondent Name:			Company Name:		Work Experience:			Position:	
Risk type		Probability Level of risk occurrence					Impact Level of risk occurrence					Risk Management Plan	Assigned to
		1	2	3	4	5	1	2	3	4	5		
A	MANAGEMENT												
A1	Inadequate cost estimate												
A2	Inadequate program scheduling												
A3	Inadequate time scheduling												
A4	Tight project schedule												
A5	Increased transport cost												
A6	Increased insurance cost												
A7	Uncertain supply and demand												
A8	Labor dispute												
A9	Lack of cooperation between project team												
B	TECHNICAL												
B1	Lack of sufficient skilled workforce												
B2	Inexperienced labors and staff												
B3	Lack of access to modern technology												
B4	Lack of access to appropriate materials												
B5	Transport vehicle failure												
B6	Unavailability of proper vehicle												
B7	Transport material safety												
B8	Unprioritized material procurement based on schedule												

Appendix C: Sample of Questionnaire (Organizational, External)

General Information		Respondent Name:			Company Name:		Work Experience:				Position:	
Risk type		**Probability Level of risk occurrence**					**Impact Level of risk occurrence**					**Risk Management Plan**	**Assigned to**
		1	2	3	4	5	1	2	3	4	5		
C	**ORGANIZATIONAL**												
C1	Lack of sufficient skilled manager												
C2	Financing issue												
C3	Delay in material procurement												
C4	Delay in production												
C5	Delay due to route disruption												
C6	Ignoring geographical condition												
D	**EXTERNAL**												
D1	Natural disasters unpredictable incidents												
D2	Supplier bankruptcy												
D3	Price fluctuation of construction materials												
D4	Product recall												
D5	Subcontractor failure												
D6	Delayed materials deliveries												
D7	Raising labor cost												
D8	Row material scarcity												
D9	Increased fuel cost												

Appendix D: Sample of Interview

<table>
<tr><td colspan="2" rowspan="6">General Information</td><td>1. Which Position do you have in the project?</td></tr>
<tr><td>2. How would you define supply chain in construction projects?</td></tr>
<tr><td>3. How much are you familiar with the concept of supply chain management and supply chain risk management process?</td></tr>
<tr><td>4. Do you formally evaluate your suppliers based on the supply chain management process?</td></tr>
<tr><td>5. Do you perform any audit of their Risk Management process?</td></tr>
<tr><td>6. Do you have any specific concern or comment about your supply chain exposures?</td></tr>
<tr><td rowspan="8">Supply Chain Risk Process</td><td rowspan="2">Identification</td><td>1. Which strategies do you apply to identify threats in construction projects? (e.g., as an individual or in the organization)</td></tr>
<tr><td>2. What are the main threats that you encounter with them?</td></tr>
<tr><td rowspan="2">Analysis</td><td>1. After identifying a number of risks on site, how would you categorize and prioritize them?</td></tr>
<tr><td>2. Which analyzing techniques have you ever used? (For instance, Probability and Impact Matrix, FMEA, FTA,...)</td></tr>
<tr><td rowspan="4">Response</td><td>1. What are the main mitigation strategies you usually take against risks?</td></tr>
<tr><td>2. How are risks controlled within your construction projects?</td></tr>
<tr><td>3. How should risk management be organized in construction projects?</td></tr>
<tr><td>4. Do you have a contingency strategy for alternative supply of critical items?</td></tr>
</table>

Appendix E: Reliability by SPSS

```
RELIABILITY
 /VARIABLES=A1 A2 A3 A4 A5 A6 A7 A8 A9 B1 B2 B3 B4 B5 B6 B7 B8 C1 C2 C3 C4 C5 C6 D1 D2 D3 D4
 /SCALE('ALL VARIABLES') ALL
 /MODEL=ALPHA
 /STATISTICS=DESCRIPTIVE SCALE CORR COV
 /SUMMARY=TOTAL MEANS VARIANCE COV CORR.
```

Reliability

Notes

Output Created		**19-MAY-2014 16:58:43**
Comments		
Input	**Data**	/Users/mehradabedini/Desktop/SPSS calculate/Untitled1.sav
	Active Dataset	**DataSet1**
	Filter	**<none>**
	Weight	**<none>**
	Split File	**<none>**
	N of Rows in Working Data File	**32**
	Matrix Input	
Missing Value Handling	**Definition of Missing**	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the procedure.
Syntax		RELIABILITY /VARIABLES=A1 A2 A3 A4 A5 A6 A7 A8 A9 B1 B2 B3 B4 B5 B6 B7 B8 C1 C2 C3 C4 C5 C6 D1 D2 D3 D4 D5 D6 D7 D8 D9 /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /STATISTICS=DESCRIPTIVE SCALE CORR COV /SUMMARY=TOTAL MEANS VARIANCE COV CORR.
Resources	**Processor Time**	**00:00:00.07**
	Elapsed Time	**00:00:00.00**

```
[DataSet1] /Users/mehradabedini/Desktop/SPSS calculate/Untitled1.sav
```

Warnings

The determinant of the covariance matrix is zero or approximately zero. Statistics based on its inverse matrix cannot be computed and they are displayed as system missing values.

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	20	62.5
	Excluded[a]	12	37.5
	Total	32	100.0

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

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.782	.706	32

Item Statistics

	Mean	Std. Deviation	N
Risk Score A1	15.6500	5.30417	20
Risk Score A2	16.6000	4.59290	20
Risk Score A3	18.0500	4.78457	20
Risk Score A4	18.8500	5.15318	20
Risk Score A5	13.7500	4.62118	20
Risk Score A6	7.0000	2.79096	20
Risk Score A7	6.6500	3.28113	20
Risk Score A8	4.3500	2.15883	20
Risk Score A9	6.0000	2.61574	20
Risk Score B1	9.8000	3.63608	20
Risk Score B2	7.0000	2.15211	20
Risk Score B3	13.5500	5.08325	20
Risk Score B4	12.0500	4.51285	20
Risk Score B5	9.6000	4.13458	20
Risk Score B6	13.4500	5.64265	20
Risk Score B7	11.5500	3.87264	20
Risk Score B8	9.3000	4.91078	20
Risk Score C1	10.3000	3.79889	20
Risk Score C2	20.3500	4.85880	20
Risk Score C3	13.6000	5.57627	20
Risk Score C4	15.0500	5.07289	20
Risk Score C5	6.5000	3.64908	20
Risk Score C6	5.9500	3.39466	20
Risk Score D1	5.8000	2.60768	20
Risk Score D2	17.8000	6.40395	20
Risk Score D3	21.2500	4.79995	20
Risk Score D4	3.2000	2.06729	20
Risk Score D5	5.3500	4.28308	20
Risk Score D6	12.7000	4.99579	20
Risk Score D7	9.6000	3.50038	20
Risk Score D8	5.6500	3.52846	20
Risk Score D9	15.0500	4.21120	20

Inter-Item Correlation Matrix

	Risk Score A1	Risk Score A2	Risk Score A3	Risk Score A4	Risk Score A5	Risk Score A6
Risk Score A1	1.000	.357	.536	.437	.376	.160
Risk Score A2	.357	1.000	.358	.371	.595	-.103
Risk Score A3	.536	.358	1.000	.265	.524	.114
Risk Score A4	.437	.371	.265	1.000	.398	.059
Risk Score A5	.376	.595	.524	.398	1.000	.147
Risk Score A6	.160	-.103	.114	.059	.147	1.000
Risk Score A7	-.137	-.045	-.016	-.218	-.124	.224
Risk Score A8	-.421	-.107	-.629	-.345	-.160	-.157
Risk Score A9	.144	.289	.248	-.086	-.039	.173
Risk Score B1	-.099	-.301	-.169	-.521	-.319	.368
Risk Score B2	.217	.186	.174	.489	.116	.096
Risk Score B3	.093	.384	.152	.232	.165	.137
Risk Score B4	.423	.458	.231	.175	.276	-.209
Risk Score B5	.562	.232	.501	.419	.314	.182
Risk Score B6	.466	.137	.508	.381	.368	.501
Risk Score B7	.115	.288	.342	.442	.526	.331
Risk Score B8	.134	-.011	.035	.264	.284	.311
Risk Score C1	-.052	.342	-.067	.126	.100	-.486
Risk Score C2	.479	.287	.649	.172	.381	.225
Risk Score C3	.196	.254	.192	.349	.020	-.315
Risk Score C4	.235	.166	.594	.365	.045	-.123
Risk Score C5	.007	.047	-.351	.264	.161	-.083
Risk Score C6	-.466	-.430	-.363	-.355	-.531	-.056
Risk Score D1	.135	-.073	-.235	.264	-.297	.130
Risk Score D2	.687	.711	.742	.438	.683	-.053
Risk Score D3	.181	.313	.341	.144	.300	.020
Risk Score D4	-.574	-.246	-.464	-.264	-.441	.055
Risk Score D5	-.184	.109	-.366	-.024	-.479	.018
Risk Score D6	.423	-.132	.067	.507	-.286	.268
Risk Score D7	.236	.258	.312	-.252	.400	-.458
Risk Score D8	.246	-.006	.132	.194	.007	.358
Risk Score D9	.345	-.015	.298	-.085	.220	.233

Inter-Item Correlation Matrix

	Risk Score A7	Risk Score A8	Risk Score A9	Risk Score B1	Risk Score B2	Risk Score B3
Risk Score A1	-.137	-.421	.144	-.099	.217	.093
Risk Score A2	-.045	-.107	.289	-.301	.186	.384
Risk Score A3	-.016	-.629	.248	-.169	.174	.152
Risk Score A4	-.218	-.345	-.086	-.521	.489	.232
Risk Score A5	-.124	-.160	-.039	-.319	.116	.165
Risk Score A6	.224	-.157	.173	.368	.096	.137
Risk Score A7	1.000	-.301	.675	.082	.276	.315
Risk Score A8	-.301	1.000	-.317	.164	-.295	-.292
Risk Score A9	.675	-.317	1.000	.061	.271	.455
Risk Score B1	.082	.164	.061	1.000	-.336	-.008
Risk Score B2	.276	-.295	.271	-.336	1.000	.313
Risk Score B3	.315	-.292	.455	-.008	.313	1.000
Risk Score B4	.090	-.234	.232	-.022	.168	.336
Risk Score B5	.051	-.585	.180	-.167	.384	.286
Risk Score B6	-.287	-.070	.036	.074	.017	.220
Risk Score B7	.264	-.364	.166	-.141	.512	.601
Risk Score B8	.324	-.015	.266	-.220	.279	.269
Risk Score C1	-.253	.179	-.244	-.445	-.064	.005
Risk Score C2	-.286	-.133	.083	.216	.035	.139
Risk Score C3	-.100	-.394	.123	-.326	-.167	.253
Risk Score C4	-.100	-.622	.186	-.276	.212	.152
Risk Score C5	-.086	.150	-.083	-.250	-.067	.070
Risk Score C6	.305	-.184	.030	.208	.043	.243
Risk Score D1	-.421	.163	-.139	-.182	.084	-.114
Risk Score D2	-.229	-.284	.160	-.370	.103	.254
Risk Score D3	-.238	.113	-.038	.277	-.066	.083
Risk Score D4	.438	.267	.204	.055	.142	.289
Risk Score D5	.328	.111	.282	.245	.246	.544
Risk Score D6	.106	-.419	.201	-.215	.377	.247
Risk Score D7	-.279	.159	.040	-.118	-.245	-.185
Risk Score D8	.139	-.170	.171	.011	-.035	.381
Risk Score D9	-.406	.224	-.253	.245	.006	-.417

Inter-Item Correlation Matrix

	Risk Score B4	Risk Score B5	Risk Score B6	Risk Score B7	Risk Score B8	Risk Score C1
Risk Score A1	.423	.562	.466	.115	.134	-.052
Risk Score A2	.458	.232	.137	.288	-.011	.342
Risk Score A3	.231	.501	.508	.342	.035	-.067
Risk Score A4	.175	.419	.381	.442	.264	.126
Risk Score A5	.276	.314	.368	.526	.284	.100
Risk Score A6	-.209	.182	.501	.331	.311	-.486
Risk Score A7	.090	.051	-.287	.264	.324	-.253
Risk Score A8	-.234	-.585	-.070	-.364	-.015	.179
Risk Score A9	.232	.180	.036	.166	.266	-.244
Risk Score B1	-.022	-.167	.074	-.141	-.220	-.445
Risk Score B2	.168	.384	.017	.512	.279	-.064
Risk Score B3	.336	.286	.220	.601	.269	.005
Risk Score B4	1.000	.469	-.024	.290	.125	.294
Risk Score B5	.469	1.000	.367	.448	.413	.186
Risk Score B6	-.024	.367	1.000	.186	.420	-.110
Risk Score B7	.290	.448	.186	1.000	.243	-.069
Risk Score B8	.125	.413	.420	.243	1.000	-.073
Risk Score C1	.294	.186	-.110	-.069	-.073	1.000
Risk Score C2	.196	.104	.708	.051	.011	-.194
Risk Score C3	.499	.415	-.021	.120	.074	.220
Risk Score C4	.227	.450	.247	.111	-.022	-.001
Risk Score C5	-.142	-.359	-.068	-.155	.241	-.243
Risk Score C6	-.141	-.268	-.438	-.146	-.125	-.178
Risk Score D1	-.075	.207	.235	-.233	.058	.378
Risk Score D2	.394	.492	.517	.304	.154	.158
Risk Score D3	.211	-.135	.281	.222	-.238	-.224
Risk Score D4	-.306	-.550	-.297	-.001	.046	-.269
Risk Score D5	.149	-.218	-.185	.102	-.090	.013
Risk Score D6	-.027	.481	.296	.134	.296	-.178
Risk Score D7	.151	.017	.060	-.243	-.045	.168
Risk Score D8	.305	.484	.410	.327	.517	-.098
Risk Score D9	.130	.294	.391	.018	-.026	.075

Inter-Item Correlation Matrix

	Risk Score C2	Risk Score C3	Risk Score C4	Risk Score C5	Risk Score C6	Risk Score D1
Risk Score A1	.479	.196	.235	.007	-.466	.135
Risk Score A2	.287	.254	.166	.047	-.430	-.073
Risk Score A3	.649	.192	.594	-.351	-.363	-.235
Risk Score A4	.172	.349	.365	.264	-.355	.264
Risk Score A5	.381	.020	.045	.161	-.531	-.297
Risk Score A6	.225	-.315	-.123	-.083	-.056	.130
Risk Score A7	-.286	-.100	-.100	-.086	.305	-.421
Risk Score A8	-.133	-.394	-.622	.150	-.184	.163
Risk Score A9	.083	.123	.186	-.083	.030	-.139
Risk Score B1	.216	-.326	-.276	-.250	.208	-.182
Risk Score B2	.035	-.167	.212	-.067	.043	.084
Risk Score B3	.139	.253	.152	.070	.243	-.114
Risk Score B4	.196	.499	.227	-.142	-.141	-.075
Risk Score B5	.104	.415	.450	-.359	-.268	.207
Risk Score B6	.708	-.021	.247	-.068	-.438	.235
Risk Score B7	.051	.120	.111	-.155	-.146	-.233
Risk Score B8	.011	.074	-.022	.241	-.125	.058
Risk Score C1	-.194	.220	-.001	-.243	-.178	.378
Risk Score C2	1.000	-.140	.375	-.016	-.312	-.036
Risk Score C3	-.140	1.000	.516	.044	-.126	.103
Risk Score C4	.375	.516	1.000	-.081	-.058	.104
Risk Score C5	-.016	.044	-.081	1.000	.066	-.006
Risk Score C6	-.312	-.126	-.058	.066	1.000	-.174
Risk Score D1	-.036	.103	.104	-.006	-.174	1.000
Risk Score D2	.532	.390	.392	-.038	-.671	-.066
Risk Score D3	.648	.018	.136	.053	-.468	-.177
Risk Score D4	-.306	-.262	-.367	.153	.586	-.168
Risk Score D5	-.150	-.009	-.238	-.083	.457	.035
Risk Score D6	-.121	.356	.279	-.009	.021	.423
Risk Score D7	.241	-.009	.043	.008	-.338	-.303
Risk Score D8	-.042	.544	.063	-.178	-.133	.124
Risk Score D9	.390	-.243	-.012	-.481	-.596	.236

Inter-Item Correlation Matrix

	Risk Score D2	Risk Score D3	Risk Score D4	Risk Score D5	Risk Score D6	Risk Score D7
Risk Score A1	.687	.181	-.574	-.184	.423	.236
Risk Score A2	.711	.313	-.246	.109	-.132	.258
Risk Score A3	.742	.341	-.464	-.366	.067	.312
Risk Score A4	.438	.144	-.264	-.024	.507	-.252
Risk Score A5	.683	.300	-.441	-.479	-.286	.400
Risk Score A6	-.053	.020	.055	.018	.268	-.458
Risk Score A7	-.229	-.238	.438	.328	.106	-.279
Risk Score A8	-.284	.113	.267	.111	-.419	.159
Risk Score A9	.160	-.038	.204	.282	.201	.040
Risk Score B1	-.370	.277	.055	.245	-.215	-.118
Risk Score B2	.103	-.066	.142	.246	.377	-.245
Risk Score B3	.254	.083	.289	.544	.247	-.185
Risk Score B4	.394	.211	-.306	.149	-.027	.151
Risk Score B5	.492	-.135	-.550	-.218	.481	.017
Risk Score B6	.517	.281	-.297	-.185	.296	.060
Risk Score B7	.304	.222	-.001	.102	.134	-.243
Risk Score B8	.154	-.238	.046	-.090	.296	-.045
Risk Score C1	.158	-.224	-.269	.013	-.178	.168
Risk Score C2	.532	.648	-.306	-.150	-.121	.241
Risk Score C3	.390	.018	-.262	-.009	.356	-.009
Risk Score C4	.392	.136	-.367	-.238	.279	.043
Risk Score C5	-.038	.053	.153	-.083	-.009	.008
Risk Score C6	-.671	-.468	.586	.457	.021	-.338
Risk Score D1	-.066	-.177	-.168	.035	.423	-.303
Risk Score D2	1.000	.406	-.518	-.293	.113	.456
Risk Score D3	.406	1.000	-.133	-.004	-.273	.034
Risk Score D4	-.518	-.133	1.000	.634	.083	-.468
Risk Score D5	-.293	-.004	.634	1.000	.222	-.513
Risk Score D6	.113	-.273	.083	.222	1.000	-.468
Risk Score D7	.456	.034	-.468	-.513	-.468	1.000
Risk Score D8	.279	-.032	.061	.193	.579	-.297
Risk Score D9	.278	.291	-.600	-.395	-.177	.298

Inter-Item Correlation Matrix

	Risk Score D8	Risk Score D9
Risk Score A1	.246	.345
Risk Score A2	-.006	-.015
Risk Score A3	.132	.298
Risk Score A4	.194	-.085
Risk Score A5	.007	.220
Risk Score A6	.358	.233
Risk Score A7	.139	-.406
Risk Score A8	-.170	.224
Risk Score A9	.171	-.253
Risk Score B1	.011	.245
Risk Score B2	-.035	.006
Risk Score B3	.381	-.417
Risk Score B4	.305	.130
Risk Score B5	.484	.294
Risk Score B6	.410	.391
Risk Score B7	.327	.018
Risk Score B8	.517	-.026
Risk Score C1	-.098	.075
Risk Score C2	-.042	.390
Risk Score C3	.544	-.243
Risk Score C4	.063	-.012
Risk Score C5	-.178	-.481
Risk Score C6	-.133	-.596
Risk Score D1	.124	.236
Risk Score D2	.279	.278
Risk Score D3	-.032	.291
Risk Score D4	.061	-.600
Risk Score D5	.193	-.395
Risk Score D6	.579	-.177
Risk Score D7	-.297	.298
Risk Score D8	1.000	.037
Risk Score D9	.037	1.000

Inter-Item Covariance Matrix

	Risk Score A1	Risk Score A2	Risk Score A3	Risk Score A4	Risk Score A5	Risk Score A6
Risk Score A1	28.134	8.695	13.597	11.945	9.224	2.368
Risk Score A2	8.695	21.095	7.863	8.779	12.632	-1.316
Risk Score A3	13.597	7.863	22.892	6.534	11.592	1.526
Risk Score A4	11.945	8.779	6.534	26.555	9.487	.842
Risk Score A5	9.224	12.632	11.592	9.487	21.355	1.895
Risk Score A6	2.368	-1.316	1.526	.842	1.895	7.789
Risk Score A7	-2.392	-.674	-.245	-3.687	-1.882	2.053
Risk Score A8	-4.818	-1.063	-6.492	-3.839	-1.592	-.947
Risk Score A9	2.000	3.474	3.105	-1.158	-.474	1.263
Risk Score B1	-1.916	-5.032	-2.937	-9.768	-5.368	3.737
Risk Score B2	2.474	1.842	1.789	5.421	1.158	.579
Risk Score B3	2.518	8.968	3.708	6.087	3.882	1.947
Risk Score B4	10.124	9.495	4.997	4.061	5.750	-2.632
Risk Score B5	12.326	4.411	9.916	8.937	6.000	2.105
Risk Score B6	13.955	3.558	13.713	11.071	9.592	7.895
Risk Score B7	2.361	5.126	6.339	8.824	9.408	3.579
Risk Score B8	3.479	-.242	.826	6.679	6.447	4.263
Risk Score C1	-1.047	5.968	-1.226	2.468	1.763	-5.158
Risk Score C2	12.339	6.411	15.087	4.318	8.566	3.053
Risk Score C3	5.800	6.516	5.126	10.042	.526	-4.895
Risk Score C4	6.334	3.863	14.418	9.534	1.066	-1.737
Risk Score C5	.132	.789	-6.132	4.974	2.711	-.842
Risk Score C6	-8.387	-6.705	-5.892	-6.218	-8.329	-.526
Risk Score D1	1.874	-.874	-2.937	3.547	-3.579	.947
Risk Score D2	23.347	20.916	22.747	14.442	20.211	-.947
Risk Score D3	4.618	6.895	7.829	3.566	6.645	.263
Risk Score D4	-6.295	-2.337	-4.589	-2.811	-4.211	.316
Risk Score D5	-4.187	2.147	-7.492	-.524	-9.487	.211
Risk Score D6	11.205	-3.021	1.595	13.058	-6.605	3.737
Risk Score D7	4.379	4.147	5.232	-4.537	6.474	-4.474
Risk Score D8	4.608	-.095	2.229	3.524	.118	3.526
Risk Score D9	7.703	-.295	5.997	-1.834	4.276	2.737

Inter-Item Covariance Matrix

	Risk Score A7	Risk Score A8	Risk Score A9	Risk Score B1	Risk Score B2	Risk Score B3
Risk Score A1	-2.392	-4.818	2.000	-1.916	2.474	2.518
Risk Score A2	-.674	-1.063	3.474	-5.032	1.842	8.968
Risk Score A3	-.245	-6.492	3.105	-2.937	1.789	3.708
Risk Score A4	-3.687	-3.839	-1.158	-9.768	5.421	6.087
Risk Score A5	-1.882	-1.592	-.474	-5.368	1.158	3.882
Risk Score A6	2.053	-.947	1.263	3.737	.579	1.947
Risk Score A7	10.766	-2.134	5.789	.979	1.947	5.255
Risk Score A8	-2.134	4.661	-1.789	1.284	-1.368	-3.203
Risk Score A9	5.789	-1.789	6.842	.579	1.526	6.053
Risk Score B1	.979	1.284	.579	13.221	-2.632	-.147
Risk Score B2	1.947	-1.368	1.526	-2.632	4.632	3.421
Risk Score B3	5.255	-3.203	6.053	-.147	3.421	25.839
Risk Score B4	1.334	-2.282	2.737	-.358	1.632	7.708
Risk Score B5	.695	-5.221	1.947	-2.505	3.421	6.021
Risk Score B6	-5.308	-.850	.526	1.516	.211	6.318
Risk Score B7	3.361	-3.045	1.684	-1.989	4.263	11.839
Risk Score B8	5.216	-.163	3.421	-3.937	2.947	6.721
Risk Score C1	-3.153	1.468	-2.421	-6.147	-.526	.089
Risk Score C2	-4.555	-1.392	1.053	3.811	.368	3.429
Risk Score C3	-1.832	-4.747	1.789	-6.611	-2.000	7.179
Risk Score C4	-1.666	-6.808	2.474	-5.095	2.316	3.918
Risk Score C5	-1.026	1.184	-.789	-3.316	-.526	1.289
Risk Score C6	3.403	-1.350	.263	2.568	.316	4.187
Risk Score D1	-3.600	.916	-.947	-1.726	.474	-1.516
Risk Score D2	-4.811	-3.926	2.684	-8.621	1.421	8.274
Risk Score D3	-3.750	1.171	-.474	4.842	-.684	2.013
Risk Score D4	2.968	1.189	1.105	.411	.632	3.042
Risk Score D5	4.603	1.029	3.158	3.811	2.263	11.850
Risk Score D6	1.732	-4.521	2.632	-3.905	4.053	6.279
Risk Score D7	-3.200	1.200	.368	-1.505	-1.842	-3.295
Risk Score D8	1.608	-1.292	1.579	.137	-.263	6.834
Risk Score D9	-5.613	2.034	-2.789	3.747	.053	-8.924

Inter-Item Covariance Matrix

	Risk Score B4	Risk Score B5	Risk Score B6	Risk Score B7	Risk Score B8	Risk Score C1
Risk Score A1	10.124	12.326	13.955	2.361	3.479	-1.047
Risk Score A2	9.495	4.411	3.558	5.126	-.242	5.968
Risk Score A3	4.997	9.916	13.713	6.339	.826	-1.226
Risk Score A4	4.061	8.937	11.071	8.824	6.679	2.468
Risk Score A5	5.750	6.000	9.592	9.408	6.447	1.763
Risk Score A6	-2.632	2.105	7.895	3.579	4.263	-5.158
Risk Score A7	1.334	.695	-5.308	3.361	5.216	-3.153
Risk Score A8	-2.282	-5.221	-.850	-3.045	-.163	1.468
Risk Score A9	2.737	1.947	.526	1.684	3.421	-2.421
Risk Score B1	-.358	-2.505	1.516	-1.989	-3.937	-6.147
Risk Score B2	1.632	3.421	.211	4.263	2.947	-.526
Risk Score B3	7.708	6.021	6.318	11.839	6.721	.089
Risk Score B4	20.366	8.758	-.603	5.076	2.774	5.037
Risk Score B5	8.758	17.095	8.558	7.179	8.389	2.916
Risk Score B6	-.603	8.558	31.839	4.055	11.647	-2.353
Risk Score B7	5.076	7.179	4.055	14.997	4.616	-1.016
Risk Score B8	2.774	8.389	11.647	4.616	24.116	-1.358
Risk Score C1	5.037	2.916	-2.353	-1.016	-1.358	14.432
Risk Score C2	4.297	2.095	19.413	.955	.258	-3.584
Risk Score C3	12.547	9.568	-.653	2.600	2.021	4.653
Risk Score C4	5.208	9.442	7.082	2.182	-.542	-.016
Risk Score C5	-2.342	-5.421	-1.395	-2.184	4.316	-3.368
Risk Score C6	-2.155	-3.758	-8.397	-1.918	-2.089	-2.300
Risk Score D1	-.884	2.232	3.463	-2.358	.747	3.747
Risk Score D2	11.379	13.021	18.674	7.537	4.853	3.853
Risk Score D3	4.566	-2.684	7.618	4.118	-5.605	-4.079
Risk Score D4	-2.853	-4.705	-3.463	-.011	.463	-2.116
Risk Score D5	2.876	-3.853	-4.482	1.692	-1.900	.205
Risk Score D6	-.616	9.926	8.353	2.595	7.253	-3.379
Risk Score D7	2.389	.253	1.189	-3.295	-.768	2.232
Risk Score D8	4.861	7.063	8.166	4.466	8.953	-1.311
Risk Score D9	2.471	5.126	9.292	.287	-.542	1.195

Inter-Item Covariance Matrix

	Risk Score C2	Risk Score C3	Risk Score C4	Risk Score C5	Risk Score C6	Risk Score D1
Risk Score A1	12.339	5.800	6.334	.132	-8.387	1.874
Risk Score A2	6.411	6.516	3.863	.789	-6.705	-.874
Risk Score A3	15.087	5.126	14.418	-6.132	-5.892	-2.937
Risk Score A4	4.318	10.042	9.534	4.974	-6.218	3.547
Risk Score A5	8.566	.526	1.066	2.711	-8.329	-3.579
Risk Score A6	3.053	-4.895	-1.737	-.842	-.526	.947
Risk Score A7	-4.555	-1.832	-1.666	-1.026	3.403	-3.600
Risk Score A8	-1.392	-4.747	-6.808	1.184	-1.350	.916
Risk Score A9	1.053	1.789	2.474	-.789	.263	-.947
Risk Score B1	3.811	-6.611	-5.095	-3.316	2.568	-1.726
Risk Score B2	.368	-2.000	2.316	-.526	.316	.474
Risk Score B3	3.429	7.179	3.918	1.289	4.187	-1.516
Risk Score B4	4.297	12.547	5.208	-2.342	-2.155	-.884
Risk Score B5	2.095	9.568	9.442	-5.421	-3.758	2.232
Risk Score B6	19.413	-.653	7.082	-1.395	-8.397	3.463
Risk Score B7	.955	2.600	2.182	-2.184	-1.918	-2.358
Risk Score B8	.258	2.021	-.542	4.316	-2.089	.747
Risk Score C1	-3.584	4.653	-.016	-3.368	-2.300	3.747
Risk Score C2	23.608	-3.800	9.245	-.289	-5.139	-.453
Risk Score C3	-3.800	31.095	14.600	.895	-2.389	1.495
Risk Score C4	9.245	14.600	25.734	-1.500	-.997	1.379
Risk Score C5	-.289	.895	-1.500	13.316	.816	-.053
Risk Score C6	-5.139	-2.389	-.997	.816	11.524	-1.537
Risk Score D1	-.453	1.495	1.379	-.053	-1.537	6.800
Risk Score D2	16.547	13.916	12.747	-.895	-14.589	-1.095
Risk Score D3	15.118	.474	3.303	.921	-7.618	-2.211
Risk Score D4	-3.074	-3.021	-3.853	1.158	4.116	-.905
Risk Score D5	-3.129	-.221	-5.176	-1.289	6.650	.389
Risk Score D6	-2.942	9.926	7.068	-.158	.353	5.516
Risk Score D7	4.095	-.168	.758	.105	-4.021	-2.768
Risk Score D8	-.713	10.695	1.124	-2.289	-1.597	1.137
Risk Score D9	7.982	-5.716	-.266	-7.395	-8.524	2.589

Inter-Item Covariance Matrix

	Risk Score D2	Risk Score D3	Risk Score D4	Risk Score D5	Risk Score D6	Risk Score D7
Risk Score A1	23.347	4.618	-6.295	-4.187	11.205	4.379
Risk Score A2	20.916	6.895	-2.337	2.147	-3.021	4.147
Risk Score A3	22.747	7.829	-4.589	-7.492	1.595	5.232
Risk Score A4	14.442	3.566	-2.811	-.524	13.058	-4.537
Risk Score A5	20.211	6.645	-4.211	-9.487	-6.605	6.474
Risk Score A6	-.947	.263	.316	.211	3.737	-4.474
Risk Score A7	-4.811	-3.750	2.968	4.603	1.732	-3.200
Risk Score A8	-3.926	1.171	1.189	1.029	-4.521	1.200
Risk Score A9	2.684	-.474	1.105	3.158	2.632	.368
Risk Score B1	-8.621	4.842	.411	3.811	-3.905	-1.505
Risk Score B2	1.421	-.684	.632	2.263	4.053	-1.842
Risk Score B3	8.274	2.013	3.042	11.850	6.279	-3.295
Risk Score B4	11.379	4.566	-2.853	2.876	-.616	2.389
Risk Score B5	13.021	-2.684	-4.705	-3.853	9.926	.253
Risk Score B6	18.674	7.618	-3.463	-4.482	8.353	1.189
Risk Score B7	7.537	4.118	-.011	1.692	2.595	-3.295
Risk Score B8	4.853	-5.605	.463	-1.900	7.253	-.768
Risk Score C1	3.853	-4.079	-2.116	.205	-3.379	2.232
Risk Score C2	16.547	15.118	-3.074	-3.129	-2.942	4.095
Risk Score C3	13.916	.474	-3.021	-.221	9.926	-.168
Risk Score C4	12.747	3.303	-3.853	-5.176	7.068	.758
Risk Score C5	-.895	.921	1.158	-1.289	-.158	.105
Risk Score C6	-14.589	-7.618	4.116	6.650	.353	-4.021
Risk Score D1	-1.095	-2.211	-.905	.389	5.516	-2.768
Risk Score D2	41.011	12.474	-6.853	-8.032	3.621	10.232
Risk Score D3	12.474	23.039	-1.316	-.092	-6.553	.579
Risk Score D4	-6.853	-1.316	4.274	5.611	.853	-3.389
Risk Score D5	-8.032	-.092	5.611	18.345	4.742	-7.695
Risk Score D6	3.621	-6.553	.853	4.742	24.958	-8.179
Risk Score D7	10.232	.579	-3.389	-7.695	-8.179	12.253
Risk Score D8	6.295	-.539	.442	2.918	10.205	-3.674
Risk Score D9	7.484	5.882	-5.221	-7.124	-3.721	4.389

Inter-Item Covariance Matrix

	Risk Score D8	Risk Score D9
Risk Score A1	4.608	7.703
Risk Score A2	-.095	-.295
Risk Score A3	2.229	5.997
Risk Score A4	3.524	-1.834
Risk Score A5	.118	4.276
Risk Score A6	3.526	2.737
Risk Score A7	1.608	-5.613
Risk Score A8	-1.292	2.034
Risk Score A9	1.579	-2.789
Risk Score B1	.137	3.747
Risk Score B2	-.263	.053
Risk Score B3	6.834	-8.924
Risk Score B4	4.861	2.471
Risk Score B5	7.063	5.126
Risk Score B6	8.166	9.292
Risk Score B7	4.466	.287
Risk Score B8	8.953	-.542
Risk Score C1	-1.311	1.195
Risk Score C2	-.713	7.982
Risk Score C3	10.695	-5.716
Risk Score C4	1.124	-.266
Risk Score C5	-2.289	-7.395
Risk Score C6	-1.597	-8.524
Risk Score D1	1.137	2.589
Risk Score D2	6.295	7.484
Risk Score D3	-.539	5.882
Risk Score D4	.442	-5.221
Risk Score D5	2.918	-7.124
Risk Score D6	10.205	-3.721
Risk Score D7	-3.674	4.389
Risk Score D8	12.450	.545
Risk Score D9	.545	17.734

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	11.292	3.200	21.250	18.050	6.641	25.396	32
Item Variances	18.211	4.274	41.011	36.737	9.596	80.844	32
Inter-Item Covariances	1.834	-14.589	23.347	37.937	-1.600	29.685	32
Inter-Item Correlations	.070	-.671	.742	1.414	-1.106	.080	32

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Risk Score A1	345.7000	2076.853	.614	.	.757
Risk Score A2	344.7500	2158.934	.519	.	.765
Risk Score A3	343.3000	2123.168	.580	.	.761
Risk Score A4	342.5000	2127.632	.521	.	.763
Risk Score A5	347.6000	2184.568	.453	.	.768
Risk Score A6	354.3500	2343.187	.188	.	.780
Risk Score A7	354.7000	2408.116	-.053	.	.788
Risk Score A8	357.0000	2499.789	-.476	.	.794
Risk Score A9	355.3500	2314.134	.321	.	.776
Risk Score B1	351.5500	2480.682	-.255	.	.796
Risk Score B2	354.3500	2327.713	.334	.	.777
Risk Score B3	347.8000	2132.379	.519	.	.763
Risk Score B4	349.3000	2170.642	.501	.	.766
Risk Score B5	351.7500	2140.303	.639	.	.760
Risk Score B6	347.9000	2073.147	.577	.	.759
Risk Score B7	349.8000	2210.063	.485	.	.768
Risk Score B8	352.0500	2219.313	.342	.	.773
Risk Score C1	351.0500	2405.208	-.048	.	.789
Risk Score C2	341.0000	2159.368	.484	.	.766
Risk Score C3	347.7500	2201.987	.322	.	.774
Risk Score C4	346.3000	2195.168	.380	.	.771
Risk Score C5	354.8500	2432.239	-.122	.	.791
Risk Score C6	355.4000	2553.726	-.477	.	.802
Risk Score D1	355.5500	2388.892	.024	.	.784
Risk Score D2	343.5500	1946.892	.732	.	.746
Risk Score D3	340.1000	2264.095	.251	.	.778
Risk Score D4	358.1500	2474.871	-.376	.	.792
Risk Score D5	356.0000	2404.421	-.050	.	.791
Risk Score D6	348.6500	2234.555	.301	.	.775
Risk Score D7	351.7500	2399.039	-.028	.	.788
Risk Score D8	355.7000	2230.747	.476	.	.769
Risk Score D9	346.3000	2352.326	.077	.	.785

Scale Statistics

Mean	Variance	Std. Deviation	N of Items
361.3500	2401.713	49.00728	32