Investigation of Supply Chain Risk Management Implementation in Canadian Construction Industry

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ABSTRACT

In today's world, construction industry in known to be associated with high and critical risk factors. The industry is also known for being a fragmented, low productive, conflicted industry, which is mostly associated with time or cost overruns. Considering these properties, the riskiness of this sector becomes more critical. On the other hand, if the huge amount of investment in the industry is well-thought-out, employing solution techniques, to overcome the problems and cope with the risks, seems to be crucial. Bearing this in mind, supply chain management is nowadays well known for being an innovative method, providing new solutions to the problems, specifically in construction industry.

Supply chain management is known to be an innovative method of resolving these issues, especially that if the substantial amount of investment in the industry, in a country like Canada is considered, which also can indicate the industry's riskiness level. It is even more crucial, as the risks are associated with supply chain implementation, which affects the success or failure of the projects. Admittedly, implementation of supply chain risk management, even in a developed country like Canada, demands progress and a day-by-day more extensive structure.

Having all these ideas in mind, this research study has been done, focusing on supply chain management implementation in Canadian construction industry. The research was conducted through a checklist and a questionnaire survey.

A hierarchical structure, to identify risks, based on previous studies was prepared. The identified risks were assessed by means of probability and impact matrix, which is a popular qualitative method, to assess the risks and prioritize them for further analysis. In the last stage, as the high risks were determined, suitable responses to cope with each of them, in the case of their occurrence, were proposed.

Keywords: Canadian construction industry, supply chain, supply chain management, risk factor, risk management

ÖZ

Günümüzde İnşaat Endüstrisi yüksek ve kritik risk faktörleri içermekte. Endüstri aynı zamanda parçalanmış, verimi düşük, ve sektörde fikir ayrılıkları olmasından dolayı zaman alan ve maaliyetli bir endüstri olarak görünmekte. Bu özellikleri göz önünde bulundurduğumuz zaman sektördeki risk düzeyi daha da kritik olmakta. Bu sebeple, problemleri çözmek ve risklere karşı durabilmek için sektördeki yüksek miktardaki yatırımın iyi düşünülmüş olması ve çözüm tekniklerinin kullanılması büyük önem kazanmakta. Tedarik Zinciri Yönetimi, bugünlerde özellikle inşaat sektöründe karşılaşılan problemlere yönelik yeni çözüm olanakları sunan yenilikçi bir metod olarak bilinmekte.

Kanada gibi önemli yatırımların dolayısıyle risk faktörlerinin yüksek olduğu bir ülkede Tedarik Zinciri Yönetimi'nin kullanılması bahsedilen sorunların çözümüne katkı sağlayacaktır. Özellikle de Tedarik Zinciri Yönetimi'nden kaynaklanan risklerin yönetilmesinde ki bu projenin başarılı olup olmayacağını etkiler. Kabul etmek gerekir ki, Kanada gibi gelişmiş bir ülkede bile tedarik zinciri yönetiminin her geçen gün daha iyi olması için çaba gösterilmeli.

Bahsedilen konulan çerçevesinde bu çalışma Kanada İnşaat Sektöründeki Tedarik Ziniciri Yönetimi uygulanmasına yönelik yapıldı.

Riskleri tanımlamak için, bir hiyerarşik yapı, daha önceki araştırmacıların çalışmalarına dayanılarak hazırlandı Tanımlanan riskler populer nitel bir test olan olasılık testleri ve etki matrixleri yöntemleri ile ölçülerek risk değerlendirmesi ve daha sonraki analiz için önem değerlendirmesi yapıldı. Son olarak yüksek risk tanımlandığı durumlarda uygun yöntemlerin kullanılması gerektiği sonucuna varıldı.

Anahtar kelimeler: Kanada İnşaat endüstrisi, Tedarik zinciri, tedarik zinciri yönetimi, risk faktörleri, risk yönetimi

This thesis is dedicated to my parents, brother and sisters

For their endless love, support and encouragement

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LIST OF ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
BPR	Business Process Reengineering
CD	Concurrent Design
CE	Concurrent Engineering
CEA	Ishikawa Cause and Effect Analysis
CLM	Council of Logistics Management
CSC	Construction Supply Chain
CSCM	Construction Supply Chain Management
CSCRM	Construction Supply Chain Risk Management
DPM	Dynamic Planning and control Methodology
EDI	Electronic Data Interchange
EMV	Expected Monetary Value
ERP	Enterprise Resource Planning
FMEA	Failure Mode and Effect Analysis
GC	General Contractor
ICT	Information and Communication Technologies
ISO	International Standard Organization
IT	Information Technology
NRC	National Research Council Canada
PIM	Probability and Impact Matrix
PMBOK	Project Management Body of Knowledge
PMI	Project Management Institute
RBS	Risk Breakdown Structure

RM	Risk Management
SC	Supply Chain
SCM	Supply Chain Management
SCRM	Supply Chain Risk Management
SCRMP	Supply Chain Risk Management Process
SGML	Standard Generalized Markup Language
SPSS	Statistical Package for Social Sciences
SRA	Solicitors Regulation Authority
SWOT	Strengths, Weaknesses, Opportunities, and Threats
VMI	Vendor Managed Inventory
WBS	Work Breakdown Structure
XML	eXtensible Markup Language

Chapter 1

INTRODUCTION

1.1 Introduction

In this chapter, the background information, brief explanations about supply chain and supply chain management, employment of this concept in construction industry and techniques of managing risks in the concept are provided along with methodology, aims, achievement and the outlines of this thesis.

1.2 Background Information

According to an explanation, supply chain is a network of parties, or organizations connected to each other, through linkages of upstream and downstream, and are involved in various activities, producing services and products and delivering them to the ultimate customers (Christopher, 1992).

Managing supply chain is aiming to improve performance of individual companies in long term, along with overall improving the supply chain performance (Mentzer, et al., 2001). Supply chain management is a strategic structured harmonization of the customary business function of a specific company, in a supply chain.

The idea of supply chain management (SCM) was originated from manufacturing industry, aiming to rise the efficiency and usefulness, resulting in greater cooperation (Harland, 1996). Obviously, the need for boosting the performance of projects and their profitability was also emerged to construction industry, leading to suggestions of changing methods of managing supply chains of construction sector (Agapiou et.al., 1998).

Usually there are many risk factors associated with construction industry projects, which may be attributed to substantial investments in this sector. Bearing this in mind, implementing SCM principles in the sectors becomes a crucial fact, which can even affect its success or failure. Risks within the concept of supply chain are mainly defined as threats having negative, unanticipated impacts on the objectives and produce undesirable results. Therefore, they need to be managed effectively (Walker et al., 2003).

Risk management is about taking necessary actions against the potential risks, in order to reduce their occurrence probability and impacts, affecting the projects (Shahriari, 2011). It is mainly the procedure of potential risks' identification, analyzing them and responding to them, in an organization (Waters, 2011).

Although Canada is a well-developed country which is employing supply chain management efficiently, there is still an essential need to employ the method more structured by developing more regulated methods.

The current research work aims to investigate implementation of supply chain risk management in Canadian construction sector. The stage of risk identification was mainly based on the research work of Aloini et al. (2012 a), which includes a broad range research papers (approximately 140), published by famous international journals like Science Direct (Elsevier), Springer and IEEE-Xplore. Following risk identification, hierarchal classification of risks was done along with the idea of Risk

Breakdown Structure (RBS), which was mainly obtained from previous studies of Simons (1999) and Meulbroek (2000).

A checklist including sorts of risks, the identified risk factors, and SCM sub-contexts were arranged after the mentioned stages. Moreover, the aim of preparing questionnaires was to understand how much the survey participants are knowledgeable of the concept of risk management in construction supply chain. Furthermore, probability and impact matrix was selected to perform qualitative risk assessment and prioritization. As this stage was done based on the prioritization, high risks were conveyed to the next stage, i.e. risks response planning.

Eventually, it has revealed from qualitative analysis by means of (PIM), total 13, 13, 5 and 14 top ranked risks were recognized for time, cost, quality and overall case of projects' risks, which have most negative impact on project objectives. In addition, it has achieved from questionnaire survey nearly all the participants used various methods for risk identification and risk assessment. Moreover, they have own specific framework for risk response strategies.

1.3 Aims and Objectives

The following points indicate the main objectives of this research study:

- To understand the main objectives of construction supply chain management (CSCM) in Canadian construction industry.
- Identification and classification of the main risk factors negatively affecting CSCM implementation in the mentioned industry.
- To explore commonly employed methods of risk response planning in the mentioned industry.

- Proposing a framework to overcome the pitfalls of CSCM in Canadian construction industry.

To fulfill the aims, the following research questions have been developed to support the study:

i. What are the most important functions of internal organization in supply chain management?
ii. What are the most influential factors of SCM on suppliers and clients relationships?
iii. Which factors are the main objectives of developing the employment of CSCM in Canadian construction sector?
iv. Which factors are effective on CSC relationships?
v. What are the most negatively influencing factors on CSCM implementation of Canadian construction industry?
vi. Which strategies are mainly employed against the risks in Canadian construction companies?

1.4 Works Carried Out

To carry out this research, the following works and stages have been implemented:

i. A comprehensive literature review has been performed according to the available sources and previous studies.
ii. The core topic of this research was chosen to be about implementation of supply chain management in Canadian construction sector.
iii. A checklist was prepared for analysis, to understand which risks are effective on implementation of CSCM.

iv. To understand the respondents' knowledgeability level of risk management in construction supply chain, a questionnaire survey was conducted.

v. Having the necessary data collected, risk assessment and prioritization was done through qualitative method by means of the popular method of probability and impact matrix.

vi. Finally, to find an appropriate method of responding and treating the high risks, a framework has been suggested according to previous literatures and participants' responses.

1.5 Achievements

The following points present the main achievements of this research study:

i. Performing the literature review revealed that there is a lack of theoretical literature on construction supply chain risk management (CSCRM) which is mainly focused on risk assessment stage.

ii. Qualitative analysis of this research revealed that a total number of 13, 13, 5 and 14 risks were found to be highly influential (critical), in terms of time, cost, quality and the overall case, respectively, having the largest negative impacts on the project objectives. Comparing the risks together, the 14 risks of overall case also include the other recognized risks in terms of time, cost, and quality. Further investigations revealed that these 14 risks are in fact generated from five main risk factors, which are inadequate communication, late involvement of parts, inadequate IT system, weakness of concurrent design, and inadequate selection of suppliers.

iii. According to the checklist survey's results, the risk percentages which are affecting project's time are having larger share, compared to cost and quality, which are coming afterwards respectively.

iv. It was revealed by questionnaire survey that various methods are employed by companies (participated in survey), to identify and assess risks. In addition, to face with the risks, each company employs a specific framework.

v. Finally, in order to find the suitable and practical responding method to treat the identified high risks, a framework has been proposed according to the participants' responds and previous studies done on this field.

1.6 Thesis Outline

Chapter 2, named as the literature review, includes a broad review of the previous research studies on supply chain management, construction industry, construction supply chain management (CSCM) and the application of risk management (RM) in construction supply chain management (CSCM).

In chapter 3, the methodology, the chosen methods employed in four sections of risk identification, data collection, risk analysis and response will be presented. The methods were selected based on literature reviews and the properties of each method.

Chapter 4 presents the questionnaire survey and checklists results from each respondent's perspective along with the analysis performed on the raw collected data to fulfill this study's purposes.

Chapter 5 consists of results and discussions obtained from checklists and questionnaire surveys.

Summary of outcomes of this study along with some recommendations for future studies have been brought in chapter 6.

Chapter 2

BACKGROUND & LITERATURE REVIEW

2.1 Introduction

Nowadays, one of the major worldwide financially influential industrial sectors is the construction sectors, which at the same time is complex and suffering from underachievement (Aloini, Dulmin, & Mininno, 2012). Furthermore, it is known that the supply chain as the producer and provider of raw materials play a crucial role in success or failure of construction projects. Therefore, management of this part, the supply chain, is steadily becoming more and more important. Discussions on supply chain management (SCM) in constructions sector is frequently associated with a broad range of definitions.

This chapter is covering a broad review of previous research works and published literatures on supply chain management (SCM), supply chain management in construction industry (CSCM) and finally, the employment of risk management (RM) methods in construction supply chain management (CSCM). In a list form, the outline of this chapter is as follows:

- Construction industry
- Supply chain management (SCM)
- Construction industry supply chain management (CSCM)
- Risk and employment of risk management (RM) in (CSCM)

2.2 Construction Industry

Construction industry is a huge sector nowadays which deals with various stages from design and renovation to manufacture and production of construction materials. This sector is a dynamic process, usually offering high incomes for the contractors and workers, and therefore is indeed attractive. However, the seasonal and irregular nature of it often affects the yearly income of workers, significantly.

It is accepted that construction industry which is indeed competitive and risky, is a combination of science and art. That is to say, understanding the technical aspects of construction is not the key point to gain success and it is vital for construction professionals to be aware and knowledgeable of business and management aspects of this job as well. On the other hand, day-by-day technological progression and worldwide competitions in this sector cause the acceleration of development in construction management techniques, supply chain management, and risk management methods.

Consequently, increasing demand to employ new innovative expert professionals in construction management field will be an increasing trend in the coming years (Nunnally, 2004).

2.2.1 Construction Industry in Canada

Construction industry is a huge sector in Canada and is in fact an indicator of the country's financial strength. Consuming nearly 40% of Canada's energy and 50% of the primary resources, currently 1.24 million people are in this sector (NRC, 2014) and, to keep its influence and vitality, better, more energy-efficient and affordable construction materials are required.

Construction projects are aiming extensive functionalities, from houses, to residential complexes, schools, hospitals, as well as dams, highways, nuclear power stations etc. It is providing the main portion of the other sections' capital investment, governments, businesses, citizens, as well as other industries. Therefore, the industry is both a production and a service industry, offering means for industrial growth, and being including works, responding others orders and investment decisions (Historica Canada , 2014).

Considerable investments in construction industry, specifically in Canada, increases the riskiness of this section. Moreover, being associated with supply chain, which in fact affects its success or failure, makes implementation of SCM principles more crucial.

2.3 Supply Chain Management (SCM)

To understand the concept of supply chain management, it is essential to understand the definition of supply chain firstly.

2.3.1 Supply Chain Definition

It is important to have a clear distinct definition of supply chain. However, likewise most of the management concepts, there are various definitions given for it. Some of these definitions are listed in Table 2.1.

Table 2.1: Supply chain definitions (Hatmoko, 2008)

Authors	Supply chain definitions
(Lee and Billington, 1992)	*"... a network of facilities that procure raw materials, transform them into intermediate goods and then final products, and deliver the products to customers through a distribution system"*
(La Londe and Masters, 1994)	a set of companies that pass materials forward
(Towill, 1996)	*"a system whose constituent parts include materials supplies, production facilities, distribution services and customers linked via the feed-forward flow of materials and the feedback flow of information"*
(Holmberg, 1997)	*"... a set of organizations performing activities with the purpose of satisfying the ultimate consumer. "*
(Christopher, 1998)	*"The supply chain is the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate customer"*
(Lambert et al., 1998)	*".. the alignment of firms that brings products or services to a market"*
(Handfeld and Nichols, 1999)	all activities related to the flow and transformation of products from the raw material through the end customer
(Mentzer et al., 2001)	*"... a set of three or more companies directly linked by one or more of the upstream and downstream flows of products, services, finances and information from a source to a customer"*
(Tommelein et al., 2003)	*"a group of companies and individuals working collaborately in a network of interrelated processes" (as quoted from Arbulu and Ballard (2004))*

What can be understood from the definitions in Table 2.1 is that a supply chain is a set of three objects: flows of materials, services and information, from the source to the costumers.

This definition is the general understanding of the supply chain. Moreover, various types of supply chain based on the involved organization level are shown in Figure 2.1 (Mentzer, et al., 2001).

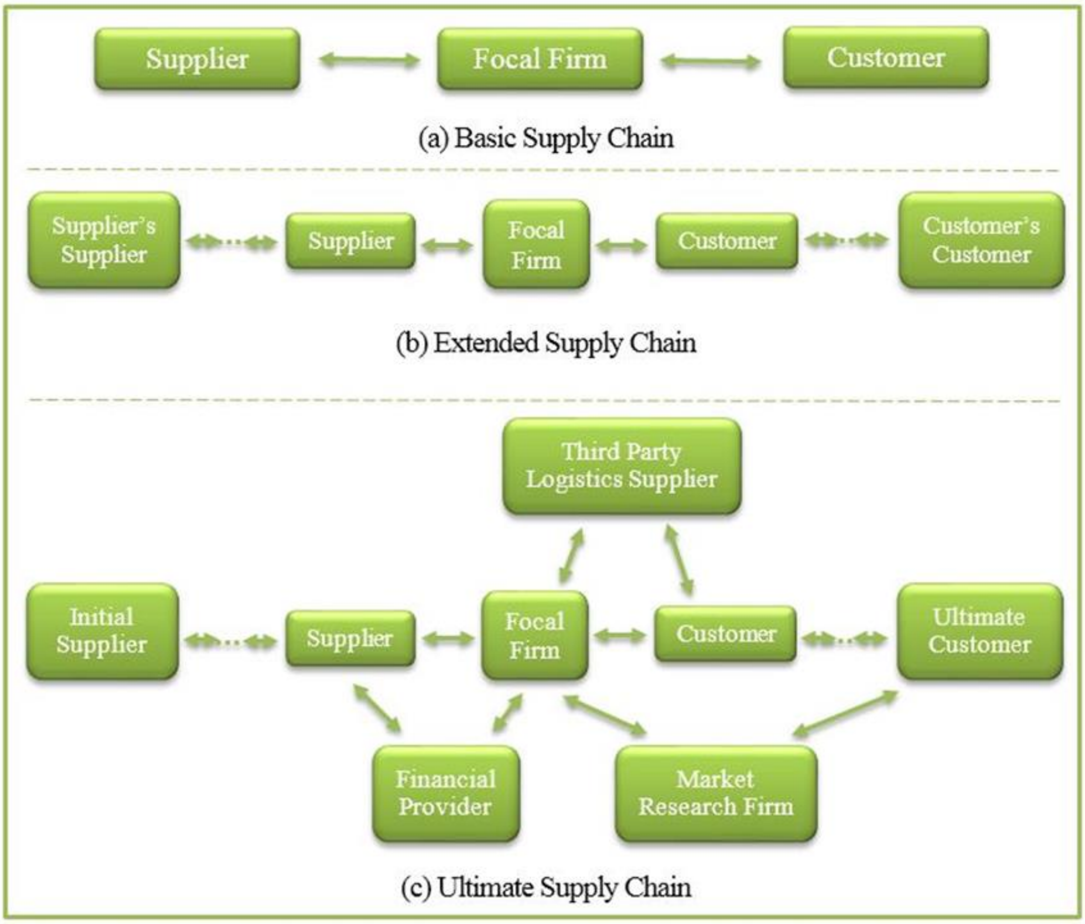


Figure 2.1: Types of chain relationships (adapted from Mentzer et al., (2001))

- A simple supply chain includes a producer, a company, and a costumer, which are directly connected via one, and more flows of products (materials, services, information and finances, etc.) (Figure 2.1 a).
- In the extended supply chain, there are immediate suppliers of customers and suppliers, dealing with upstream or downstream flow of products, materials, services etc. (Figure 2.l b).
- In the ultimate supply chain, there are organizations dealing with up and down streams of products, services, materials, and finances and information, from the ultimate suppliers to ultimate customers (Figure 2.l c).

This classification is done based on the level and number of organizations connected via up or down flow streams. More complex supply chains are made, when more organizations are involved.

2.3.2 Defining Supply Chain Management

Although there are various definitions given for the "supply chain" concept compared to the given definitions of "supply chain management", the former one seems to be defined more variously, since the concept of it has been under focused since early years of 1980s (Cooper & Ellram, 1993; La Londe & Masters, 1994). Collection and classification of these definitions has been done by Mentzer et al. (2001). Three main categories of definitions are proposed, which are as follows:

- A joint management procedure
- The employment of a management philosophy
- A management philosophy

In Table 2.2, these three categories are summarized with their own definitions separately.

Table 2.2: Categorization of SCM (developed from Mentzer et al., (2001))

Categories of SCM	Definition	Characteristics
As a management philosophy (Ellram & Cooper (1990), Houlihan (1985), Ellram (1990), Jones & Riley (1985), Cooper et al., (1997), Ross (1998), Langley & Holcomb (1992)	*"a set of beliefs that each firm in the supply chain directly and indirectly affects the performance of all the other supply chain members, as well as ultimate, overall channel performance"*	adopts a system approach to viewing the channels as a single entity, rather than as a set of fragmented parts performing individually system approach, and to managing the total flow of goods inventory from the supplier to the ultimate customer, *"a strategic orientation toward cooperative efforts to synchronize and converge intrafirm operational and strategic capabilities into a unified whole, a customer to create unique and individualized source of customer value, leading to customer satisfaction"*
As the implementation of management philosophy Cooper & Ellram (1993), Cooper et al. (1997), Ellram & Cooper (1990), Novack et al., (1995)	a set of activities to carry out the philosophy of SCM	*"Integrated behavior Mutually sharing information Mutually sharing channel risk and rewards Cooperation The same goal and the same focus of serving customers Integration of processes Partners to build and maintain long-term relationship"*
As a set of management processes La Londe (1997), Ross (1998), Cooper et al (1997), Lambert et al., (1998)	a process of managing relationships, information and materials flow across organization boundaries in order to meet customer demand	All functions within a supply chain are reorganized as key processes, including customer relationship management customer service management, demand management, order fulfilment, manufacturing flow management procurement, and product development and commercialization.

On the other hand, unlike Mentzer et al., (2001) who collected and classified different definitions of SCM, Saunders (1995) believed that having one single definition of SCM concept improves the research about SCM and its practicing. Having this in mind, different definitions from various viewpoints have been collected together and the following definition have been proposed:

The systemic, strategic coordination of the traditional business functions within a particular company and across businesses within the supply Chain, for the purposes of improving the long term performance of the individual companies and the supply chain as a whole.

2.3.3 Evolution of Supply Chain Management

Due to different ways of defining the concept of supply chain management, there are also various standpoints, which the evolution of this concept can be viewed. Evolution of SCM was defined by Rushton et al. (2000) from logistics and distribution viewpoint as:

The competition among firms is increasing which has led the idea of redefining business goals and reengineering of entire systems. including logistics. Logistics is seen as a key enabler for business improvement which has a positive value added. and no longer seen as a cost burden (Rushton et al.. 2000).

Production management viewpoint is another perspective from which Tan (2001) has proposed another definition for the evolution of SCM:

Organizations extended best practice in managing corporate resources to include strategic suppliers and the logistics function in the value chain. Cost and quality consideration was emphasized more in supplier efficiency. Manufacturers bought products only from certified suppliers in order to avoid duplicating non-value adding activities such as inspection. More recently. many manufacturers and retailers adopt the concept of supply chain management to improve efficiency across the value chain. They involve their suppliers in new product development. Retailers also integrate their physical distribution function with transportation partners for direct store delivery without any necessary inspection (Tan, 2001).

According to the multi perspectives of SCM evolution, Croom et al., (2000) stated:

Such a multidisciplinary origin and evolution is reflected in the lack of robust conceptual frameworks for the development of theory on supply chain management. As a consequence the schemes of interpretation of supply chain management are mostly partial or anecdotal with a relatively poor supply of empirically validated models explaining the scope and form of supply chain management, its costs and its benefits.

2.3.4 SCM, Logistics and Purchasing

Supply chain management is a huge field consisting various sub-fields, which often overlap each other. Among these sub-fields, two of them, logistics and purchasing will be described in detailed in the next sections. These two items have been selected as they are related clearly to SCM, but at the same time, cause debates and confusions.

2.3.4.1 Logistics

An explanation given by the Council of Logistics Management (CLM) describes logistics as the part of supply chain management, which is mainly dealing with controlling and implementation of efficient frontward or backward flow and goods storage, services and relevant information, between the origin and consumption points, to fulfill the consumers and clients' demands (Council of Logistics Management (CLM) , 2004). However, there are other discussions which define logistics as the procedure of management and coordination of all the actions within the supply chain from sourcing and obtaining to producing and distributing to the clients.

Knowing these definitions, logistics can be viewed as a supply chain management section.

2.3.4.2 Logistics and SCM

There are still debates and disagreements about the relevance between supply chain management and logistics. Regarding this, there are different viewpoints of relation between SCM and logistics, which are namely as re-labeling, unionist, traditionalist, and intersectionist, according to Larson & Halldorsson (2004). Figure 2.2 shows the idea schematically.

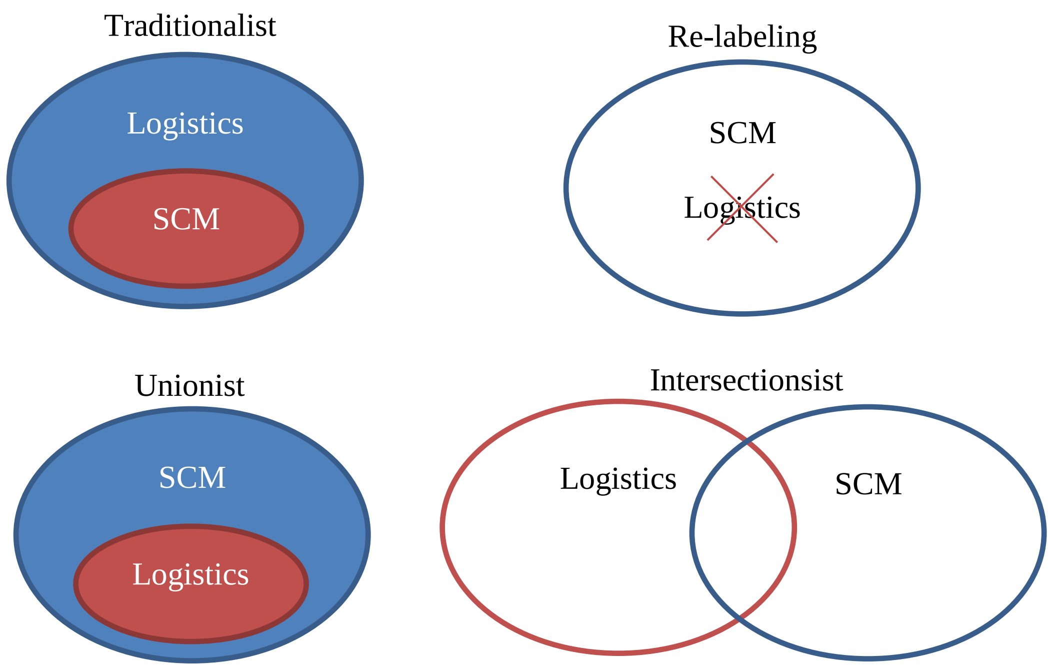


Figure 2.2: Perspective on logistics versus SCM (Larson and Halldorsson, 2004)

To explain each of these viewpoints in brief, the traditionalist perspective considers SCM as a small portion of logistics, while the unionist view is reversed, i.e. the logistics as a small part of SCM, working similar to other parts like purchasing, marketing, etc. From relabeling viewpoint, logistics is just equal to SCM (logistics is renamed as SCM) and the intersectionists view logistics and SCM separately, but with overlaps in some areas.

Among these perspectives, unionist view was accepted and adopted in this research. According to Council of Logistics Management (CLM) (2004), unionist view is defined as logistics being a section of SCM, like other sections of marketing, operation, purchasing and etc. Further explanations will be given about purchasing in the following section.

2.3.4.3 Purchasing

Purchasing can be defined as the process of buying, during which, the right material, with the right quantity and right price is obtained and through the right delivery system is distributed from the source (Arnold, 1991).

According to Rushton et al. (2000), purchasing can be classified based on importance, which is shown in Figure 2.3. The reason of this basis is to guarantee that appropriate time and energy is assigned to more important organizational purchases. Based on importance and annual value of purchase, four different categories can be found, i.e. the critical items, commodities, routine purchases, which are having the lower annual value and are not critical, and the strategic items that are very critical, with high annual purchase value.

On the other hand, another classification is based on products' buying process. Routine purchases are the one that can be made rapidly, via online catalogues, accelerating the process of purchasing. The economically suitable process for high annual purchase values supplies is a tendering process. Low annual purchase values with high criticality, demand a formal system of approved suppliers, and a fixed system of approving suppliers. For the strategic items, with high annual purchase values and importance, the most suitable system is to have a strategic partnership.

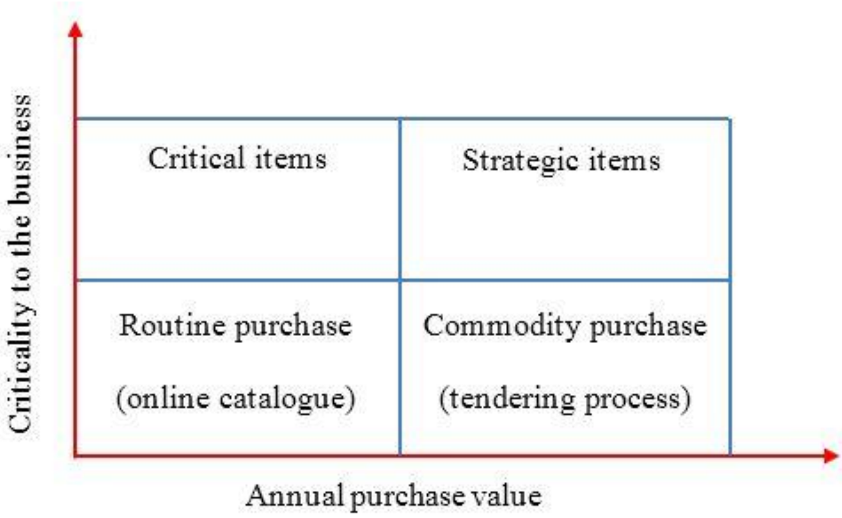


Figure 2.3: Purchase categorization and appropriate buying process (adapted from Rushton et al. (2000))

2.4 Supply Chain Management in Construction Industry

2.4.1 Theoretical Background of CSCM

The idea of SCM was firstly invented in the manufacturing industry, with the purpose of increasing both efficiency and effectiveness to fulfill the aims and lead to higher collaboration (Harland, 1996). SCM has always had an evolutionary concept, which has been developed by innovative tools and methods. This process is related to the total flows of transactions between the contributors to make the most of chain effectiveness and profitability (Ha & Krishnan, 2008).

Gradually, due to the need for advancements in construction programs implementations, and of course the profit gains, changes and innovations in supply chain managements were brought into this section (construction programs) (Agapiou et al., 1998).

Despite all the known necessities, yet there is not a significant advancement of SCM employment in construction industry; since the obtained benefits in other sections do not seem to be repeated in construction section (Aloini et al., 2012 a). In fact, different parts have so far been focused on, depending on the projects circumstances, to improve the efficiency of projects (the supply chain or construction site, or both) (Vrijhoef & Koskela, 2000).

2.4.2 Application of SCM in Construction Industry

In construction sector projects, usually several organizations are collaborating, thus, there are already difficulties in management of the organizations, companies, and materials products, which particularly create obstacles in application of SCM in these projects (Aloini et al., 2012 a).

It is explained that the current SCM application researches in manufacturing cannot be directly conveyed to construction sector, as the products of this section (construction) are temporary by nature. Although there is no doubt about the benefits of employing SCM to the construction section, to reduce the costs, very few researches have up to now been conducted in this field, and in fact, small number of studies have given a definition of what SCM is, within the field of construction (O'Brien, 1999).

Therefore, at first, a definition will be given for what construction supply chain management (CSCM) is:

It is the coordination and the integration of key construction business both processes and members involved in CSC, extending traditional intra-enterprise activities in a management philosophy by bringing together partners who have the common goals of optimization and efficiency so establishing long-term, win/win, and cooperative relationships between stakeholders in a systemic perspective.

Construction supply chain is not a real chain. It is in fact, a web of various organizations, containing the flow of materials, amenities, products, information, or funds between different parties of the projects, i.e. the customers, contactors, designers (Xue, et al., 2007). Meanwhile, construction projects are also multi-stage procedure, including designing, construction, renovation and maintenance, etc., which are mostly dealing with different parties such as designers and contractors.

SCM network forms as a substitution of conventional vertical forms were first proposed by Crowley and Karim (1995) and Xue et al. (2007) and were aimed to improve the systems to support cooperating. Obviously, these proposals fit the construction supply chain properties better.

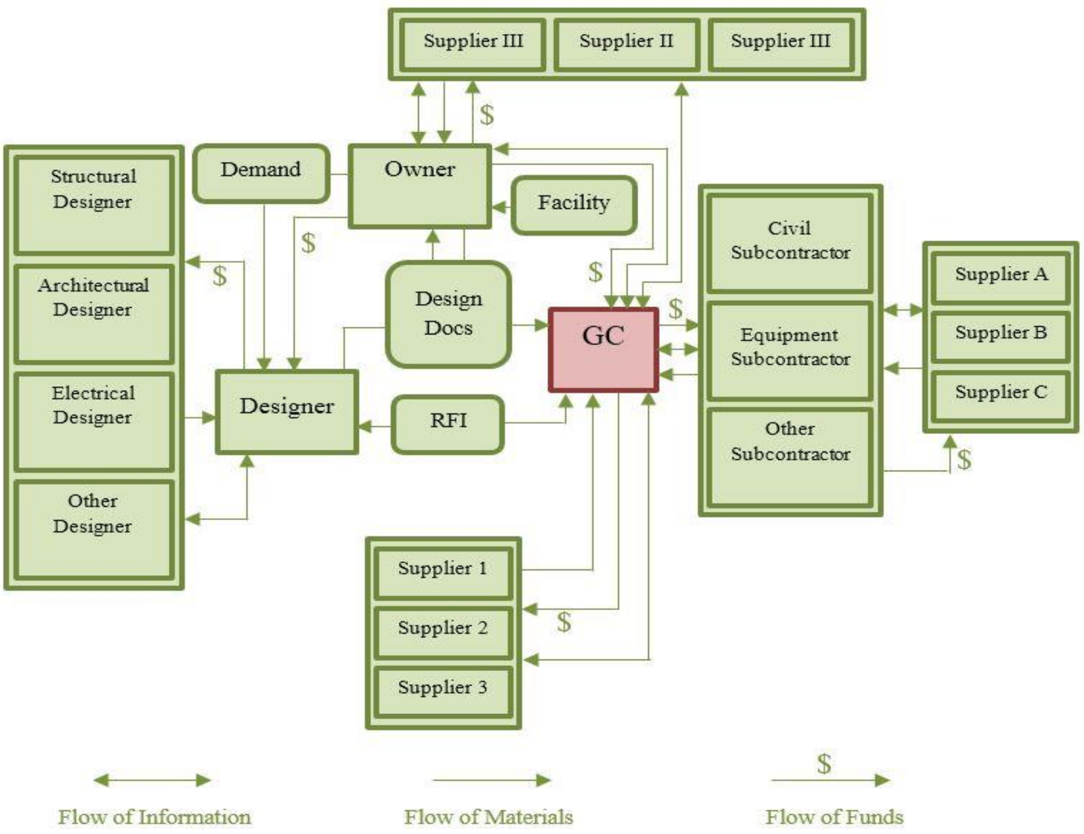


Figure 2.4: Construction supply network (Xue et al., 2007)

The properties of construction sector projects that can strongly affect application of SCM are listed below:

- **Production Systems:** Construction, as the production industry, functions in a complexity and uncertainty environment (Fearne & Fowler, 2006).
- **Customer Influence:** Customers significantly influence the final products, relative to its physical aspects to logistic parameter values (Kornelius & Wamelink, 1998).
- **Fragmentation:** Both market and process fragmentation are influential in SCM application (Baiden, et al., 2006).
- **Number and Type of Stakeholders:** Several organizations and relations are involved in a usual network, such as flows of information, services, materials etc. between customers, designers, contractors. However, the key matters are owners, contractors, providers and designers (Xue, et al., 2007).
- **Buyer-supplier Relationship:** Relation between buyers and suppliers is most of the time debatable, strained by wariness and clashes (Lu & Yan, 2007). It is well known that in construction section, tender prices are the main parameters considered in bid evaluations. So focusing the prices is the main cause of project delivery problems (Hatush & Skitmore, 1998).
- **Temporary Configuration:** The temporary nature of production in construction sites by temporary organization generates the short-term thoughts with the parties that try to benefit and control as much as possible, resulting in an opportunism dominant environment (Kamann, et al.; 2006).
- **Change Inertia:** There is always a conservatism against change in construction projects, due to the risks often associated with the projects procurement (Love, et al.,2002).

The mentioned existing factors make the influences of SCM essential, since they change the concentration towards viewing productions as a flow and as value generations (Koskela, 2000). Simultaneously, those characteristics also make the employment of SCM in construction risky due to complexity of supply networks of this sector. In order to improve the effectiveness and efficiency of supply network, managers should identify the associated risks and manage them. Having this aim, to simplify and operate the SCM in construction industries, risk management principles and methods have been established. In the following section, risk and risks management concepts will be explained.

2.5 Risk and Risk Management (RM) in (CSCM)

2.5.1 Risk and Risk Management Definition

Risk can be defined as an uncertain event which might occur and in the case of occurrence, result in hindrances and disruptions, affecting the aims or performance of projects, as it was planned. From supply chain point of view, risks are viewed as negative occurrences having impacts on the operations and cause undesired results (Walker et al., 2003). The impacts and probability of occurrence of events indicates the seriousness of events. The original reason of risks is ambiguity about the future (Mentzer, et al., 2001). Risk management is described as the procedure of identifying, analyzing and responding to the risks and is about managing risks through taking proper actions against them, to mitigate the likelihood of their occurrence and reduce the undesired consequences (Waters, 2007; Shahriari, 2011).

The risks that happen in supply chain can be categorized into two main groups, which are external and internal risks. The external risks are those caused by external events, out of the chain, such as political principles. These risks are less frequent, but more difficult to be controlled or mitigated. On the other hand, there are internal risks, such as equipment failure, poor forecasts, etc., which are relevant to the internal organization procedures and daily operations. Compared to external risks, internal ones have lighter influences on supply chain and occur much frequently.

2.5.2 Supply Chain Risk Management

SCM process must be employed and performed in a proper, formulated, and structured way. To do so, the adopting organizations, will be dealing with organizational, technical, relational, as well as management issues. These issues have to be managed suitably, in order to have an efficient and effective implementation of SCM ideas, models and tools, and solve the problems associated with SC application in construction (Palaneeswaran et al., 2003). To reach this aim, risk management seems to be a suitable approach which helps in prioritizing the problematic issues in risky complex projects and choose the suitable response against them (Finch, 2004). From project management viewpoint risks are inexact events that if occur, there will be negative influences on the project objectives. The process of managing risks is not just about risks identification, assessment and setting up mitigation and contingency methods, but capabilities should also be to delivered to recognize the threats as they start up, along with quick and influential responds against them.

A key concept to obtain optimized efficiency in organizations is known as SCRM (Supply Chain Risk Management) (Waters, 2011). As it is schematically shown in Figure 2.5, SCRM is established on two strategies of supply chain and risk management. Various definitions have been proposed for SCRM, such as a concept, which is involved in controlling the risks that are associated with logistics and the relevant activities (Waters, 2011). Risks management employments mostly conclude avoiding the financial losses in projects. These losses are caused by disorganizations in chains and disruptions when considering supply chains (Waters, 2011).

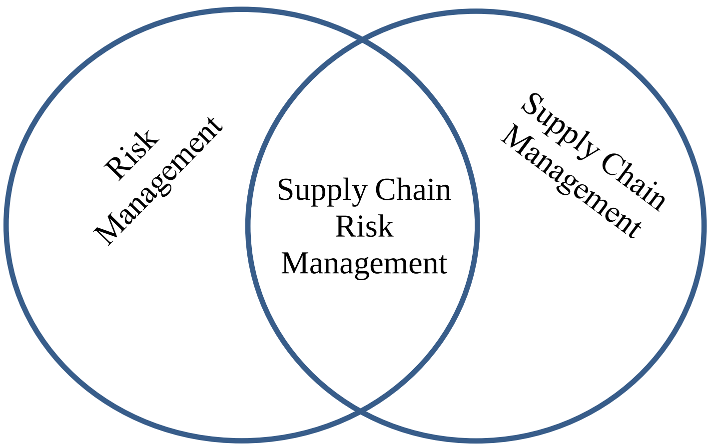


Figure 2.5: Supply Chain Risk Management (adapted from Vilko (2012))

For a SCRM to be effectively adopted, no single action or individualism is allowed. Due to the organizational nature of activities, any sector or party which is involved in and affects the supply chain should participate in the process (Jüttner, 2005).

The following sections are mainly about the process of supply chain risk management and different definitions of it, by various researchers. Various stages are defined along with comments about each stage and finally one of them is chosen for further risk analysis.

2.5.3 Supply Chain Risk Management Process (SCRMP)

Independent of the supply's size and complexity, there are some risks that always exist in all recent supply chains (Norrman & Lindroth, 2004). Special strategies are needed to be developed to face with risks in organizations, to avoid disruptions and negative impacts on supply chain efficiencies. These strategies can be fixed systematically by a practical approach to risk management, which is defined as supply chain risk management process (Tummala & Schoenherr, 2011). The process of SCRM is denoted to number of steps, followed by organizations, to reduce and mitigate the risks of supply chain and their impacts, including actions such as the below list (Vanany, et al., 2009):

- Risks identification
- Assessment of probability
- Consequence evaluation
- Prioritizing the risk

Although there are several definitions given for SCRM, most of them have equal purposes and the differences are there to fit the planned situations (Norrman & Lindroth, 2004) . A basic model was proposed by Solicitors Regulation Authority, to simplify the definition and generate better understanding of the concept of risk management process. The model is shown in Figure 2.6.

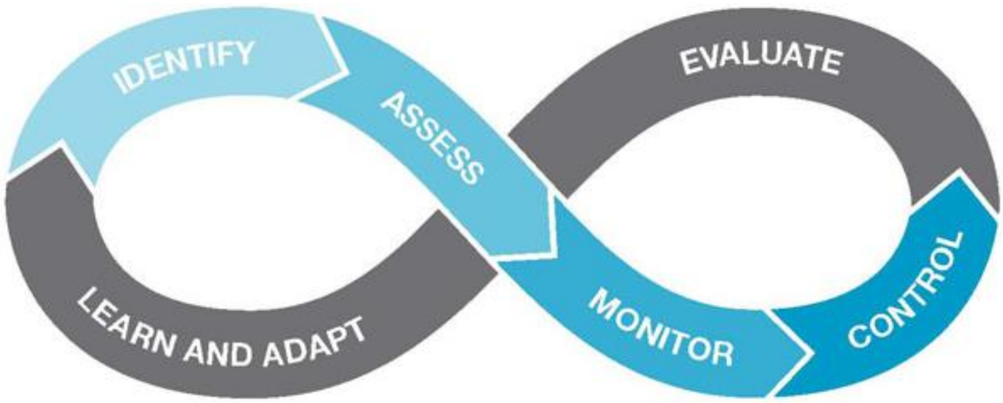


Figure 2.6: Solicitors Regulation Authority (SRA) risk framework (2014)

The function of risk management is necessary to be understood when its principles and techniques are being applied to implement supply chain management in construction industry projects. According to Waters (2007), three steps are included in a typical SCRM process (Figure 2.7).

Figure 2.7: SCRM Framework (Waters, 2007)

The model of SCRM provided by Waters (2007) will be further employed in this research work. Moreover, definitions will be given for risk identification, analysis, response and control, along with an in detailed information about SCRM.

2.5.3.1 Risk Identification

This step is accepted widely to be the first and the key step of SCRM process, because of the fact that all the succeeding steps and actions will be based on it. It is important to identify and list as many risks as possible, although it is not possible to mark and identify every single likely risk. In fact, in this stage, only the risks that are the most influential on supply chain will be identified. To identify the risks, specific supply chain and its characteristics must be understood.

This stage is indeed a crucial stage which demands a formal fixed process in an organization, not depending on individual knowledge or informal procedure. If informal procedures or individual information are employed, inadequate risk identification will be resulted (Waters, 2011). Consequently, the later stages will also be affected by poor risk identification. In fact, in this stage, a thorough approach to perform the potential risks identification of supply chain is needed, meaning that it is important to know the risk verities, interrelations and the connections to the other sectors are important to be understood, in terms of supply chain (Tummala & Schoenherr, 2011).

There are various techniques to perform risk identification in supply chain management. Some of them are brought in the following list according to PMBOK (2013) and Smith et al. (2006).

- Reviewing documents
- Techniques of collecting information
  - Brainstorming
  - Questionnaire survey
  - Experts' opinions or interviewing
  - Delphi technique
  - Risk Breakdown Structure (RBS)
  - SWOT analysis
- Checklist analysis
- Assumption analysis
- Diagramming techniques
  - Cause and effect diagrams
  - Influence diagrams
  - System or process flow charts

The following techniques are known to be helpful in identification of possible supply chain risks (Tummala & Schoenherr, 2011).

- Mapping the supply chain
- Performing fault tree or event tree analysis
- Failure mode and effect analysis (FMEA)
- Ishikawa cause and effect analysis (CEA)

The key idea behind these points is to map the supply chain variously, to simplify identification of related risks (Tummala & Schoenherr, 2011). Some of these tools are described in the following sections.

2.5.3.1.1 Documentation Reviews

Project documentation can be performed, through a structured review of the project, consisting the plans, assumptions, contracts, etc. Quality of plans, and the level of uniformity between these plans and the expectations or requirements from the project can be indicating the potential risks.

2.5.3.1.2 Techniques of Collecting Information

- ***Brainstorming:*** Brainstorming is known to be a technique of producing thoughts from a group of people. It is not necessary to employ this technique only in risk identification stage, but in the literature, it is extensively employed as a risk identification tool (Akintoye & MacLeod, 1997). Among literature, there are differences between types of brainstorming, which are named as structured, or simple. Although there is no significant distinction between the two types, the structured ones has shown to produce solutions that are more comprehensive (Edwards & Bowen, 2007).
- ***Questionnaire Survey:*** The survey is consisting of a questions list that are asked from respondents, and are designated to collect specific information. There are four basic purposes for them:
    - Collecting the correct data
    - Make the data comparable and open to analysis
    - Lessen bias as much as possible, in asking question and formulating
    - Ask engaging and diverse questions

Besides having all the advantages, although questionnaire survey is known to be a simple handy and suitable method, a notable disadvantage is associated with the method is lack of creative thinking. However, according to the previous research works, the method's advantages are quite outweighing the disadvantage (Robson, 2002). In this research, to investigate how supply chain management is performed, questionnaire survey was employed as the major method of data collection

- ***Delphi Technique:*** This technique is a useful one, to obtain agreement between specialists of a field. Considering project risk management, the experts of this field are asked to participate in this technique namelessly, and questionnaires about important risks of projects are distributed among them. Finally, the responses are collected, summarized and then returned to the experts for their additional comments. A few round of this technique might be enough to obtain the finalized agreement of the experts. By means of this technique, individualism, biases and prejudices are tried to be eliminated from researches.
- ***Interviewing or Expert Opinion:*** Interviewing the fields' experts is a convenient tool to identify the potential risks in the field. The appropriate interviewees are chosen and interviews are preformed with them. Potential risks in this method are identified based on the participants' (interviewees) experience, information about the project, and other useful sources. This method is unsystematic; the same as questionnaire survey, and time consuming, because of the need to arrange the results according to an organized structure for further analyses.

- ***Risk Breakdown Structure (RBS):*** Risk breakdown structure has the same basis as work breakdown structure. In the method, the risks are divided into two classes of manageable and definable, in a graded arrangement (Chapman, 2011; Hillson, 2002). Risk identifications in this format lets the evaluators to review the risks and perform the analyses of stages in the risk management process. The risk breakdown structure is not a list of risks sources; it is an arrangement with increasing the level of details (Hillson, 2002). Each level's elements of RBS can be considered to evaluate the risks. Figure 2.8 shows a sample of RBS for better understanding of this concept.

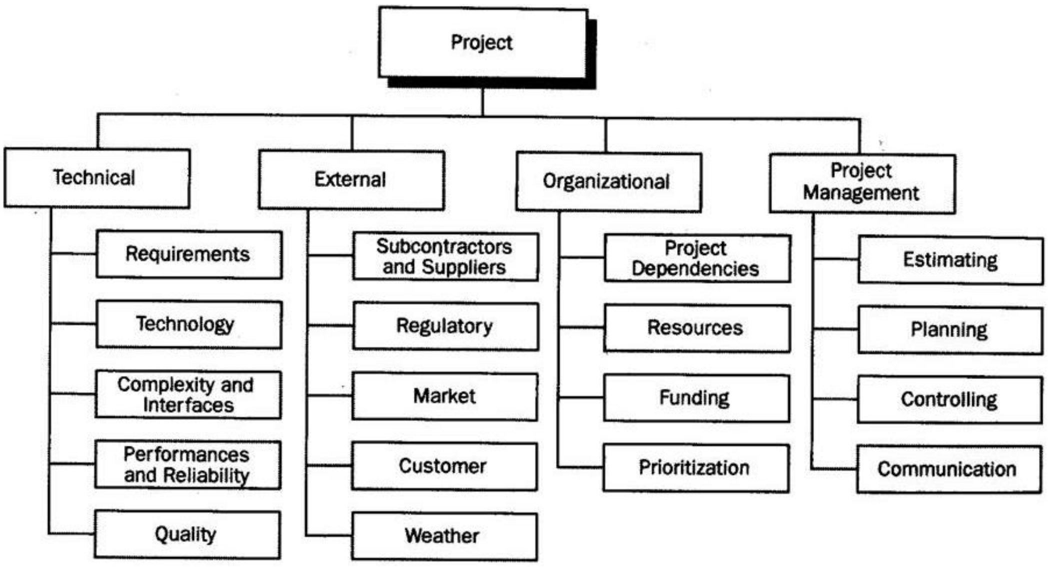


Figure 2.8: Sample of Risk Breakdown Structure (PMI, 2008)

2.5.3.1.3 Checklist

Checklists are simple convenient methods to identify the potential risks. If there are similarities between the current project and the previous ones, checklists can be employed as the technique to identify the risks. The disadvantage associated with this method is the restricted categories of risks in the checklist, which limits the participants. In fact, it is almost impossible to create a complete practical checklist.

Risk identification checklists are based on historical knowledge, collected from previous similar projects and the other information sources (PMBOK, 2008).

2.5.3.1.4 Mapping the Supply Chain

Mapping the supply chain is a method of stimulating and displaying supply chain, and the associating flows of goods, money and information, from the upstream producers and providers to the downstream consumers and customers. A strategic mapping of supply chain, is a technique to arrange and coordinate the chain strategy with the company (industry) strategy and assist in managing and modifying the supply chain (Gardner & Cooper, 2003). As the supply chain has been mapped comprehensively, potential risks will be identified easier.

2.5.3.1.5 Event Tree or Fault Tree Analysis

By means of this analysis technique, all possibilities and outcomes of these possibilities are displayed in a graphical representation (Paté-Cornell, 1984). While both of the trees might seem alike, there can be basic important differences between them (Hollnagel, 2004). As an example, a tree may outline the potential events and the responses that are likely to trigger due to a supply chain failure.

2.5.3.1.6 Failure Mode and Effect Analysis (FMEA)

Failure modes are the states or modes in which failure occurs. Failures are potential or real errors or faults that might affect the customers. Effect analysis denotes the investigation of those failures' consequences. Failure mode and effect analysis is the technique of identifying potential risks at the design, manufacturing and consumption stages (Karim et al., 2008). The failures are ranked according to their significance, their impacts, their detection simplicity and their occurrence frequency. By means of this prioritization in FMEA, reduction and elimination of failures is aimed, beginning from the top priority ones (Tague, 2004).

2.5.3.1.7 Ishikawa Cause and Effect Analysis

Brainstorming and surveying all possible relations between the potential risks (causes) and the failures are involved in this method. The diagrams of cause and effect analysis are sometimes called as fishbone diagrams, because of their structure (Chase et al., 2006). As a failure is diagnosed, the exact root of its occurrence can be identified, by means of these diagrams.

2.5.3.2 Risk Analysis

The next stage after risk identification is the evaluation and analysis of them, regarding their occurrence likelihood and impacts. To do this stage, risks must be firstly prioritized and to have a precise prioritization, trustworthy estimations of impacts and probability of risks, are required. In a general view, risks can be evaluated by means of both qualitative and quantitative analysis methods (Winch, 2010).

Qualitative methods are the most applicable methods, when the probability and impacts of risks can be estimated descriptively, varying from low to high. On the other hand, quantitative methods are employed to determine the risks probability and impact numerically (Winch, 2010).

2.5.3.2.1 Qualitative Method

In this method, the identified risks in the project are qualified, the probability of their occurrence and their impacts are examined, as if they really occurred. This method is especially useful when there is a lack of necessary numerical data and limitations of time and money (Radu, 2009).

Accuracy of data to perform a reliable analysis is the limitation associated with this method. To have a reliable analysis, it is essential to provide accurate, reliable and high-quality data, along with an acceptable realistic understanding of them. Results of qualitative analysis can lead to more accurate comprehensive quantitative analysis, or even straightly to risk response planning.

According to PMBOK (2013), six stages have been designated to perform a qualitative analysis correctly: risks possibility and impact evaluation, probability and impact matrix, risk data quality evaluation, risk classification and risk urgency evaluation. Each of these stages are explained briefly in the following sections.

Risk Probability and Impact Assessment

In this stage, the identified risks' occurrence likelihood, along with the risks potential impacts on the objectives of projects are evaluated. The objectives are such as cost, schedule, performance and quality of project, and the investigated impacts on them are including both positive opportunities and negative threats (Cooper et al., 2005). Raking the risks are done based on the impacts and probability of occurrence. Two types of ranking are employed in this stage:

- Ordinal scales that describe the risks in terms of very low, low, moderate, high, very high.
- Cardinal scales that allocate numbers to probability and impact of risks (i.e. 1, 2, 3, 4, and 5).

The scales should also be defined and accepted in risk management plans. In brief, it is explained that by means of checklists, questionnaires and interviews, each identified risk can be evaluated, and then level of its impact and probability can be determined (Tabanfar, 2014).

Probability and Impact Matrix

probability and impact matrix is designated to prioritize the risks. Prioritization of risks are done based on their rates (PMBOK, 2013). In the matrix, the rating and color are assigned to show the importance of each risk (Westland, 2007). The matrix's elements that are the risks scores as shown in equation 2.1 are multiplication of values of risks occurrence probability and its impacts.

$$Total\ risk\ score = Probability\ \times Impact \qquad \text{(Equation 2.1)}$$

The compiled results of probability and impact are shown in the matrix in Figure 2.9.

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

Impact

Figure 2.9: Probability and impact matrix (PMBOK, 2013)

As typically shown in Figure 2.9, risk ratings can be done separately for each project objectives (cost, time, etc.). Both threats and opportunities are dealt in the same matrix, using different levels of definition. To decide about risk responses, the organizations place the risks in different categories, commonly three categories, based on risk scores (PMI, 2008):

- Red: Indicating the high risks, having high impacts on objectives and high occurrence probability.
- Yellow condition: Indicating the risks that are comparatively high in impact and probability.
- Green condition: Green label indicates the risks with low impact or low occurrence probability.

Risk Data Quality Assessment

This technique is employed to evaluate the level of credibility of the data, which are useful in risk management and investigates how much the risks are understood, and how much the data are accurate and reliable.

Risk Categorization

A classification of projects risks according to PMBOK (2013) categorizes them based on the employed methods:

- Risk sources (by means of Risk Breakdown Structure (RBS))
- Affected area of the project (by means of Work Breakdown Structure (WBS))
- Other beneficial categories (e.g. project phase)

When RBS is employed, the risks are categorized and their dependencies are shown and when WBS is employed, large activities are broken down into small controllable items, and connected ranked series of independent activities are created (Dallas, 2006; Maylor, et al., 2005).

Risk Urgency Assessment

This assessment clarifies the stages of project at which each risk might be activated (Rowley, 2013). More urgency is allocated to those risks which may occur at earlier stages of the project, demanding sooner appropriate responses compared to those with lower level of urgency. It is also likely that some organizations and companies consider urgency together with occurrence probability and impact to obtain the overall risk rating and prioritize them.

2.5.3.2.2 Quantitative Method

Unlike the qualitative analysis which is mainly dealing with descriptive data, quantitative analysis is a complete numerical analysis of evaluating the risks occurrence probability, affecting the objectives of the project and its overall risk score. Qualitative risk analysis is typically heading to quantitative analysis, which is a more expensive time-consuming process (PMI, 2008). Due to these properties, quantitative analysis is mostly applicable to medium to large projects. There are five common quantitative analysis techniques, described in the following sections.

Decision Making Matrix

The risk matrix or the decision-making matrix is merging information such as consequences of an event, in the case of occurrence and the events' probability of occurrence, to quantify the risk. Comparatively, this tool is a rapid, easy to use one, and so it is preferred (Barringer, 2008). Simplicity of this tool is related to the simplicity of calculations and the fact that it is based on the experts' ideas (Mullur et al., 2003).

Decision Tree Analysis

Is it a graphical technique which is aiming to choose the best possible option by means of considering and comparing various situations and consequences. The analysis includes the cost of choices and probability of occurrence, then allocates a value and outcome (Olivas, 2007). The decision trees offer a greatly effective structure, by means of which, possible consequences of choosing the options can be surveyed.

Risk analysis tree is a convenient tool to map a well-adjusted picture of risks and the outcomes of each of them (Dey, 2002). Some types of risks can only be handled by the method of decision tree analysis, specifically, the risks that are consecutive (Hulett, 2006).

Monte Carlo Method

This method gained its name as a code for the work that Ulam and Von Neumann were performing during World War II, for the atomic bomb. The method was employed for integration of mathematical functions (Vose, 2008). Monte Carlo method is about application of probability and statistics to the natural and physical sciences, in which, the effects of the main risks on a plan are explored, as there might be other effects on the so far obtained results. Diverse distributions of random numbers has made this method particular (Hulett, 2004; Anderson, 1986).

Expected Monetary Value (EMV)

Expected monetary value is a technique of risk qualification and is in fact the product of risk occurrence probability and the risk event value (Raftery, 1994). This method is having a statistical concept, calculating the average outcomes of uncertain scenarios (PMI, 2009). All possible results of each decision or strategy are considered in this method. Each possible outcome value is multiplied by the probability, and the results are summed up together to gain the total outcome. This total outcome can be positive and negative for opportunities and threats, respectively (Stefanovic & Stefanovic, 2005).

$$EMV = \sum_{n-1}^{N} Value_n \times Probability_n \qquad \text{(Equation 2.2)}$$

Sensitivity Analysis

Sensitivity analysis is mainly done to find out which risks are the most influential on the project (PMBOK, 2008). In fact, the sensitivity of the model (of the project) to changes in the structure and different parameters is determined in this method (Saltelli, 2004). It is done by changing the values of inputs and see how the outputs change, and how the project objectives are affected. In short, this method can be defined as the determination of impacts of input variations on the model's results (Frey & Patil, 2002).

In the next section, the actions and techniques that are employed to respond and face with identified risks in supply chains will be explained.

2.5.3.3 Risk Response and Control

Risk response is the next step after the identification and analyzing the potential risks (Tummala & Schoenherr, 2011). This stage is generally about designing an appropriate responding plan, with the aim of handling the potential risks in the best possible way (Waters, 2011). Implementation of risk response, monitoring the risks, new threats discovering and analyzing them, is called the risk control (Tabanfar, 2014).

It is possible to define supply chain management in two terms: the supply and the demand risk management. While supply chain management is mainly related to the network planning, relationships, transportation and logistics; demand risk management is dealing with demands predicting, planning and inventory management. Absolutely, it is essential for the organizations to be ready for possible disruptions during these activities (Tang, 2007). The positive point about the process of risk control, as defined previously, is that it improves the efficiency of risk approach, and optimizes the risk responses (PMBOK, 2013).

There are several risk response methods, among which, four of them which are avoiding, transferring, mitigating and accepting, are explained in continuance:

- **Avoid:** Refers to protecting the project and elimination of the threats.
- **Transfer:** Indicates moving the threats' impacts to a third party.
- **Mitigate:** Mitigation is in fact the reduction in the impacts of threats or their occurrence probability.
- **Accept:** Refers to risks acceptance and not taking any significant action, until the risk actually occurs.

Figure 2.10 indicates the explained risk response methods.

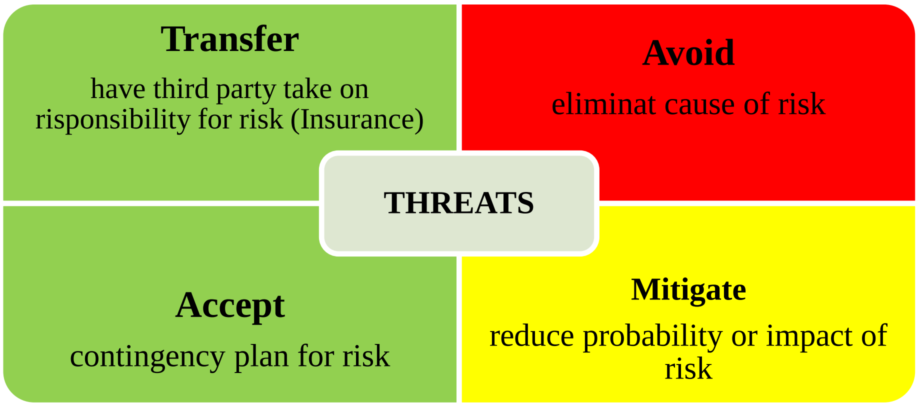


Figure 2.10: Risk response strategies (Rowley, 2013)

Risk control process may also be different depending on the organizations and their perception of risk (Shahriari, 2011).

A definition has been given as "as low as reasonably practicable" or ALARP risk. As shown in Figure 2.11, there are three levels for each risk, which are unacceptable level that can only be accepted in extreme cases, mid-level which is the tolerable range. Risks in this level are just accepted if the other responses are not practical. Finally, there is the bottom-level. Risks in this region are the insignificant, accepted risks, which will be controlled (Shahriari, 2011).

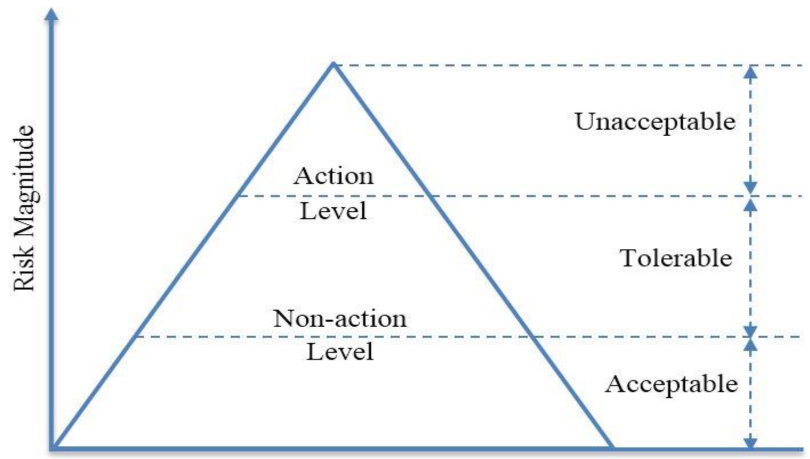


Figure 2.11: Triangular ALARP model (Tumumala & Schoenherr, 2011)

Moreover, there are again numbers of options to respond to risks with regard to their seriousness and acceptance level. Accordingly, risks can be accepted or ignored, their outcomes can be restricted or reduced, and they can be transferred to the other parties. Some risks' occurrence probability can be reduced; they can also be deflected or shared. Finally, making contingency plans, changing or moving to another environment can also be other possible responses. ALARP principle can be employed to rate and classify the risks as the unacceptable risks are mitigated (Waters, 2011).

In this chapter, majorly the previous published literature about supply chain management (SCM), construction supply chain management (CSCM) and risk management (RM) were explored, although there is a lack of previous research works, specifically about risk factors affecting the implementation of SCM principles. In the next chapter, the research methodology that was employed in this study, the data collection method and the analysis will be explained.

Chapter 3

METHODOLOGY

3.1 Introduction

Employing supply chain management (SCM) is accepted to be essential for the business organization success, in the competitive environment of nowadays world (Punniyamoorthy, et al., 2011). In this study, it is aimed to survey and suggest some methods for incorporation of supply chain management in construction industry of Canada, along with identifying the risk factors affecting SCM implementation and analyzing the factors responses in the environment.

Obviously, in order to fulfill the research aim of this study, proper methods must be chosen. This chapter is mainly consisting the method of preforming the analysis, selected according to the previous literature, and properties of various methods. The outline of this chapter includes the following headings:

- Identification of risks
- Data collection
- Implementing risk analysis
- Risk responses

3.2 Identification of Risks

In this stage, the literature review was performed according to the research work of Aloini et al. (2012 a). The research work included a broad range of 140 previously published works which were classified and analyzed from risk management (RM) viewpoint. SCM studies during 11 years, specifically in construction field had been investigated in the paper, although none of the reviews about SCM principles were focused on risk management area of construction field. Outcomes are as the first attempts of developing a practical risk assessment framework with a successful context of SCM in this field (Aloini, et al., 2012 b).

Reviewing the available literature signified the absence of a construction supply chain risk management (CSCRM), which is theoretically and descriptively focused on risk assessment phase. Based on literature review, thirteen risk factors were identified, which signify the necessity to pay attention to project planning phase and approve the main contractor as the chief responsible party to practice the SCM.

Second stage of risk identification involves classifying the risks orderly, according to perception of risk breakddown structure (RBS), arranged according to previous studies of Simons (1999) and Meulbroek (2000). The classification includes the following groups of risks:

1) Strategic risks: Affecting implementation of business strategies.
2) Operation risks: Influencing the organization or the companies' capability of producing goods and services.
3) Supply risks or input risks: Affecting the resources' inflows, which are fitted to operation implementation (Meulbroek, 2000; Simons, 1999).

Figure 3.1 shows the identified risks separately in different mentioned sub-categories.

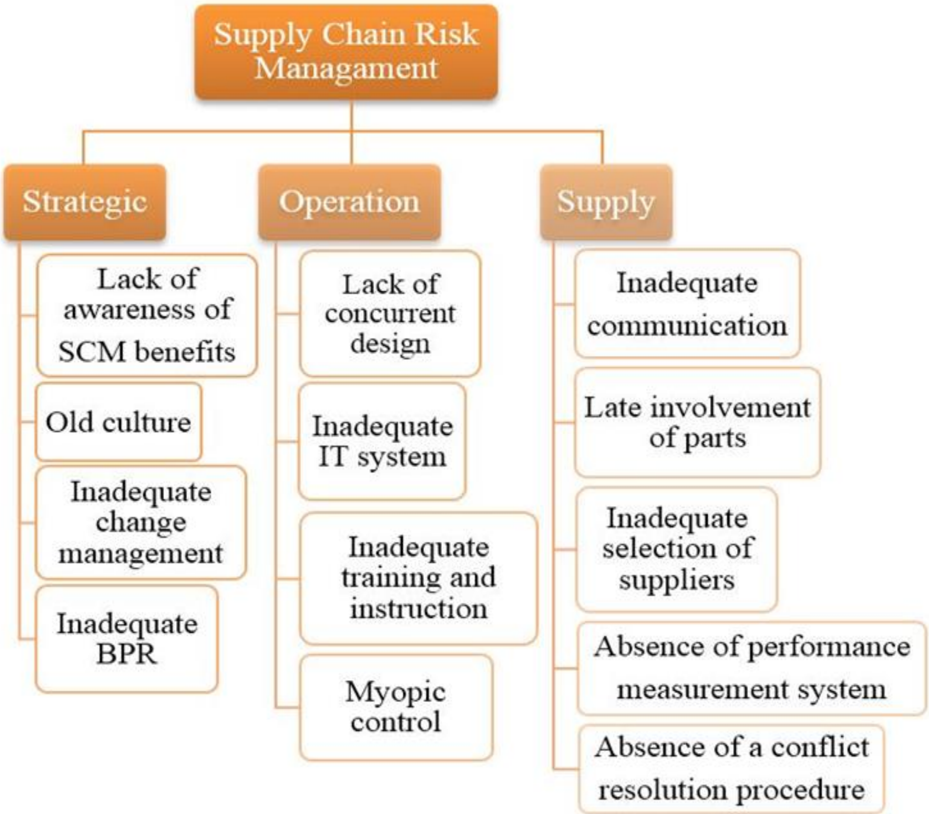


Figure 3.1: Supply chain management risk breakdown structure

The third stage of risk identification involves the preparation of a checklist, including different types of risks (as mentioned previously), identified risk factors, and SCM sub-context. The checklist is based on qualitative method of risk assessment, consisting of a column allocated to the probability value, and three separated columns to consider the impact level of each risk on time, cost and quality. The probability and level of impact are shown by numbers from one to five. The risk scores were calculated by multiplying the risk probability and risk impact (Equation 2.1). To find out the proper risk response and control the threats, according to the respondents' experience, another column has been assigned (see Appendix B).

The questionnaire survey was also prepared to understand the respondents' level of knowledge about the concept of risk management, specifically in supply chain management, and their experience, in order to choose the best possible technique to control and respond the threats in this field (see Appendix A).

The following three sections are designed in the questionnaire.

- Background information
- SCM relevance
- RM relevance

3.3 Data Collection

To collect the necessary data for this investigation, the prepared checklists and questionnaire were sent to construction companies in Vancouver, the capital of British Columbia, Canada. Directors, quality managers, project managers, executive engineers, procurement and logistics managers, who have enough experience and knowledge about supply chain management in the industry in Canada, were the respondents of the survey. During the survey, to improve understanding of the risk factors concepts and SCM sub-contexts, verbal information were also provided to the respondents additionally.

3.4 Implementing Risk Analysis

Nature of the research problem should be the basis of selecting the method. In this research work, qualitative method of analysis, as a cost-effective, popular method, among the companies was chosen to be employed. A successful qualitative assessment can be obtained by data collection and documenting them for further analysis.

The surveys participants were asked to evaluate the risks occurrence probabilities, along with their impacts on the projects' cost, quality and timing. Tables 3.1 and 3.2 indicate the employed scales for assessment, which have been adopted in PMBOK (2013).

Table 3.1: Scale of probability (PMBOK, 2013)

Probability	Very Low	Low	Moderate	High	Very High
Risk Event	1	2	3	4	5

Table 3.2: Impact scale on time, cost and quality (PMBOK, 2013)

Identified Risk	Project Objective	Very Low 1	Low 2	Moderate 3	High 4	Very High 5
Risk Event	Time	Insignificant time increase	<5% time increase	5-10% time increase	10-20% time increase	>20% time increase
	Cost	Insignificant cost increase	<10% cost increase	10-20% cost increase	20-40% cost increase	>40% cost increase
	Quality	Quality degradation barely noticeable	Only very demanding applications are affected	Quality reduction requires sponsor approval	Quality reduction unacceptable to sponsor	Project end item is effectively useless

In Figure 3.2, a typical probability and impact matrix is shown, which is a frequently employed tool for performing qualitative assessment, ranking and prioritizing risks for future analysis. Elements of this matrix have been calculated by Equation 2.1 and knowing the necessary variables.

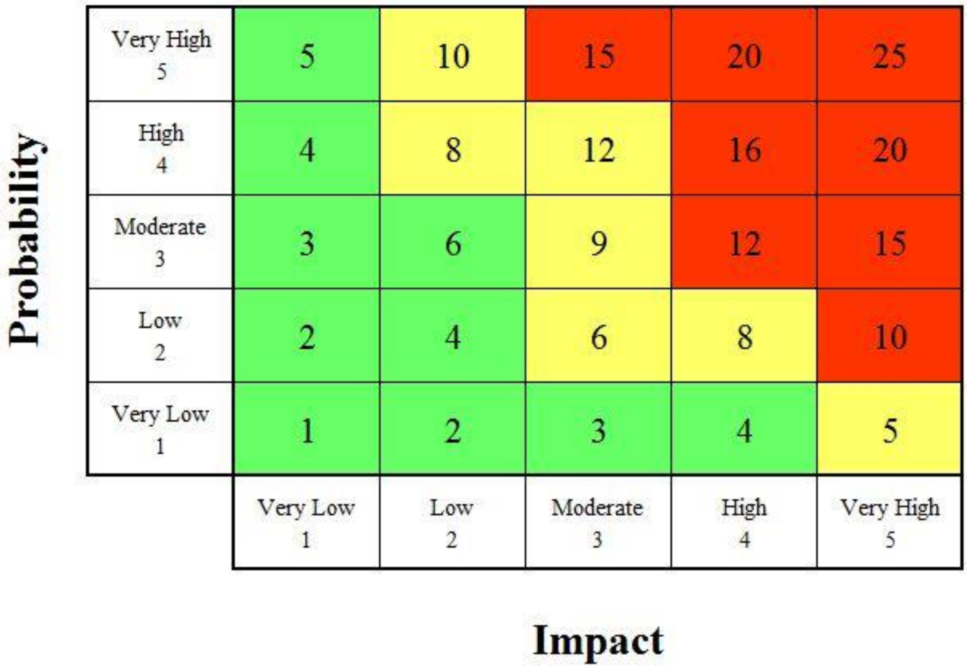


Figure 3.2: Probability and impact matrix (PMBOK, 2013)

The colors of impact and probability matrix can be different and in fact, each organization can have its own specific colors. As shown in Figure 3.2., all risks have been rated and prioritized by different colors, which are explained as below (Flanagan & Norman, 1993).

- Red: Indicates the high-risk condition, coloring the risks with high impact level, or occurrence probability, or both.
- Yellow: Indicates the moderate risk conditions, situated in the central part of matrix.
- Green: Indicates the low risk condition, coloring the risks with low enough impact, or occurrence probability, or both.

As all the identified risks are evaluated and prioritized, the following stage will be investigating appropriate strategies and responses to handle the risks that may impact the implementation of SCM negatively.

3.5 Risk Responses

Risk response stage is mainly dealing with deciding about the methods of managing and responding the risks properly. Several risk response techniques are available according to PMBOK (2013), among which, four of them were explained previously, to cope with threats of risks, and are so-called as avoiding, mitigating, transferring and accepting.

Risks with high scores (red colored in the matrix) are those that will be transferred to the risk response stage, to be decided about, which has also been followed in this research. Moderate risks (yellow colored) require monitoring and control or/ and urgent management responsiveness. Finally, low risks (green colored) are those that should be accepted and documented for future investigations (PMI, 2008).

In the next chapter, results and statistical analysis will be presented and explanations will be given about the adoption of the chosen methodology.

Chapter 4

RESULTS AND STATISTICAL ANALYSIS

4.1 Introduction

In this chapter, the employed techniques of data collection will be explained. These techniques are known to have major influences on the result suitability. In this research, as it is also explained previously, checklists and questionnaire surveys were selected as the main method of data collection. The reasons of these choices are the techniques' simplicity, rapidness, and cost-effectiveness. The techniques have been chosen to collect data and to analyze how risk identification have been done in implementation of supply chain management in construction sector of Canada.

Summary of results, from checklists and questionnaire surveys will be presented in this chapter, from each respondent's viewpoint. Statistical analysis have also been done on the raw data. Discussions about these results will be presented in the next chapter.

4.2 Survey Results

Canada as one of the world's leading countries that has made significant progresses in construction industry, has been chosen for this study. In the construction sector, supply chain management is gradually becoming more and more important and role-playing in advancement of all major ideas.

Fast changes in global business society has resulted in increasing the risk exposure in all functions of supply chain; therefore, considering a major efficient risk management plan, addressing a broad range of risks seems to be vital, which should be done by senior managers.

By means of this research study, it is aimed to signify the importance of employing supply chain risk management by managers, find out how this management is implemented, along with improving (or widening) the range of identified risks spectrum and uncertainty, with the modern supply chain management process.

To achieve the aims of this study, 22 construction companies located in British Columbia State in Canada were selected to participate in the survey. A set of checklist and questionnaire survey were sent to the companies. Among them, 16 companies participated in the survey. Table 4.1 shows an overview of the survey results, which are provided comprehensively in the following sections.

Table 4.1: Overview of survey results

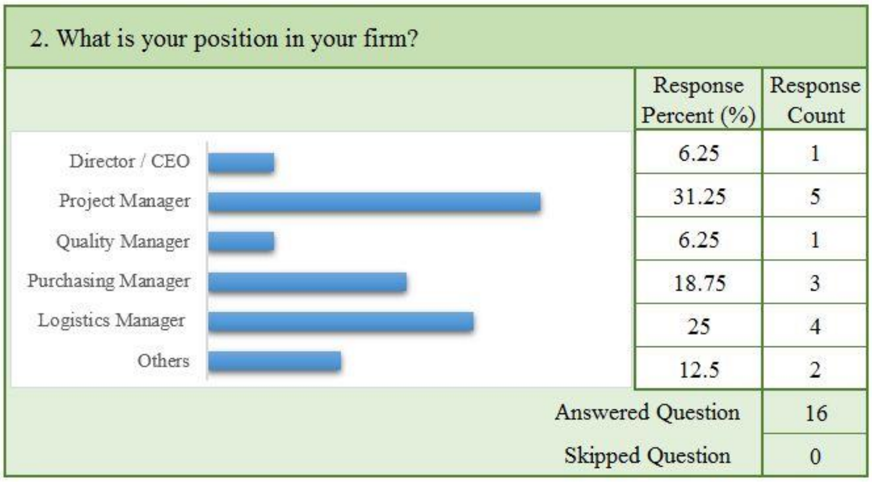
Number of distributed questionnaires and checklists	22
Number of responded questionnaires and checklists	16
Total response rate (%)	72.70%
Average of respondent's work experience (Years)	13.6 Years

4.2.1 Questionnaire Survey

The structure, outline and questions of the questionnaire, which are indeed important in obtaining desirable results from participants were designed in a way to fulfill the aims of this study. Appendix A shows a questionnaire sample.

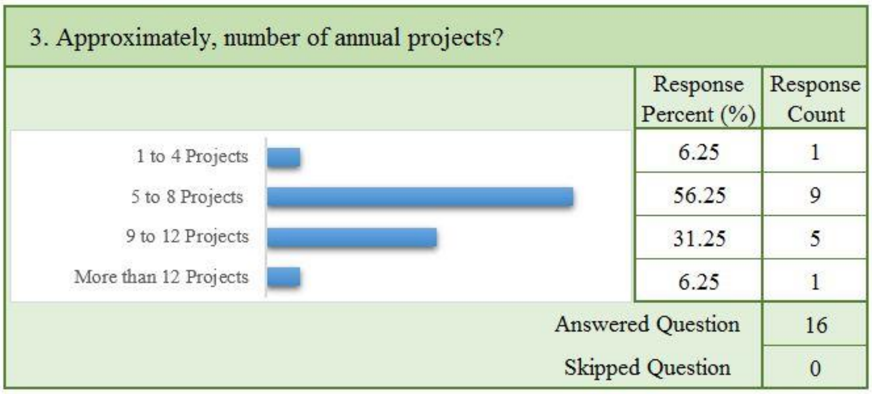
By means of distributing the questionnaires, it was meant to obtain general information about the participants, assess how familiar they are with supply chain management, and which techniques and tools are employed in the companies to identify, analyze and respond to risk factors affecting supply chain management implementation.

In the following sections, results of respondents to the questionnaire survey will be presented in details from Figure 4.1 to 4.20 respectively. Moreover, Appendix C shows the survey respondents' specifications and profiles.



2. What is your position in your firm?	Response Percent (%)	Response Count
Director / CEO	6.25	1
Project Manager	31.25	5
Quality Manager	6.25	1
Purchasing Manager	18.75	3
Logistics Manager	25	4
Others	12.5	2
Answered Question		16
Skipped Question		0

Figure 4.1: Participants position in the firm



3. Approximately, number of annual projects?	Response Percent (%)	Response Count
1 to 4 Projects	6.25	1
5 to 8 Projects	56.25	9
9 to 12 Projects	31.25	5
More than 12 Projects	6.25	1
Answered Question		16
Skipped Question		0

Figure 4.2: Number of annual projects

4. Approximately, how many full-time employees work for your company?	Response Percent (%)	Response Count
Less than 50	6.25	1
50 to 100	0	0
101 to 200	25	4
201 to 300	12.5	2
More than 300	56.25	9
	Answered Question	16
	Skipped Question	0

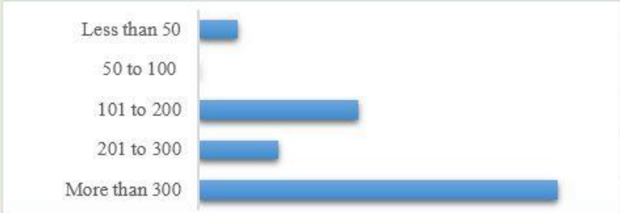


Figure 4.3: Number of employees

5. How long have you been involved in Canada construction industry?	Response Percent (%)	Response Count
1 to 5 Years	0	0
6 to 10 Years	18.75	3
11 to 15 Years	50	8
More than 15 Years	31.25	5
	Answered Question	16
	Skipped Question	0

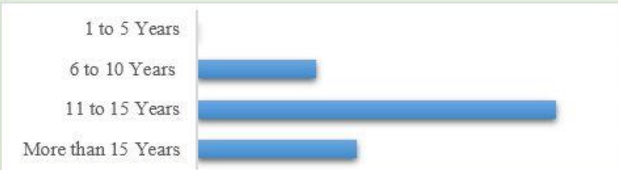


Figure 4.4: Work experience

6. Approximately, what is the annual turnover of your organization (US Dollar) if comfortable to share?	Response Percent (%)	Response Count
Less than $10 million	6.25	1
Between $10 to $30 million	18.75	3
Between $30 to $50 million	12.5	2
More than $50 million	62.5	10
	Answered Question	16
	Skipped Question	0

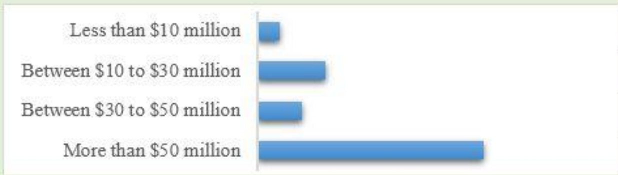


Figure 4.5: Annual turnover

7. Do you support that implementation of Supply chain management can help to save cost?	Response Percent (%)	Response Count
Yes	100	16
No	0	0
Not sure	0	0
Answered Question		16
Skipped Question		0

Figure 4.6: Save cost by means of SCM

8. Do you think that with efficient implementation of SCM can raise quality of construction and save time?	Response Percent (%)	Response Count
Yes	81.25	13
No	0	0
Not sure	18.75	3
Answered Question		16
Skipped Question		0

Figure 4.7: Save time and raise quality by means of SCM

9. Does your organization conduct team building sessions arrange meetings with the client and vendors during the project implementation phase?	Response Percent (%)	Response Count
Weekly meetings	6.25	1
Bi-weekly meetings	12.5	2
Monthly meetings	75	12
Once in Three months	6.25	1
No meetings at all	0	0
Don't know	0	0
Answered Question		16
Skipped Question		0

Figure 4.8: Meeting schedule

10. Does your organization have any system in place for the selection of suppliers, if yes how does your company select a vendor or supplier based on?	Response Percent (%)	Response Count
Recommendation	62.5	10
Price	12.5	2
Experience	18.75	3
Geographic location	6.25	1
Market reputation	0	0
Others	0	0
Answered Question		16
Skipped Question		0

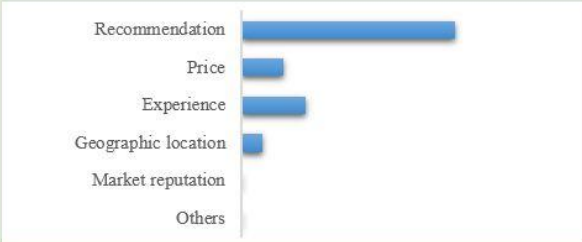


Figure 4.9: Selection of suppliers

11. Is supply chain management related to your business and do you think that your organization has system in place to manage the project in an efficient way?	Response Percent (%)	Response Count
Yes	93.25	15
No	0	0
Not sure	6.25	1
Answered Question		16
Skipped Question		0

Figure 4.10: Business relation with SCM

12. Which functions of SCM are most important to internal organization of your company?

	Not sure	To a small extent	To a moderate extent	To a great extent	To a very great extent	Response Count
Transport	6.25% (1)	0.0% (0)	12.5% (2)	18.75% (3)	62.5% (10)	16
Inventory	0.0% (0)	0.0% (0)	6.25% (1)	50.0% (8)	43.75% (7)	16
Production planning	0.0% (0)	0.0% (0)	6.25% (1)	18.75% (3)	75.0% (12)	16
Storage	0.0% (0)	0.0% (0)	0.0% (0)	50.0% (8)	50.0% (8)	16
Purchasing	0.0% (0)	0.0% (0)	12.5% (2)	12.5% (2)	75.0% (12)	16
Others	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0
					Answered Question	16
					Skipped Question	0

Figure 4.11: Internal organization functions in SCM

13. Which factors of SCM are important in relationship with your client?						
	Not sure	To a small extent	To a moderate extent	To a great extent	To a very great extent	Response Count
Cost benefits	0.0% (0)	0.0% (0)	0.0% (0)	31.25% (5)	68.75% (11)	16
Creating standardisation of processes	6.25% (1)	0.0% (0)	31.25% (5)	25.0% (4)	37.5% (6)	16
Simplifying the construction process	6.25% (1)	0.0% (0)	6.25% (1)	25.0% (4)	62.5% (10)	16
Simplifying the design stage	18.75% (3)	0.0% (0)	6.25% (1)	25.0% (4)	50.0% (8)	16
Simplifying the tendering process	12.5% (2)	0.0% (0)	0.0% (0)	37.5% (6)	50.0% (8)	16
Others	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0
					Answered Question	16
					Skipped Question	0

Figure 4.12: SCM relationship with the clients

14. Which factors of SCM are important in relationship with your supplier?						
	Not sure	To a small extent	To a moderate extent	To a great extent	To a very great extent	Response Count
Simplify the ordering process	6.25% (1)	0.0% (0)	0.0% (0)	31.25% (5)	62.5% (10)	16
Cost benefits	12.5% (2)	0.0% (0)	0.0% (0)	31.25% (5)	56.25% (9)	16
Simplify the construction process	12.5% (1)	0.0% (0)	0.0% (0)	56.25% (9)	37.5% (6)	16
Better quality service	0.0% (0)	0.0% (0)	0.0% (0)	37.5% (6)	62.5% (10)	16
Others	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	100% (1)	1
					Answered Question	16
					Skipped Question	0

Figure 4.13: SCM relationship with the supplier

15. What are the principal objective(s) in developing CSCM in your organization?						
	Not sure	To a small extent	To a moderate extent	To a great extent	To a very great extent	Response Count
Improved customer service	12.5% (2)	0.0% (0)	0.0% (0)	43.75% (7)	43.75% (7)	16
Benefits to client	0.0% (0)	0.0% (0)	0.0% (0)	18.75% (3)	81.25% (13)	16
Benefits to supplier	0.0% (0)	0.0% (0)	0.0% (0)	43.75% (7)	56.25% (9)	16
Enhanced profitability	0.0% (0)	0.0% (0)	0.0% (0)	31.25% (5)	68.75% (11)	16
Enhanced competitiveness	6.25% (1)	0.0% (0)	6.25% (1)	43.75% (7)	43.75% (7)	16
Reducing paperwork	6.25% (1)	0.0% (0)	18.75% (3)	31.25% (5)	43.75% (7)	16
Cost reduction within organization	18.75% (3)	0.0% (0)	0.0% (0)	50.0% (8)	31.25% (5)	16
Modified quality assurance	0.0% (0)	0.0% (0)	0.0% (0)	12.5% (2)	87.5% (14)	16
Overall supply chain reduction	6.25% (1)	0.0% (0)	0.0% (0)	31.25% (5)	62.5% (10)	16
Others	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0
					Answered Question	16
					Skipped Question	0

Figure 4.14: CSCM development objectives

16. What are key factors in effective CSC relationships?						
	Not sure	To a small extent	To a moderate extent	To a great extent	To a very great extent	Response Count
More frequent meetings	12.5% (2)	12.5% (2)	18.75% (3)	31.25% (5)	25% (4)	16
Integrated information systems	0.0% (0)	0.0% (0)	31.25% (5)	37.5% (6)	31.25% (5)	16
Top management support	6.25% (1)	0.0% (0)	0.0% (0)	12.5% (2)	81.25% (13)	16
Free flow of information	0.0% (0)	0.0% (0)	0.0% (0)	31.25% (5)	68.75% (11)	16
Joint business planning	6.25% (1)	0.0% (0)	6.25% (1)	43.75% (7)	43.75% (7)	16
Trust	0.0% (0)	0.0% (0)	0.0% (0)	6.25% (1)	93.75% (15)	16
Closer links between demand/ supply	6.25% (1)	0.0% (0)	25.0% (4)	31.25% (5)	37.5% (6)	16
Manpower development	6.25% (1)	0.0% (0)	37.5% (6)	25.0% (4)	31.25% (5)	16
Reliability of supply	0.0% (0)	0.0% (0)	0.0% (0)	18.75% (3)	81.25% (13)	16
Mutual interest	0.0% (0)	0.0% (0)	6.25% (1)	18.75% (3)	75.0% (12)	16
Others	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0.0% (0)	0
					Answered Question	16
					Skipped Question	0

Figure 4.15: CSC effective key factors

17. Are the efficient risk management program considered in your organization? (if yes follow next questions)		
	Response Percent (%)	Response Count
Yes	100	16
No	0	0
Not sure	0	0
Answered Question		16
Skipped Question		0

Figure 4.16: Participants risk management program

18. Which types of tools and technique do your organization use for risks and opportunity identification?	Response Percent (%)	Response Count
Documentation Reviews	37.5	6
Brainstorming	0	0
Questionnaire Survey	0	0
Scenario analysis	0	0
Delphi Technique	0	0
Risk Breakdown Structure…	18.75	3
SWOT/PESTLE Analysis	6.25	1
Checklist Analysis	31.25	5
Failure mode and effect…	0	0
Others	6.25	1
Answered Question		16
Skipped Question		0

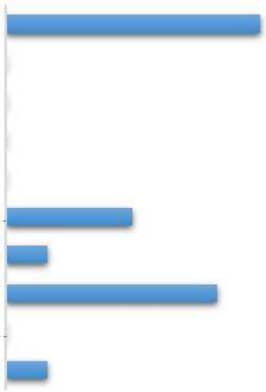


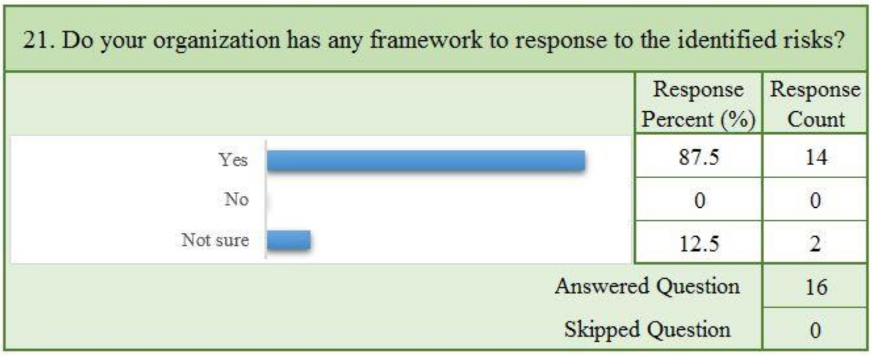
Figure 4.17: Risk and opportunity tools and technique

19. Which method do your organization use for risk assessment?	Response Percent (%)	Response Count
Qualitative Method	37.5	6
Quantitative Method	12.5	2
Both Method	18.75	3
Others	12.5	2
Answered Question		13
Skipped Question		3

Figure 4.18: Participants risk assessment methods

20. Which method do your organization use for qualitative and quantitative risk analysis?	Response Percent (%)	Response Count
Probability and Impact...	37.5	6
Decision Making Matrix	12.5	2
Decision Tree Analysis	0	0
Expected Monetary Value...	6.25	1
Monte Carlo Method	6.25	1
Others	18.75	3
	Answered Question	13
	Skipped Question	3

Figure 4.19: Participants risk analyze methods



21. Do your organization has any framework to response to the identified risks?	Response Percent (%)	Response Count
Yes	87.5	14
No	0	0
Not sure	12.5	2
	Answered Question	16
	Skipped Question	0

Figure 4.20: Participants risk response framework

4.2.2 Checklist

4.2.2.1 Risk Identification

To identify the potential risks, there are many techniques, among which checklists are popular due to their simplicity and quickness, which are mainly established based on previous information and the collected data from similar projects and other sources of information.

As also explained previously, the identified risks of this study were mainly based on the research work of Aloini et al. (2012 b). Totally, thirteen risk factors and their sub-contexts were recognized and explained in the literature review section.

In the following section, the risks which were identified, are classified hierarchically based on the idea of risk breakdown structure (RBS). The structure was mainly achieved from research studies of Simons (1999) and Meulbroek (2000). In Table 4.2, this hierarchical structure have been displayed.

4.2.2.2 Risk Analysis

After the risk identification stage and rating it by the survey participants, it is time to analyze and evaluate them by means of qualitative method. This method was employed because of its popularity, due to cost-effectiveness and rapidness, to prioritize the risks (the process of calculations are shown in Appendix E). Other necessary calculations are obtaining the average risk score, calculating the risk percentages separately, considering time, cost, quality, and overall cases. Lastly calculating the overall risk percentage, shown in Table 4.3, has also been performed.

Table 4.2: Hierarchical structure of identified risks

Type of Risk	Risk factor	SCM sub-context
Strategic	Lack of awareness of SCM benefits	Strategic networks
		Relationships development
		Cost reduction
		Communication
	Old culture	Organisational culture
		Communication
		Capability development
		Strategic alliances
		Trust
	Inadequate change management	Change management
	Inadequate Business Process Re-engineering (BPR)	Strategic alliances
		Strategic networks
Operation	Weakness of concurrent design	Concurrent engineering
	Inadequate IT system	Integration of materials and information flows
		Communication
		Vendor Managed Inventory (VMI)
	Inadequate training and instruction	Organisational culture
		Knowledge transfer
		Capability development
	Myopic control	Contract management
		Trust
Supply	Inadequate communication	Communication
		Partnership performance
		Vendor Managed Inventory (VMI)
		Knowledge transfer
		Integration of material and information flows
	Late involvement of parts	Relationship development
		Strategic alliances
		Concurrent engineering
		Lean thinking
	Inadequate selection of suppliers	Strategic Sourcing / Purchasing
	Absence of performance measurement system	Partnership performance
		Cost reduction
		Communication
		Contract management
	Absence of a conflict resolution procedure	Trust
		Relationships development
		Organisational culture

Table 4.3: Statistical analysis of identified risks

Type of Risk	Risk factor	SCM sub-context	Average of Probabilities	Average of Impacts			Average of Total Impacts	Average of Risk Scores			Risk Percentages			Total Risk Percentages			Overall Risk Score	Overall Risk Score Percentage
				Time	Cost	Quality		Time	Cost	Quality	Time	Cost	Quality	Time	Cost	Quality		
Strategic	Lack of awareness of SCM benefits	Strategic networks	1.50	3.25	3.06	2.50	2.94	4.94	4.63	3.81	1.46	1.42	1.32	35.42	34.23	30.35	4.49	1.40
		Relationships development	1.63	3.19	2.94	2.44	2.85	5.13	4.63	3.94	1.52	1.42	1.36				4.59	1.44
		Cost reduction	1.44	3.13	2.94	2.50	2.85	4.50	4.13	3.56	1.33	1.26	1.23				4.09	1.28
		Communication	1.38	2.81	2.63	2.19	2.54	3.88	3.63	3.06	1.15	1.11	1.06				3.54	1.11
	Old culture	Organisational culture	1.56	3.31	3.06	3.00	3.13	5.25	4.81	4.75	1.55	1.47	1.64				4.95	1.55
		Communication	1.56	3.13	3.00	2.94	3.02	4.88	4.69	4.63	1.44	1.43	1.60				4.73	1.48
		Capability development	1.56	3.19	3.06	3.00	3.08	5.00	4.75	4.69	1.48	1.45	1.62				4.82	1.51
		Strategic alliances	1.56	3.06	2.75	2.75	2.85	4.75	4.31	4.38	1.40	1.32	1.51				4.49	1.40
		Trust	1.50	2.81	2.75	2.69	2.75	4.25	4.06	4.00	1.26	1.24	1.38				4.11	1.29
	Inadequate change management	Change management	2.63	3.44	2.25	2.06	2.58	8.94	6.00	5.38	2.64	1.84	1.86				6.85	2.14
	Inadequate Business Process Re-engineering (BPR)	Strategic alliances	2.06	2.38	3.81	2.31	2.83	4.88	7.75	4.69	1.44	2.37	1.62				5.80	1.82
		Strategic networks	2.13	2.44	3.81	2.31	2.85	5.19	8.00	4.88	1.53	2.45	1.68				6.06	1.89
Operation	Weakness of concurrent design	Concurrent engineering	3.88	4.19	4.25	2.94	3.79	16.25	16.38	11.44	4.81	5.01	3.95				14.83	4.64
	Inadequate IT system	Integration of materials and information flows	3.63	3.81	3.75	3.19	3.58	13.81	13.63	11.50	4.09	4.17	3.97				13.05	4.08
		Communication	3.50	3.88	3.63	3.44	3.65	13.69	12.63	12.06	4.05	3.86	4.16				12.83	4.01
		Vendor Managed Inventory (VMI)	3.75	3.88	3.69	3.19	3.58	14.50	13.81	11.88	4.29	4.23	4.10				13.47	4.21
	Inadequate training and instruction	Organisational culture	1.75	4.38	3.69	2.50	3.52	7.69	6.44	4.31	2.27	1.97	1.49				6.24	1.95
		Knowledge transfer	1.63	4.13	3.69	2.50	3.44	6.69	6.00	4.00	1.98	1.84	1.38				5.64	1.76
		Capability development	1.75	4.19	3.56	2.50	3.42	7.31	6.19	4.38	2.16	1.89	1.51				6.04	1.89
	Myopic control	Contract management	1.69	2.56	3.50	3.69	3.25	4.31	5.88	6.25	1.28	1.80	2.16				5.44	1.70
		Trust	1.63	2.31	2.19	2.44	2.31	3.75	3.63	4.00	1.11	1.11	1.38				3.78	1.18
Supply	Inadequate communication	Communication	3.31	4.13	3.88	3.50	3.83	13.69	12.81	11.56	4.05	3.92	3.99				12.74	3.99
		Partnership performance	3.50	4.25	4.00	3.63	3.96	14.94	14.00	12.63	4.42	4.28	4.36				13.91	4.35
		Vendor Managed Inventory (VMI)	3.56	4.31	3.94	3.75	4.00	15.38	14.06	13.25	4.55	4.30	4.57				14.28	4.47
		Knowledge transfer	3.44	4.19	3.94	3.94	4.02	14.50	13.63	13.50	4.29	4.17	4.66				13.90	4.35
		Integration of materials and information flows	4.25	3.69	4.31	4.50	4.17	15.69	18.31	19.25	4.64	5.60	6.64				17.67	5.53
	Late involvement of parts	Relationship development	4.00	4.44	4.31	2.63	3.79	17.88	17.50	10.81	5.29	5.35	3.73				15.60	4.88
		Strategic alliances	3.69	4.31	4.25	2.69	3.75	16.06	15.81	10.13	4.75	4.84	3.49				14.17	4.44
		Concurrent engineering	3.63	4.25	4.13	2.69	3.69	15.44	15.19	10.00	4.57	4.65	3.45				13.70	4.29
		Lean thinking	3.25	4.31	4.31	2.88	3.83	14.19	14.13	9.50	4.20	4.32	3.28				12.74	3.99
	Inadequate selection of suppliers	Strategic Sourcing / Purchasing	4.00	2.38	3.06	4.63	3.35	9.81	12.25	18.63	2.90	3.75	6.43				13.32	4.17
	Absence of performance measurement system	Partnership performance	1.94	2.44	2.56	4.00	3.00	4.81	5.06	7.88	1.42	1.55	2.72				5.83	1.82
		Cost reduction	1.81	2.44	2.56	4.00	3.00	4.56	4.81	7.38	1.35	1.47	2.55				5.50	1.72
		Communication	1.50	2.31	2.50	3.81	2.88	3.75	3.94	5.81	1.11	1.20	2.01				4.44	1.39
		Contract management	1.75	2.38	2.50	4.00	2.96	4.38	4.56	7.19	1.29	1.40	2.48				5.29	1.66
	Absence of a conflict resolution procedure	Trust	2.00	4.13	2.63	1.94	2.90	8.25	5.13	3.81	2.44	1.57	1.32				5.83	1.83
		Relationships development	1.94	4.19	2.69	1.88	2.92	8.19	5.19	3.56	2.42	1.59	1.23				5.76	1.80
		Organisational culture	1.75	4.00	2.56	1.88	2.81	7.06	4.50	3.31	2.09	1.38	1.14				5.05	1.58

Results of Table 4.3 have also been prioritized based on the risk scores of time, cost, quality and the overall case. As prioritizing has been done, each risk was ranked and colored based on the previously defined coloring system in a probability and impact matrix. The results are indicated in Tables 4.4, 4.5, 4.6 and 4.7. A bar chart has also been plotted and illustrated in Figures 4.21 to 4.24 for each mentioned table respectively. Comparing the risks' conditions, in terms of time, cost, quality and overall, the complete results of above tables have been brought in Table 4.8. Furthermore, a bar chart been drawn in order to more understanding of comparison between rank of each risk according to Table 4.8 and shown in Figure 4.25.

According to the total risk percentages of the project's objectives (time, cost and quality) which are calculated in Table 4.3, a bar chart plotted to show share of each objective risk and also are indicated in Figure 4.26.

It is worth mentioning that, the evaluations of reliabilities has been done by means of SPSS software program and shown in Appendix F.

Table 4.4: Risk prioritize, considering time risk scores

No.	Type of Risk	Risk Factor	Sub-Context	Average Time Risk Score
1	Supply	Late involvement of parts	Relationship development	17.88
2	Operation	Weakness of concurrent design	Concurrent engineering	16.25
3	Supply	Late involvement of parts	Strategic alliances	16.06
4	Supply	Inadequate communication	Integration of material and information flows	15.69
5	Supply	Late involvement of parts	Concurrent engineering	15.44
6	Supply	Inadequate communication	Vendor Managed Inventory (VMI)	15.38
7	Supply	Inadequate communication	Partnership performance	14.94
8	Operation	Inadequate IT system	Vendor Managed Inventory (VMI)	14.50
9	Supply	Inadequate communication	Knowledge transfer	14.50
10	Supply	Late involvement of parts	Lean thinking	14.19
11	Operation	Inadequate IT system	Integration of materials and information flows	13.81
12	Operation	Inadequate IT system	Communication	13.69
13	Supply	Inadequate communication	Communication	13.69
14	Supply	Inadequate selection of suppliers	Strategic Sourcing / Purchasing	9.81
15	Strategic	Inadequate change management	Change management	8.94
16	Supply	Absence of a conflict resolution procedure	Trust	8.25
17	Supply	Absence of a conflict resolution procedure	Relationships development	8.19
18	Operation	Inadequate training and instruction	Organisational culture	7.69
19	Operation	Inadequate training and instruction	Capability development	7.31
20	Supply	Absence of a conflict resolution procedure	Organisational culture	7.06
21	Operation	Inadequate training and instruction	Knowledge transfer	6.69
22	Strategic	Old culture	Organisational culture	5.25
23	Strategic	Inadequate Business Process Re-engineering	Strategic networks	5.19
24	Strategic	Lack of awareness of SCM benefits	Relationships development	5.13
25	Strategic	Old culture	Capability development	5.00
26	Strategic	Lack of awareness of SCM benefits	Strategic networks	4.94
27	Strategic	Old culture	Communication	4.88
28	Strategic	Inadequate Business Process Re-engineering	Strategic alliances	4.88
29	Supply	Absence of performance measurement system	Partnership performance	4.81
30	Strategic	Old culture	Strategic alliances	4.75
31	Supply	Absence of performance measurement system	Cost reduction	4.56
32	Strategic	Lack of awareness of SCM benefits	Cost reduction	4.50
33	Supply	Absence of performance measurement system	Contract management	4.38
34	Operation	Myopic control	Contract management	4.31
35	Strategic	Old culture	Trust	4.25
36	Strategic	Lack of awareness of SCM benefits	Communication	3.88
37	Operation	Myopic control	Trust	3.75
38	Supply	Absence of performance measurement system	Communication	3.75

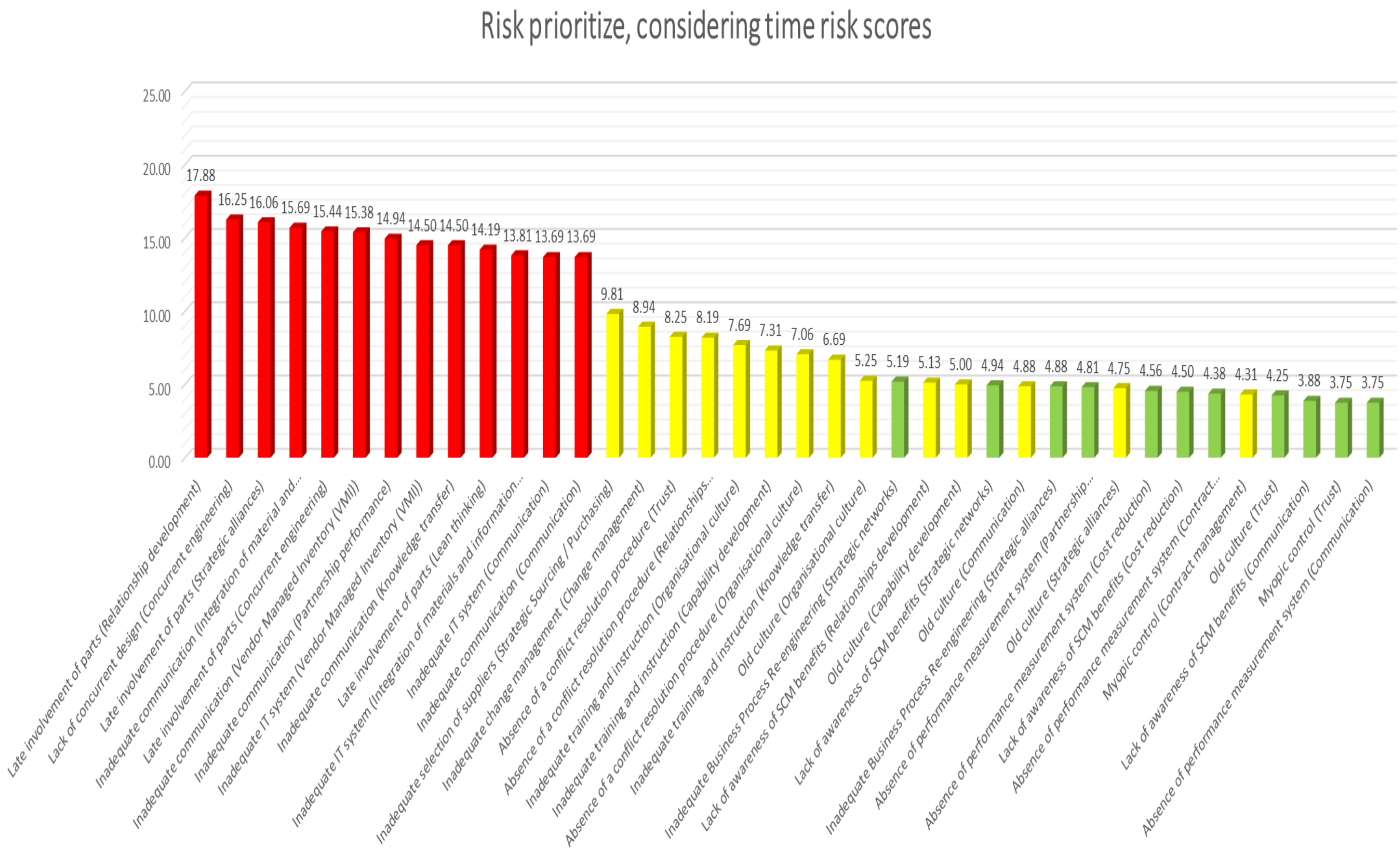


Figure 4.21: Risk prioritize, considering time risk score

Table 4.5: Risk prioritize, considering cost risk scores

No.	Type of Risk	Risk Factor	Sub-Context	Average Cost Risk Score
1	Supply	Inadequate communication	Integration of material and information flows	18.31
2	Supply	Late involvement of parts	Relationship development	17.50
3	Operation	Weakness of concurrent design	Concurrent engineering	16.38
4	Supply	Late involvement of parts	Strategic alliances	15.81
5	Supply	Late involvement of parts	Concurrent engineering	15.19
6	Supply	Late involvement of parts	Lean thinking	14.13
7	Supply	Inadequate communication	Vendor Managed Inventory (VMI)	14.06
8	Supply	Inadequate communication	Partnership performance	14.00
9	Operation	Inadequate IT system	Vendor Managed Inventory (VMI)	13.81
10	Operation	Inadequate IT system	Integration of materials and information flows	13.63
11	Supply	Inadequate communication	Knowledge transfer	13.63
12	Supply	Inadequate communication	Communication	12.81
13	Operation	Inadequate IT system	Communication	12.63
14	Supply	Inadequate selection of suppliers	Strategic Sourcing / Purchasing	12.25
15	Strategic	Inadequate Business Process Re-engineering	Strategic networks	8.00
16	Strategic	Inadequate Business Process Re-engineering	Strategic alliances	7.75
17	Operation	Inadequate training and instruction	Organisational culture	6.44
18	Operation	Inadequate training and instruction	Capability development	6.19
19	Strategic	Inadequate change management	Change management	6.00
20	Operation	Inadequate training and instruction	Knowledge transfer	6.00
21	Operation	Myopic control	Contract management	5.88
22	Supply	Absence of a conflict resolution procedure	Relationships development	5.19
23	Supply	Absence of a conflict resolution procedure	Trust	5.13
24	Supply	Absence of performance measurement system	Partnership performance	5.06
25	Strategic	Old culture	Organisational culture	4.81
26	Supply	Absence of performance measurement system	Cost reduction	4.81
27	Strategic	Old culture	Capability development	4.75
28	Strategic	Old culture	Communication	4.69
29	Strategic	Lack of awareness of SCM benefits	Strategic networks	4.63
30	Strategic	Lack of awareness of SCM benefits	Relationships development	4.63
31	Supply	Absence of performance measurement system	Contract management	4.56
32	Supply	Absence of a conflict resolution procedure	Organisational culture	4.50
33	Strategic	Old culture	Strategic alliances	4.31
34	Strategic	Lack of awareness of SCM benefits	Cost reduction	4.13
35	Strategic	Old culture	Trust	4.06
36	Supply	Absence of performance measurement system	Communication	3.94
37	Strategic	Lack of awareness of SCM benefits	Communication	3.63
38	Operation	Myopic control	Trust	3.63

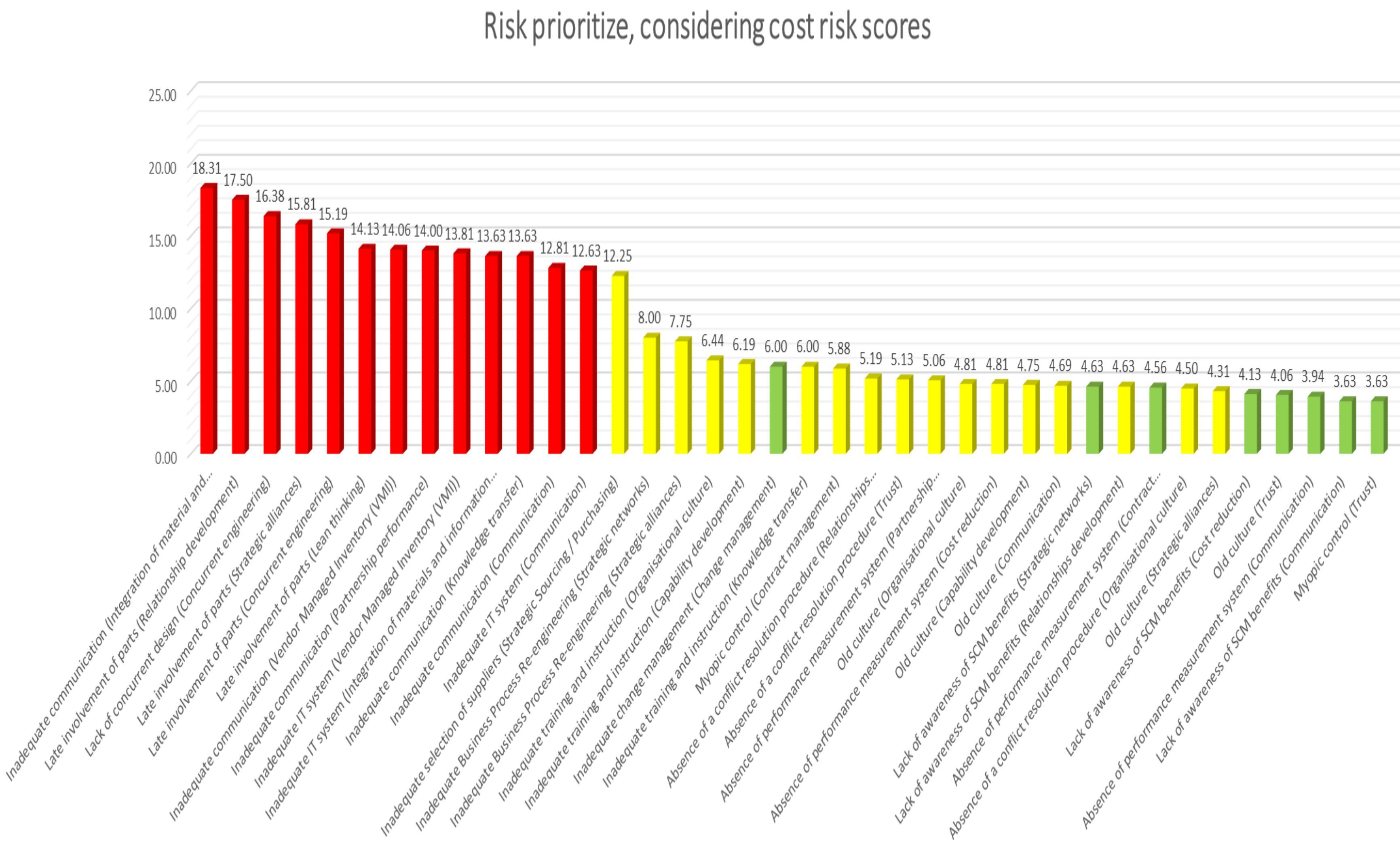


Figure 4.22: Risk prioritize, considering cost risk score

Table 4.6: Risk prioritize, considering quality risk scores

No.	Type of Risk	Risk Factor	Sub-Context	Average Quality Risk Score
1	Supply	Inadequate communication	Integration of material and information flows	19.25
2	Supply	Inadequate selection of suppliers	Strategic Sourcing / Purchasing	18.63
3	Supply	Inadequate communication	Knowledge transfer	13.50
4	Supply	Inadequate communication	Vendor Managed Inventory (VMI)	13.25
5	Supply	Inadequate communication	Partnership performance	12.63
6	Operation	Inadequate IT system	Communication	12.06
7	Operation	Inadequate IT system	Vendor Managed Inventory (VMI)	11.88
8	Supply	Inadequate communication	Communication	11.56
9	Operation	Inadequate IT system	Integration of materials and information flows	11.50
10	Operation	Weakness of concurrent design	Concurrent engineering	11.44
11	Supply	Late involvement of parts	Relationship development	10.81
12	Supply	Late involvement of parts	Strategic alliances	10.13
13	Supply	Late involvement of parts	Concurrent engineering	10.00
14	Supply	Late involvement of parts	Lean thinking	9.50
15	Supply	Absence of performance measurement system	Partnership performance	7.88
16	Supply	Absence of performance measurement system	Cost reduction	7.38
17	Supply	Absence of performance measurement system	Contract management	7.19
18	Operation	Myopic control	Contract management	6.25
19	Supply	Absence of performance measurement system	Communication	5.81
20	Strategic	Inadequate change management	Change management	5.38
21	Strategic	Inadequate Business Process Re-engineering	Strategic networks	4.88
22	Strategic	Old culture	Organisational culture	4.75
23	Strategic	Old culture	Capability development	4.69
24	Strategic	Inadequate Business Process Re-engineering	Strategic alliances	4.69
25	Strategic	Old culture	Communication	4.63
26	Strategic	Old culture	Strategic alliances	4.38
27	Operation	Inadequate training and instruction	Capability development	4.38
28	Operation	Inadequate training and instruction	Organisational culture	4.31
29	Strategic	Old culture	Trust	4.00
30	Operation	Inadequate training and instruction	Knowledge transfer	4.00
31	Operation	Myopic control	Trust	4.00
32	Strategic	Lack of awareness of SCM benefits	Relationships development	3.94
33	Strategic	Lack of awareness of SCM benefits	Strategic networks	3.81
34	Supply	Absence of a conflict resolution procedure	Trust	3.81
35	Strategic	Lack of awareness of SCM benefits	Cost reduction	3.56
36	Supply	Absence of a conflict resolution procedure	Relationships development	3.56
37	Supply	Absence of a conflict resolution procedure	Organisational culture	3.31
38	Strategic	Lack of awareness of SCM benefits	Communication	3.06

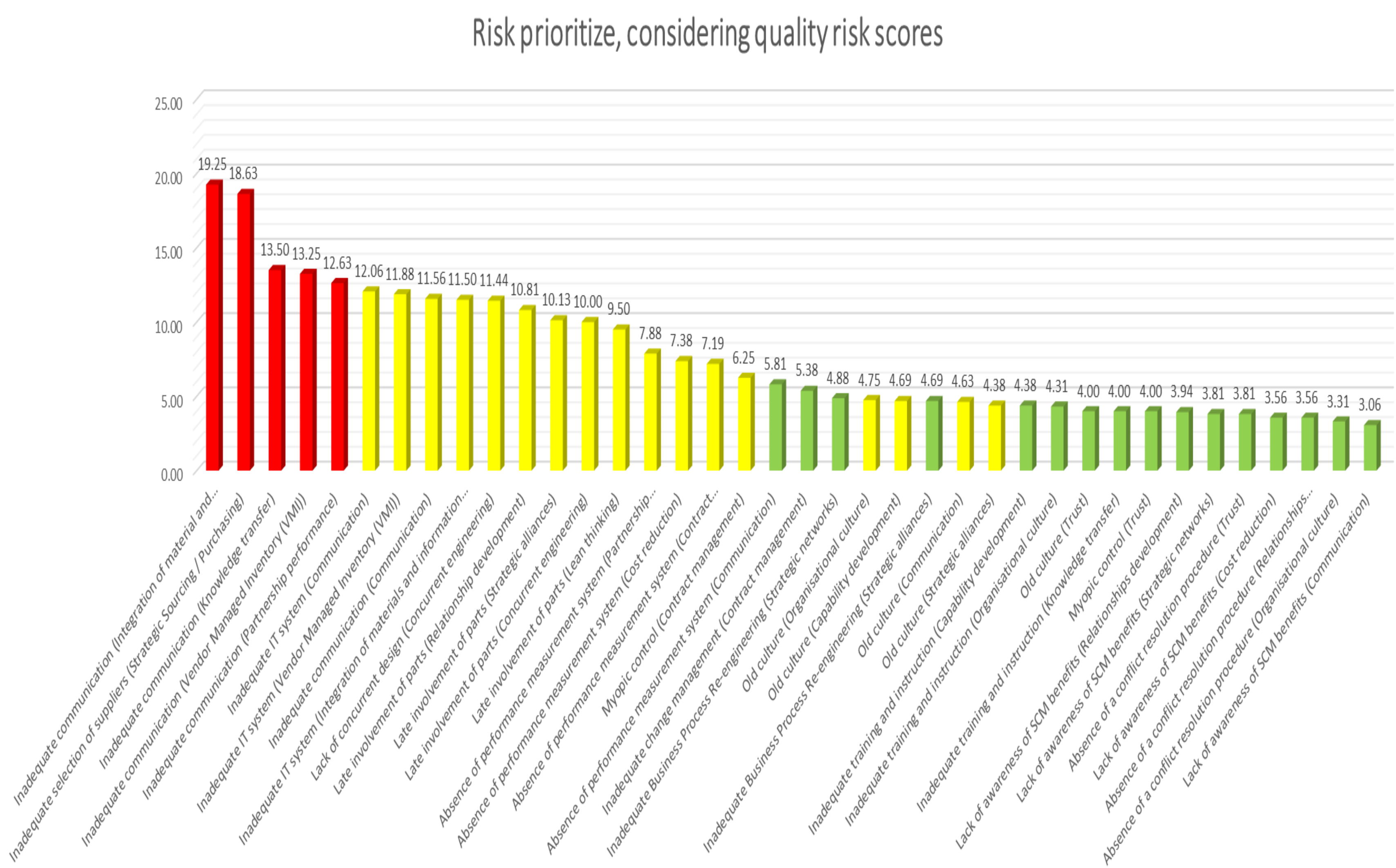


Figure 4.23: Risk prioritize, considering quality risk score

Table 4.7: Risk prioritize, considering overall risk scores

No.	Type of Risk	Risk Factor	Sub-Context	Overall Risk Score
1	Supply	Inadequate communication	Integration of material and information flows	17.67
2	Supply	Late involvement of parts	Relationship development	15.60
3	Operation	Weakness of concurrent design	Concurrent engineering	14.83
4	Supply	Inadequate communication	Vendor Managed Inventory	14.28
5	Supply	Late involvement of parts	Strategic alliances	14.17
6	Supply	Inadequate communication	Partnership performance	13.91
7	Supply	Inadequate communication	Knowledge transfer	13.90
8	Supply	Late involvement of parts	Concurrent engineering	13.70
9	Operation	Inadequate IT system	Vendor Managed Inventory	13.47
10	Supply	Inadequate selection of suppliers	Strategic Sourcing / Purchasing	13.32
11	Operation	Inadequate IT system	Integration of materials and information flows	13.05
12	Operation	Inadequate IT system	Communication	12.83
13	Supply	Late involvement of parts	Lean thinking	12.74
14	Supply	Inadequate communication	Communication	12.74
15	Strategic	Inadequate change management	Change management	6.85
16	Operation	Inadequate training and instruction	Organisational culture	6.24
17	Strategic	Inadequate Business Process Re-engineering	Strategic networks	6.06
18	Operation	Inadequate training and instruction	Capability development	6.04
19	Supply	Absence of a conflict resolution procedure	Trust	5.83
20	Supply	Absence of performance measurement system	Partnership performance	5.83
21	Strategic	Inadequate Business Process Re-engineering	Strategic alliances	5.80
22	Supply	Absence of a conflict resolution procedure	Relationships development	5.76
23	Operation	Inadequate training and instruction	Knowledge transfer	5.64
24	Supply	Absence of performance measurement system	Cost reduction	5.50
25	Operation	Myopic control	Contract management	5.44
26	Supply	Absence of performance measurement system	Contract management	5.29
27	Supply	Absence of a conflict resolution procedure	Organisational culture	5.05
28	Strategic	Old culture	Organisational culture	4.95
29	Strategic	Old culture	Capability development	4.82
30	Strategic	Old culture	Communication	4.73
31	Strategic	Lack of awareness of SCM benefits	Relationships development	4.59
32	Strategic	Lack of awareness of SCM benefits	Strategic networks	4.49
33	Strategic	Old culture	Strategic alliances	4.49
34	Supply	Absence of performance measurement system	Communication	4.44
35	Strategic	Old culture	Trust	4.11
36	Strategic	Lack of awareness of SCM benefits	Cost reduction	4.09
37	Operation	Myopic control	Trust	3.78
38	Strategic	Lack of awareness of SCM benefits	Communication	3.54

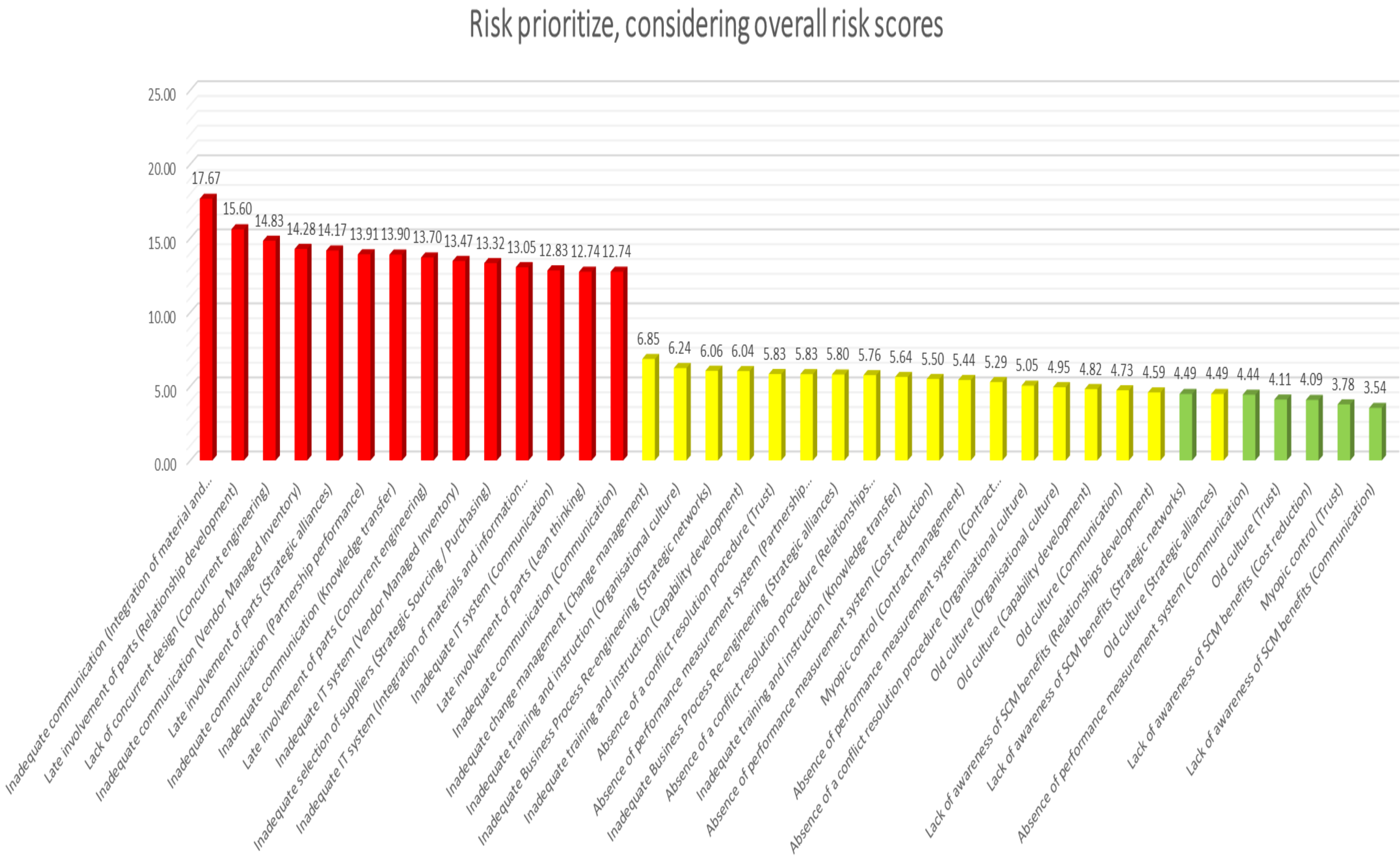


Figure 4.24: Risk prioritize, considering overall risk score

Table 4.8: Risk ranking comparison (Time, Cost, Quality, Overall)

No.	Type of Risk	Risk Factor	Sub-Context	Time	Cost	Quality	Overall
1	Supply	Inadequate communication	Integration of material and information flows	4	1	1	1
2	Supply	Late involvement of parts	Relationship development	1	2	11	2
3	Operation	Weakness of concurrent design	Concurrent engineering	2	3	10	3
4	Supply	Inadequate communication	Vendor Managed Inventory	6	7	4	4
5	Supply	Late involvement of parts	Strategic alliances	3	4	12	5
6	Supply	Inadequate communication	Partnership performance	7	8	5	6
7	Supply	Inadequate communication	Knowledge transfer	9	10	3	7
8	Supply	Late involvement of parts	Concurrent engineering	5	5	13	8
9	Operation	Inadequate IT system	Vendor Managed Inventory	8	9	7	9
10	Supply	Inadequate selection of suppliers	Strategic Sourcing / Purchasing	14	14	2	10
11	Operation	Inadequate IT system	Integration of materials and information flows	11	11	9	11
12	Operation	Inadequate IT system	Communication	12	13	6	12
13	Supply	Late involvement of parts	Lean thinking	10	6	14	13
14	Supply	Inadequate communication	Communication	13	12	8	14
15	Strategic	Inadequate change management	change management	15	19	20	15
16	Operation	Inadequate training and instruction	Organisational culture	18	17	28	16
17	Strategic	Inadequate Business Process Re-engineering	Strategic networks	23	15	21	17
18	Operation	Inadequate training and instruction	Capability development	19	18	26	18
19	Supply	Absence of a conflict resolution procedure	Trust	16	23	33	19
20	Supply	Absence of performance measurement system	Partnership performance	29	24	15	20
21	Strategic	Inadequate Business Process Re-engineering	Strategic alliances	28	16	23	21
22	Supply	Absence of a conflict resolution procedure	Relationships development	17	22	35	22
23	Operation	Inadequate training and instruction	Knowledge transfer	21	20	29	23
24	Supply	Absence of performance measurement system	Cost reduction	31	26	16	24
25	Operation	Myopic control	Contract management	34	21	18	25
26	Supply	Absence of performance measurement system	Contract management	33	31	17	26
27	Supply	Absence of a conflict resolution procedure	Organisational culture	20	32	37	27
28	Strategic	Old culture	Organisational culture	22	25	22	28
29	Strategic	Old culture	Capability development	25	27	24	29
30	Strategic	Old culture	Communication	27	28	25	30
31	Strategic	Lack of awareness of SCM benefits	Relationships development	24	29	32	31
32	Strategic	Lack of awareness of SCM benefits	Strategic networks	26	30	34	32
33	Strategic	Old culture	Strategic alliances	30	33	27	33
34	Supply	Absence of performance measurement system	Communication	38	36	19	34
35	Strategic	Old culture	Trust	35	35	30	35
36	Strategic	Lack of awareness of SCM benefits	Cost reduction	32	34	36	36
37	Operation	Myopic control	Trust	37	38	31	37
38	Strategic	Lack of awareness of SCM benefits	Communication	36	37	38	38

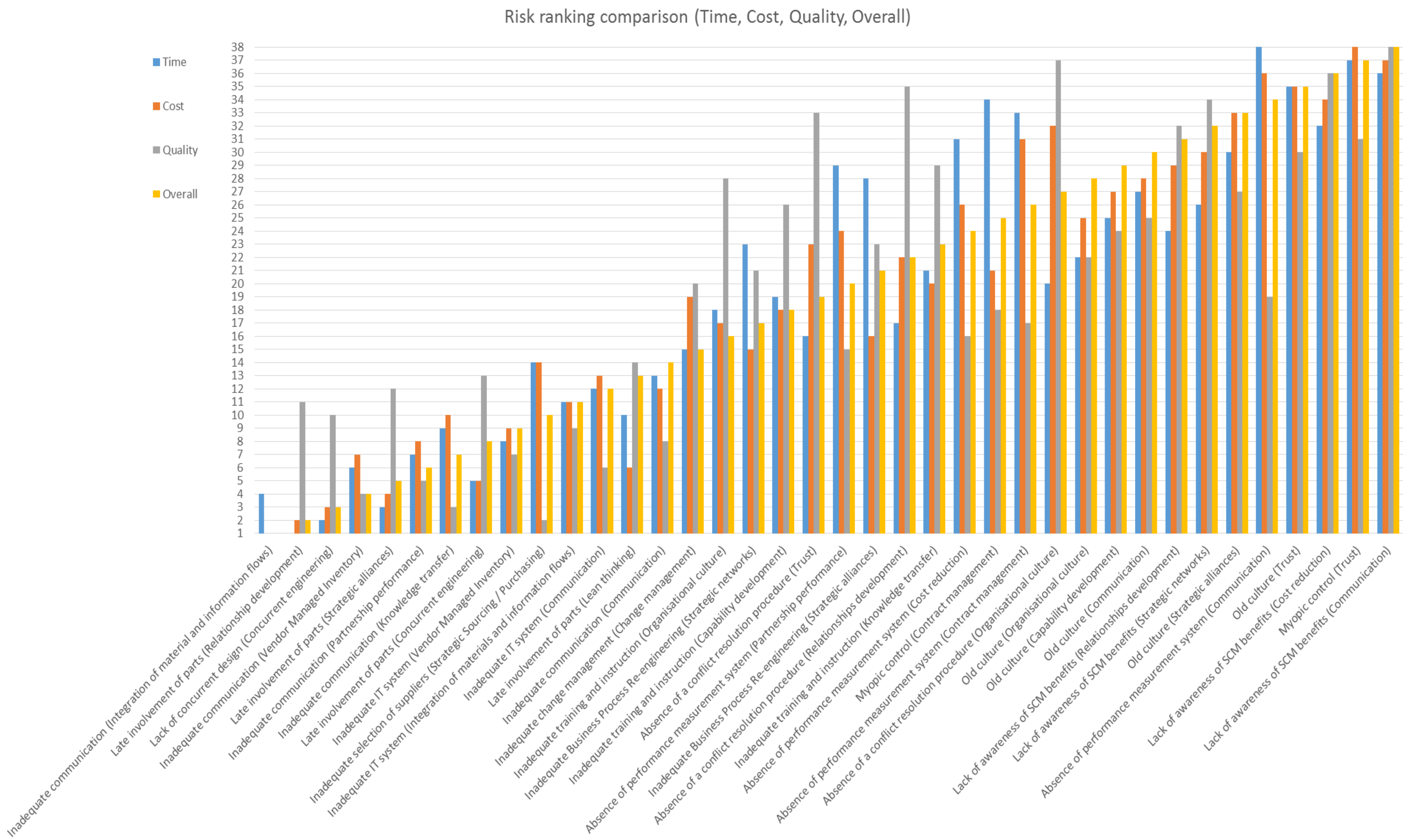


Figure 4.25: Risk rating comparison (Time, Cost, Quality, Overall)

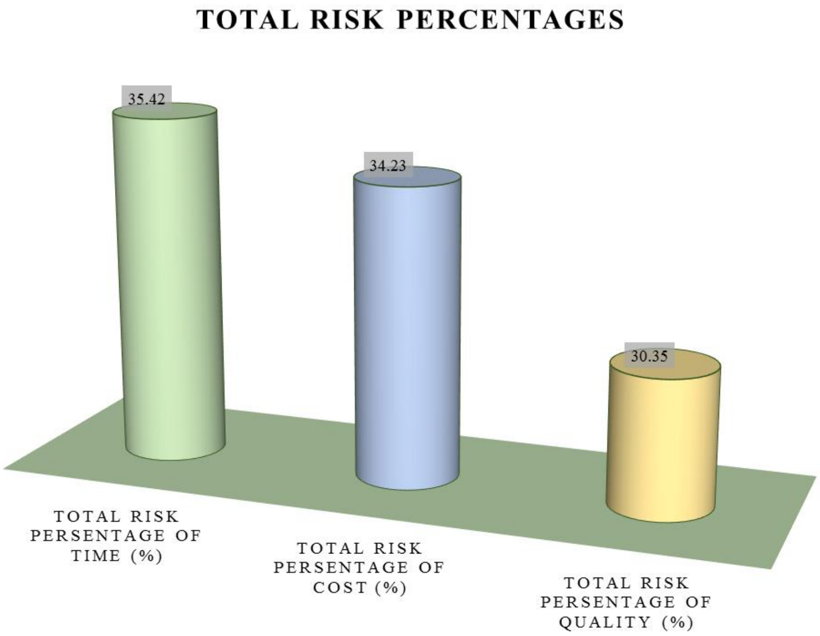


Figure 4.26: Total risk percentages (Time, Cost, Quality)

4.2.2.3 Risk Response

It is worth mentioning again that the third stage of risk assessment is the procedure of establishing strategic options and action determinations, to face with the risks and reduce their possible threats' influences on the project objectives. A general response strategy is selected typically, according to literature, to face with threats. The strategies are accepting, transferring, avoiding, and mitigating the impacts or probability of risks occurrence. According to the results of questionnaire survey, most of the participated construction companies are benefiting from frameworks, in order to respond to the risks (see Figure 4.20).

Considering the Tables 4.4, 4.5 and 4.6 that are showing the prioritized risks in terms of time, cost and quality, and comparing them to what is shown in Table 4.7, overlaps can be noticed in high risks, which are shown by red color. Due to this mutuality, for further assessments, the high risks represented in Table 4.7 will be considered in risk response stage. It is found that the whole risks included in the table are generated from five main risk factors which are ‘Inadequate communication’, ‘Late involvement of parts’, ‘Weakness of concurrent design’, ‘Inadequate IT system’ and ’Inadequate selection of suppliers’.

To clarify the risk zone of the 14 high risks according to respondents' answers, in probability and impact matrix, in terms of cost, time and quality, from each, the three highest risks have been chosen and shown in Tables of 4.9 to 4.17.

Tabel 4.9: Late involvement of parts (Relationship development) considering of time

PROBABILITY	Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
Very High (5)				Respondent 9 Respondent 13	Respondent 6 Respondent 11 Respondent 14
High (4)				Respondent 1 Respondent 3 Respondent 12	Respondent 4 Respondent 8 Respondent 16
Moderate (3)				Respondent 5 Respondent 7 Respondent 10 Respondent 15	Respondent 2
Low (2)					
Very Low (1)					

IMPACT

Tabel 4.10: Weakness of concurrent design (Concurrent design) considering of time

PROBABILITY	Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
Very High (5)				Respondent 7 Respondent 10 Respondent 14	
High (4)				Respondent 1 Respondent 4 Respondent 9 Respondent 12 Respondent 15	Respondent 5 Respondent 8 Respondent 16
Moderate (3)				Respondent 2 Respondent 3 Respondent 6 Respondent 11 Respondent 13	
Low (2)					
Very Low (1)					

IMPACT

Tabel 4.11: Late involvement of parts (Strategic alliances) considering of time

PROBABILITY	Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
Very High (5)				Respondent 11	Respondent 6
High (4)				Respondent 3 Respondent 9 Respondent 12	Respondent 4 Respondent 8 Respondent 14 Respondent 16
Moderate (3)				Respondent 1 Respondent 2 Respondent 5 Respondent 7,10 Respondent 13,15	
Low (2)					
Very Low (1)					

IMPACT

Table 4.12: Inadequate communication (Integration of material and information flows) considering of cost

PROBABILITY	Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
Very High (5)			Respondent 3	Respondent 9 Respondent 12	Respondent 8 Respondent 13
High (4)				Respondent 1 Respondent 2 Respondent 4 Respondent 11 Respondent 14,16	Respondent 5 Respondent 6 Respondent 10 Respondent 15
Moderate (3)				Respondent 7	
Low (2)					
Very Low (1)					
	IMPACT				

Table 4.13: Late involvement of parts (Relationship development) considering of cost

PROBABILITY	Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
Very High (5)				Respondent 6	Respondent 9 Respondent 11 Respondent 13 Respondent 14
High (4)				Respondent 1 Respondent 3 Respondent 4 Respondent 8 Respondent 16	Respondent 12
Moderate (3)			Respondent 5 Respondent 10	Respondent 7	Respondent 2 Respondent 15
Low (2)					
Very Low (1)					
	IMPACT				

Table 4.14: Weakness of concurrent design (Concurrent engineering) considering of cost

PROBABILITY	Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
Very High (5)				Respondent 7 Respondent 10 Respondent 14	
High (4)			Respondent 9	Respondent 4 Respondent 5 Respondent 8 Respondent 12	Respondent 1 Respondent 15 Respondent 15
Moderate (3)				Respondent 3 Respondent 6 Respondent 11	Respondent 2 Respondent 13
Low (2)					
Very Low (1)					
	IMPACT				

Table 4.15: Inadequate communication (Integration of material and information flows) considering of quality

PROBABILITY	Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
Very High (5)				Respondent 12	Respondent 3 Respondent 8 Respondent 9 Respondent 13
High (4)				Respondent 1 Respondent 2 Respondent 5 Respondent 6 Respondent 10,14	Respondent 4 Respondent 11 Respondent 15 Respondent 16
Moderate (3)				Respondent 7	
Low (2)					
Very Low (1)					
	IMPACT				

Table 4.16: Inadequate selection of suppliers (Strategic Sourcing / Purchasing) considering of quality

PROBABILITY	Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
Very High (5)					Respondent 5 Respondent 6 Respondent 12 Respondent 13
High (4)				Respondent 4 Respondent 7 Respondent 10 Respondent 15	Respondent 1 Respondent 11 Respondent 14 Respondent 16
Moderate (3)				Respondent 2 Respondent 8	Respondent 3 Respondent 9
Low (2)					
Very Low (1)					

IMPACT

Table 4.17: Inadequate communication (Knowledge transfer) considering of quality

PROBABILITY	Very Low (1)	Low (2)	Moderate (3)	High (4)	Very High (5)
Very High (5)					
High (4)			Respondent 9	Respondent 3 Respondent 4 Respondent 8 Respondent 11 Respondent 14,15	
Moderate (3)			Respondent 2 Respondent 6	Respondent 5 Respondent 7 Respondent 10 Respondent 12 Respondent 16	Respondent 1 Respondent 13
Low (2)					
Very Low (1)					

IMPACT

In brief, 14 high risky items were recognized, rooting in five main risk factors, which have been named previously.

Considering the obtained results, discussions, especially about the responding techniques to these risks, will be done in the next chapter.

Chapter 5

DISCUSSIONS ON RESULTS

5.1 Introduction

This chapter mainly includes the results obtained from checklists and questionnaire surveys carried out on Canadian companies, and discussion will be made on them. In the first section, discussions will be done on results of questionnaire survey, which revealed the following information:

- General information of respondents.
- How much the respondents are familiar with concepts of supply chain management.
- Familiarizing with the tools and techniques that the respondents are employing to identify, analyze and face with the risk factors, which are influential on implementation of supply chain management in Canada.

The second stage includes the discussions on checklist results, staring from a suggested structure, to find the effective response to face with high ranked risks. Afterwards, by employing the proposed framework, responses to each risk factor will be presented and discussed.

5.2 Discussion on the Questionnaire Survey Results

Discussions on three different parts of the questionnaire will be done in the subsequent sections:

- Background information
- SCM relevance
- RM relevance

5.2.1 Background Information

It is necessary to start the questionnaire survey with general questions, not the explicit questions about objectives, to ensure participant's correct field. Questions 1 to 6 are mainly about the respondents and his/her company's basic information.

5.2.2 SCM Relevance

SCM relevance was focused in questions 7 to 16. Separately, questions 7 and 8 concentrated on implementation of SCM and its effect on time, cost and quality of the projects. Being asked about these concepts, nearly all of the respondents had agreement on positive effect of SCM implementation on time and quality, and all of them had agreement on the positive effect of SCM implementation on cost.

Question 9 was about showing the level of relationship between construction team and clients, or vendors. Regular monthly meeting are being held between the majority of survey participants (75%) and their clients or vendors. Question 10 was about the basis of choosing vendors and suppliers, showing that selecting them is mostly based on recommendations. In question 11, the relevance of SCM to the respondents' businesses was asked. According to replies, most of them (93.25%) were involved in SCM-related businesses. According to question 12, the most important internal organization functions in SCM are listed as below, according to their importance:

- Production planning
- Purchasing

- Transport
- Storage
- Inventory

Question 13 was aimed at surveying the relationship with the clients, and the important factors of SCM in this relationship. From the results, the factors, in the order of importance are:

- Cost benefits
- Simplify the construction process
- Simplify the tendering process
- Simplify the design stage
- Create standardization of processes

Similarly, question 14 was revealing the most important factors of SCM effecting the relationship with suppliers. According to their importance, the factors are:

- Better quality services
- Cost benefits
- Simplify the construction process
- Simplify the ordering process

Question 15 was aimed to indicate the major objectives of developing SCM in construction sector, according to responses of participants in this survey. The objectives are sorted according to their importance as:

- Benefits to client
- Improved customer services

- Reducing paperwork
- Enhanced profitability
- Cost reductions within organization
- Enhanced competitiveness
- Benefits to supplier
- Modified quality assurance
- Overall supply chain reduction

The effective important factors in relationships of construction supply chain were asked in question 16 that are listed from the highest importance to lowest, as:

- Trust
- Reliability of supply
- Top management supports
- Mutual interest
- Free flow of information
- Joint business planning
- Closer link between demand / supply
- Integrated information system
- Manpower development
- More frequent meetings

5.2.3 RM Relevance

Risk Management relevance was investigated in questions of 17 to 21. According to question 17, respondents were benefitting from efficient risk management program in their companies. Various tools and techniques are being employed to identify the risks threats and opportunities. These tools were investigated in question 18. Results are listed as below.

- Documentation reviews
- Checklist analysis
- Risk Breakdown Structure (RBS)
- SWOT/PESTLE Analysis

Among the methods, documentation reviews were employed more frequently than the other methods.

Question 19 revealed the methods that companies utilize to assess the risks. It is revealed that qualitative and quantitative methods, and sometimes both are employed in companies. However, qualitative methods are more popular than the quantitative ones.

To perform the qualitative and quantitative method assessments, various methods are being employed in the companies, which have been investigated through question 20. The answered methods are:

- Probability and impact matrix
- Decision making matrix
- Expected Monetary Value (EMV)
- Monte Carlo method

In question 21, participants were asked about risk responding methods and it was replied that most of them are benefitting from a framework to cope with the identified risks.

5.3 Discussion on the Checklist Results

In this section, qualitative analysis results obtained from checklists will be discussed comprehensively. According to the statistical analysis results explained in the previous chapter, for time, cost and quality, 13, 13 and 5 high risks were identified respectively along with 14 high risks affecting project objectives in overall case. As comparison was done among the objectives' risks and the overall ones, the whole identified risks of time, cost and quality were included in the overall case risks. Considering this mutuality, totally 14 cases were the high risks, which are originated from five major risk factors:

- Inadequate communication
- Late involvement of parts
- Inadequate IT system
- Weakness of concurrent design
- Inadequate selection of suppliers

In addition, according to the results of qualitative analysis, the negative risks affecting time had greater shares. In the successive stages, there are risks affecting cost and quality consecutively.

5.3.1 Framework for Risk Response Strategies

Based on the previous studies and the participant responses, a framework will be proposed to find an adequate and efficient risk response, to cope with identified high risk factors. This practical framework addresses the following analysis fields:

- **Risk Effects on the CSC (Construction Supply Chain) Project:** A set of categories, including macro-effects relevant to failures have been identified, to keep them within the estimations of cost and time and to attain the expected and required performance (PMI, 2001). There are two main aims associated with this classification: firstly, by means of grouping the risks effects, the critical managing aspects will be revealed to the managers and secondly, to direct the risk quantification phase, by the categorization, to determine the impact of risk factors properly (Aloini et al., 2012 a).

- **Responsibility of the Risk Factor:** From risk management viewpoint, it is fundamental to identify the participants or parties who are responsible in decision making process and required authority to determine, control and manage the risk factors. Major participants in CSC are stated to be the general contractors, designers, clients or owners and suppliers. Designation of each one's responsibility is as essential point to achieve a suitable distribution of profit margins. Thus, allocating the responsibilities clearly and providing the individuals with distinct awareness is vital to accomplish the project activities (Aloini et al., 2012 a).
- **Decisional Level:** This concept, been motivated by Guarino (1997), signifies differences between levels of strategy, planning and operating. The main reason of these differences lies in action range and time. Through this classification, it is meant differentiate between the levels at which the risk factors show up their effects, so it will be possible to know at which level the proper controlling evaluations must be implemented.
- **Limitation:** This principle aims to distinguish the subjective and objective limitations, and so, identify the nature of risks influences. Objective limitations are due to the issues environment, or properties of construction generally, but subjective limitations are due to lacks in perception. Obviously,

different limitations require different tactics to face with and handle the risks (Vrijhoef & Koskela, 2000).

- **Strategies for Negative Risks or Threats:** As it was also explained earlier, there are four typical methods to cope with threats of risks (the negative impacts), named as avoiding, mitigating, transferring and accepting. Each one must be chosen according to the risks impact on objectives and occurrence probability, and have different unique influences on risks situations. Among the named strategies, mitigation and avoiding are suitable methods, especially against the critical risks having high impacts, while the other two methods (accepting and transferring) are especially suitable against less critical, low impact threats (PMBOK, 2013).

5.3.2 Risk Response and Treatment

By means of framework proposed in previous section, and the survey participants' suggestions and experiences, in this section, explanations will be given for the suitable responses and strategies employed against the high ranked risk factors.

5.3.2.1 Inadequate Communication

In existence of inadequate communication risk factor, weaknesses in partnership performance, vendor managed inventory (VMI), integration of materials and information flows and communication, are counted as the basis in this research. As for the impacts, inadequate coordination, no sharing of knowledge and misusing technology can be notified. The risk factor is a subjective limitation and its decisional level is the operation stage, and all the involved parties in the project, including client or owner, contractor, designer and supplier, are responsible for it (Aloini et al., 2012 a).

To cope with this risk, mitigation is known to be the appropriate response. To mitigate the risk and the associated problems, especially in employment of SCM strategies, and provide effective communications throughout the chain, Information and Communication Technologies (ICT) are considered as the best possible tools. Information Technology can be employed to improve communication throughout the chain, between various sides, including suppliers, retailers, logistics etc. By means of IT, communication processes between the parties are accelerated, and by this acceleration, advancements such as enabling the company to satisfy various demands, improving the competitiveness, innovation and customer services, will be achieved.

5.3.2.2 Late Involvement of Parts

This risk factor can result in faults in development of relationships, strategic alliances, and lean thinking and concurrent engineering, which are sub-contexts of this risk factor. Supply chain, as explained in chapter 2, has been defined as the network of organizations connected through upstream and downstream relations, involved in various activities, producing products and services, delivering to the customers (Christopher, 1992). The reasons of late involvements can be attributed to various reasons. One of the critical ones is irregular (or weakness in regular) meeting, between the network's different parts. Unsuitable harmonization, lack of integration, extra costs and waste of time are among the results of this risk occurrence.

This risk is considered as an objective one, with the decisional level of planning stage. Contactors are responsible for this factor and the proper method of facing with it is avoiding by assigning or specifying a representative for each section of the network and hold regular meetings, to work more coordinately and actively (Aloini et al., 2012 a).

5.3.2.3 Inadequate IT System

The reason of this risk can be attributed to weaknesses in integration of materials and information flows, vendor managed inventory, and communication, which are counted as sub-contexts of this risk in this study. Because of the potentiality of high amount of suppliers in the market, to manage and record the necessary documents and information, every business employs certain software programs (i.e. MS Word, Adobe PDF format, etc.). The produced files in each program are having different formats. To keep sharing and exchanging the necessary information and documents, format conversion is indeed an important operation. Because of differences in markup methods, about the existing documents, it is difficult to employ them. Therefore, there is limitation about the employment of existing information in a document, in future as well.

Inadequate harmonization, missing information, misusing the technology, and lack of incorporation are results of this risk. Designers, suppliers, and contractors are the responsible parties of this issue. Operation stage is the decisional level, and it is known to be a subjective limitation (Aloini et al., 2012 a).

The appropriate strategy to cope with this risk factor is avoiding it, by means of employing international standardization. Businesses can benefit from combining their specific Enterprise Resource Planning’s (ERP), to reuse the information in Business Process Reengineering (BRP), to achieve more rational and efficient operating processes. The following points are information technology standards, for documents exchange and provision:

- Extensible Markup Language (XML)
- Standard Generalized Markup Language (SGML)
- Electronic Data Interchange (EDI)

5.3.2.4 Weakness of Concurrent Design (CD)

Adopting concurrent design in project might cause uncertainty and increase complexity of project, due to errors and changes that may result in iterative cycles. This risk factor can result in concurrent engineering (CE), which is the sub-context of this risk factor. The pointed errors and changes, if are not discovered and resolved instantly, unexpected results may happen, such as unsatisfied customer demands, wastes of time, poor project description, missing information, modifications in design and reworks.

Responsible parties in this risk are designers, contractors and client/owners. Planning stage is the decisional level of this risk factor, and is obviously a subjective limitation, due to deficiencies in CD (Aloini et al., 2012 b). To cope with the risks, mitigation is the appropriate strategy. Particularly in concurrent designs, mitigation methods can be listed as below:

- Reliability and stability buffering
- Dynamic Planning and control Methodology (DPM)

By means of these strategies, the sensitivity of plans to errors and changes will be reduced, so the performance and planned schedules will be protected.

5.3.2.5 Inadequate Selection of Suppliers

Selection of suppliers is undoubtedly one of the most important decisions in the process of purchasing. Inadequate selection of suppliers can be the reason of weaknesses in strategic sourcing.

In any company, many factors affect selection of suppliers, among which a significant one is uncertainty, affecting all functions (including this item). Based on the participants answers, employment of prefabricated members and components are very popular in Canada, and most of them are imported from overseas. Thus, selecting the adequate supplier is more difficult and complicated. From the effects of this risk factor, missing or incorrect information, imperfect supply, quality loss, loss absence and logistic technical abilities can be named.

Clients, owners and contractors are said to be responsible for this risk factor, the decisional level is in the strategic stage, and it is a subjective limitation (Aloini et al., 2012 b). The appropriate technique to face with this risk factor is mitigation, considering the following circumstances:

- ISO certification
- Visit suppliers' site
- Intensive verification of suppliers
- Close relationships with suppliers
- Considering more suppliers as backup
- Detailed financial analysis of suppliers
- Good references and recommendations

In the next chapter, some brief conclusions will be presented, along with recommendations for future research studies.

Chapter 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

In this chapter, a summary of obtained knowledge about SCM implementation in construction industry of Canada will be presented together with some recommendations proposed for future studies in this field.

6.2 General Summary and Conclusions

Construction industry is often well known for being a low productive, highly fragmented, and time and cost overruns and conflicted sector, in comparison with other industries. Moreover, because of the huge amount of investments in this industry, it is always categorized as a high risky one, especially considering the mentioned characteristics. To solve these problems, supply chain management is now considered as an innovative tool, providing new creative solutions.

From a supply chain viewpoint, the concept of risk has a negative meaning, and is defined as an uncertain thing which in the case of occurrence will lead to unexpected negative impacts on operations and objectives. To cope with these factors, supply chain risks management process is known to be a minimizing technique. It is defined as the procedure of identifying potential risks, analyzing them and deciding about how to respond them in an organization.

In this research, supply chain risk management in construction sector of Canada was investigated. Canadian construction industry was focused, because although the country is a developed one in which supply chain risk management is employed efficiently in many sectors including construction, the need to employ the method more efficiently in a more structured way is undoubtedly essential.

The first stage of risk identification was done consisting of reviewing and classification of related articles. Hierarchical categorization of identified risks was done in the following stage, according to risk breakdown structure (RBS) concept.

Having finalized the previous stage, a checklist was prepared including the identified risk factors, the types of risks and supply chain management sub-contexts. Simultaneously, questionnaire survey was also prepared in order to find out how much the respondents are familiar with the concept of construction supply chain risk management.

Furthermore, to evaluate the identified risks, qualitative analysis method was employed because of its comparative rapidness and cost effectiveness. To perform this analysis, probability and impact matrix was chosen as a popular qualitative tool to evaluate the risks and prioritize them. Lastly, the risks which were found to be high were conveyed to the response planning stage to take appropriate action.

According to the questionnaire survey, nearly all participants were employing different methods to identify and evaluate methods along with benefitting from specific frameworks, to decide which strategies should be taken as risks response.

In short, according to qualitative risk analysis results, total number of 13, 13, 5 and 14 top ranked risks were identified as high risks, affecting objectives in terms of cost, time, quality, and in the overall case of projects' risks, respectively. As these factors were compared, mutuality was found between them, and in fact, it was revealed that the 14 overall risk factors are also including the other categories' risks (i.e. time, cost and quality). Further investigations showed that these 14 high risks are actually rooted in five main risk factors, which are inadequate communication, late involvement of parts, inadequate IT system, weakness of concurrent design, and inadequate selection of suppliers.

As the five main risk factors were recognized, a framework was proposed to find the best possible strategy of facing with them. The framework has been provided according to the previous studies and the survey participants' responses.

6.3 Recommendations for Future Research and Works

The following points are some recommendations for future studies in this field:

- To increase the accuracy of risk assessment, factor of time can be added to the evaluations. In other words, the factors of time to cause (TTC) and time to impact (TTI), are two important factors which are determining the speed at which a scenario leads to the primary cause and the primary impact respectively. Considering the time factor as the risk velocity, along with impacts and probability, can develop risk management in a three-dimensional form and further improve its process.
- To improve the construction supply chains' efficiency and effectiveness, organizations which are dealing with procuring and delivering construction products can adopt BIM technology.

- Automated materials locating and tracking technologies (AMLTT) can be employed as an effective method in construction supply networks aiming to improve and simplify the process of conveying the information that are related to the products of construction materials and equipment's location and state.
- To have better and more general risk management, it is recommended to expand the range of risks and identify more risk factors and categories, which are influential on SCM implementation.

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APPENDICES

Appendix A: Sample of Questionnaire Survey

1. Contact info.

Name and Surname	
Company Name	
Work Experience (Years)	
Email Address	
Phone/Cell phone No.	

2. What is your position in your firm?

☐ Director/ CEO ☐ Project Manager

☐ Quality Manager ☐ Purchasing Manager

☐ Logistics Manager ☐ Others: ………………….

3. Approximately, number of annual projects?

☐ 1 to 4 Projects ☐ 5 to 8 Projects

☐ 9 to 12 Projects ☐ More than 12 Projects

4. Approximately, how many full-time employees work for your company?

☐ Less than 50 ☐ 50 to 100

☐ 101 to 200 ☐ 201 to 300

☐ More than 300

5. How long have you been involved in Canada construction industry?

☐ 1 to 5 Years ☐ 6 to 10 Years

☐ 11 to 15 Years ☐ More than 15 Years

6. Approximately, what is the annual turnover of your organization (US Dollar) if comfortable to share?

☐ Less than $10 million ☐ Between $10 million and $30 million

☐ Between $30 million and $50 million ☐ More than $50 million

7. Do you support that implementation of Supply chain management can help to save cost?

☐ Yes ☐ No

☐ Not sure

8. Do you think that with efficient implementation of SCM can raise quality of construction and save time?

☐ Yes ☐ No

☐ Not sure

9. Does your organization conduct team building sessions arrange meetings with the client and vendors during the project implementation phase?

☐ Weekly meetings ☐ Bi-weekly meetings

☐ Monthly meetings ☐ Once in Three months

☐ No meetings at all ☐ Don't know

10. Does your organization have any system in place for the selection of suppliers, if yes how does your company select a vendor or supplier based on?

☐ Recommendation ☐ Price

☐ Experience ☐ Geographic location

☐ Market reputation ☐ Others: ………………….

11. Is supply chain management related to your business and do you think that your organization has system in place to manage the project in an efficient way?

☐ Not relevant ☐ Somewhat relevant

☐ Most relevant

12. Which functions of internal organization of your company are most important to Supply chain management?

	Not sure	To a small extent	To a moderate extent	To a great extent	To a very great extent
Transport					
Inventory					
Production planning					
Storage					
Purchasing					
Others					

13. Which factors of SCM are important in relationship with your client?

	Not sure	To a small extent	To a moderate extent	To a great extent	To a very great extent
Cost benefits					
Creating standardisation of processes					
Simplifying the construction process					
Simplifying the design stage					
Simplifying the tendering process					
Others					

14. Which factors of SCM are important in relationship with your supplier?

	Not sure	To a small extent	To a moderate extent	To a great extent	To a very great extent
Simplify the ordering process					
Cost benefits					
Simplify the construction process					
Better quality service					
Others					

15. What are the principal objective(s) in developing CSCM in your organization?

	Not sure	To a small extent	To a moderate extent	To a great extent	To a very great extent
Improved customer service					
Benefits to client					
Benefits to supplier					
Enhanced profitability					
Enhanced competitiveness					
Reducing paperwork					
Cost reduction within organization					
Modified quality assurance					
Overall supply chain reduction					
Others					

16. What are key factors in effective CSC relationships?

	Not sure	To a small extent	To a moderate extent	To a great extent	To a very great extent
More frequent meetings					
Integrated information systems					
Top management support					
Free flow of information					
Joint business planning					
Trust					
Closer links between demand/ supply					
Manpower development					
Reliability of supply					
Mutual interest					
Others					

17. Are the efficient risk management program considered in your organization? (If yes follow next questions)

☐ Yes ☐ No

☐ Not sure

18. Which types of tools and technique does your organization use for risks and opportunity identification?

☐ Documentation Reviews ☐ Brainstorming

☐ Questionnaire Survey ☐ Scenario analysis

☐ Delphi Technique ☐ Risk Breakdown Structure (RBS)

☐ SWOT/PESTLE Analysis ☐ Checklist Analysis

☐ Failure mode and effect analysis (FMEA) ☐ Others

19. Which method do your organization use for risk assessment?

☐ Qualitative Method ☐ Quantitative Method

☐ Both Method ☐ Others

20. Which method do your organization use for qualitative and quantitative risk analysis?

☐ Probability and Impact matrix ☐ Decision Making Matrix

☐ Decision Tree Analysis ☐ Expected Monetary Value (EMV)

☐ Monte Carlo Method ☐ Others

21. Do your organization has any framework to response to the identified risks?

☐ Yes ☐ No

☐ Not sure

Appendix B: Sample of Checklist

Name and Surname:			Qualitative Analysis																
Company Name:		Position:	Probability level of the Risk occurrence (1) Very Low, (2) Low, (3) Moderate, (4) High, (5) Very High	Level of Impact on Time, Cost and Quality															
				Time					Cost					Quality					
Type of Risk	Risk factor	SCM* sub-context		Very Low	Low	Moderate	High	Very High	Very Low	Low	Moderate	High	Very High	Very Low	Low	Moderate	High	Very High	Response Strategy to the Risk
Strategic	Lack of awareness of SCM benefits	Strategic networks																	
		Relationships development																	
		Cost reduction																	
		Communication																	
	Old culture	Organisational culture																	
		Communication																	
		Capability development																	
		Strategic alliances																	
		Trust																	
	Inadequate change management	Change management																	
	Inadequate BPR**	Strategic alliances																	
		Strategic networks																	
Operation	Lack of concurrent design	Concurrent engineering																	
	Inadequate IT system	Integration of materials and information flows																	
		Communication																	
		VMI***																	
	Inadequate training and instruction	Organisational culture																	
		Knowledge transfer																	
		Capability development																	
	Myopic control	Contract management																	
		Trust																	
Supply	Inadequate communication	Communication																	
		Partnership performance																	
		VMI																	
		Knowledge transfer																	
		Integration of material and information flows																	
	Late involvement of parts	Relationship development																	
		Strategic alliances																	
		Concurrent engineering																	
		Lean thinking																	
	Inadequate selection of suppliers	Strategic Sourcing / Purchasing																	
	Absence of performance measurement system	Partnership performance																	
		Cost reduction																	
		Communication																	
		Contract management																	
	Absence of a conflict resolution procedure	Trust																	
		Relationships development																	
		Organisational culture																	

* SCM: Supply Chain Management
** BPR: Business Process Re-engineering
*** VMI: Vendor Managed Inventory

Appendix C: Companies and Respondents Profile

	Company Name	Name of respondents	Position of respondents	Work Experience
Respondent 1	Reid & DeLeye Contractors Ltd.	Ken Driedger	Project Manager	15
Respondent 2	Kenaidan Contracting Ltd.	Peter Sullivan	Logistics Manager	13
Respondent 3	Durwest Construction Management Ltd.	Carl Novak	Executive Engineer	9
Respondent 4	EBC Inc.	Martin Houle	Project Manager	17
Respondent 5	Clark Builders	Jeff Rootman	Logistics Manager	13
Respondent 6	ITC Construction Group	Rick McGill	Purchasing Manager	14
Respondent 7	Walsh Canada	Michael Whelan	Logistics Manager	10
Respondent 8	Yellowridge Construction Ltd.	Steve Hawboldt	Project Manager	15
Respondent 9	Tricar Developments Inc.	Chris Leigh	Project Manager	18
Respondent 10	Strabag Inc.	Alexander Boehnke	Purchasing Manager	14
Respondent 11	Amico Affiliates	Dino Fantin	Quality Manager	11
Respondent 12	Dexter Construction	Brian Slattery	Director	19
Respondent 13	MC Group	Tony Niro	Logistics Manager	12
Respondent 14	VCM Construction Ltd.	Stefanie Swan	Project Manager	16
Respondent 15	Preview Builders International Inc.	Gerold Grahn	Executive Engineer	8
Respondent 16	LCL Builds Corporation	Hugh Kidd	Purchasing Manager	13
				Average 13.6 Years

Appendix D: Responded Checklists

Type of Risk	Risk factor	SCM* sub-context	Respondent 1							Respondent 2						
			Probability	Impact			Risk Score			Probability	Impact			Risk Score		
				Time	Cost	Quality	Time	Cost	Quality		Time	Cost	Quality	Time	Cost	Quality
Strategic	Lack of awareness of SCM benefits	Strategic networks	2	3	3	2	6	6	4	2	3	3	3	6	6	6
		Relationships development	2	3	2	2	6	4	4	3	2	2	2	6	6	6
		Cost reduction	1	3	3	3	3	3	3	2	2	2	2	4	4	4
		Communication	2	2	2	2	4	4	4	2	2	2	2	4	4	4
	Old culture	Organisational culture	2	3	3	2	6	6	4	1	2	3	3	2	3	3
		Communication	2	2	2	2	4	4	4	1	2	3	3	2	3	3
		Capability development	2	2	2	2	4	4	4	1	2	3	3	2	3	3
		Strategic alliances	2	3	2	2	6	4	4	1	2	2	2	2	2	2
		Trust	1	2	2	2	2	2	2	1	2	2	2	2	2	2
	Inadequate change management	Change management	3	3	3	3	9	9	9	2	4	2	2	8	4	4
	Inadequate BPR**	Strategic alliances	2	2	4	2	4	8	4	2	3	4	2	6	8	4
		Strategic networks	2	3	4	2	6	8	4	2	3	4	2	6	8	4
Operation	Lack of concurrent design	Concurrent engineering	4	4	5	3	16	20	12	3	4	5	3	12	15	9
	Inadequate IT system	Integration of materials and information flows	3	4	4	3	12	12	9	4	5	4	3	20	16	12
		Communication	3	4	4	4	12	12	12	3	4	5	3	12	15	9
		VMI***	3	4	4	4	12	12	12	4	5	4	3	20	16	12
	Inadequate training and instruction	Organisational culture	2	4	3	3	8	6	6	1	4	4	3	4	4	3
		Knowledge transfer	2	3	3	3	6	6	6	1	4	4	3	4	4	3
		Capability development	2	3	3	3	6	6	6	1	4	4	3	4	4	3
	Myopic control	Contract management	2	3	4	4	6	8	8	2	3	3	4	6	6	8
		Trust	1	2	2	2	2	2	2	2	2	2	3	4	4	6
Supply	Inadequate communication	Communication	3	4	4	4	12	12	12	3	5	4	3	15	12	9
		Partnership performance	4	4	4	4	16	16	16	3	5	5	4	15	15	12
		VMI	4	5	5	4	20	20	16	3	5	5	4	15	15	12
		Knowledge transfer	3	4	4	5	12	12	15	3	3	4	3	9	12	9
		Integration of material and information flows	4	3	4	4	12	16	16	4	3	4	4	12	16	16
	Late involvement of parts	Relationship development	4	4	4	3	16	16	12	3	5	5	2	15	15	6
		Strategic alliances	3	4	4	3	12	12	9	3	4	4	2	12	12	6
		Concurrent engineering	4	4	4	3	16	16	12	3	4	4	2	12	12	6
		Lean thinking	3	4	4	3	12	12	9	3	4	4	2	12	12	6
	Inadequate selection of suppliers	Strategic Sourcing / Purchasing	4	3	3	5	12	12	20	3	2	4	4	6	12	12
	Absence of performance measurement system	Partnership performance	2	3	3	4	6	6	8	2	2	3	4	4	6	8
		Cost reduction	2	3	3	4	6	6	8	2	2	3	4	4	6	8
		Communication	2	3	3	4	6	6	8	1	2	3	4	2	3	4
		Contract management	2	3	3	4	6	6	8	1	2	3	4	2	3	4
	Absence of a conflict resolution procedure	Trust	2	4	3	2	8	6	4	2	4	2	1	8	4	2
		Relationships development	2	5	3	2	10	6	4	3	4	3	1	12	9	3
		Organisational culture	2	4	3	2	8	6	4	2	4	2	1	8	4	2

Type of Risk	Risk factor	SCM* sub-context	Respondent 3							Respondent 4						
			Probability	Impact			Risk Score			Probability	Impact			Risk Score		
				Time	Cost	Quality	Time	Cost	Quality		Time	Cost	Quality	Time	Cost	Quality
Strategic	Lack of awareness of SCM benefits	Strategic networks	3	3	2	2	9	6	6	1	3	3	1	3	3	1
		Relationships development	3	3	2	2	9	6	6	1	3	3	1	3	3	1
		Cost reduction	2	3	2	2	6	4	4	1	3	3	1	3	3	1
		Communication	2	3	2	2	6	4	4	1	3	3	1	3	3	1
	Old culture	Organisational culture	2	3	2	2	6	4	4	1	3	3	2	3	3	2
		Communication	2	2	3	2	4	6	4	1	3	3	2	3	3	2
		Capability development	2	2	3	2	4	6	4	1	3	3	2	3	3	2
		Strategic alliances	1	3	2	2	3	2	2	1	3	3	2	3	3	2
		Trust	2	2	1	1	4	2	2	1	3	3	2	3	3	2
	Inadequate change management	Change management	3	4	3	3	12	9	9	3	3	2	2	9	6	6
	Inadequate BPR**	Strategic alliances	2	3	4	3	6	8	6	3	2	3	2	6	9	6
		Strategic networks	3	3	4	3	9	12	9	3	2	3	2	6	9	6
Operation	Lack of concurrent design	Concurrent engineering	3	4	4	2	12	12	6	4	4	4	3	16	16	12
	Inadequate IT system	Integration of materials and information flows	4	4	3	3	16	12	12	3	5	4	4	15	12	12
		Communication	4	4	3	4	16	12	16	4	4	3	4	16	12	16
		VMI***	4	3	3	3	12	12	12	4	3	3	2	12	12	8
	Inadequate training and instruction	Organisational culture	2	3	4	3	6	8	6	2	4	3	2	8	6	4
		Knowledge transfer	2	3	4	3	6	8	6	1	4	3	2	4	3	2
		Capability development	2	3	4	3	6	8	6	2	4	3	2	8	6	4
	Myopic control	Contract management	2	3	4	4	6	8	8	2	2	3	4	4	6	8
		Trust	2	2	2	2	4	4	4	2	3	3	3	6	6	6
Supply	Inadequate communication	Communication	4	4	3	4	16	12	16	4	4	4	3	16	16	12
		Partnership performance	3	4	3	4	12	9	12	4	5	4	4	20	16	16
		VMI	4	5	4	4	20	16	16	4	5	4	4	20	16	16
		Knowledge transfer	4	5	4	4	20	16	16	4	5	4	4	20	16	16
		Integration of material and information flows	5	3	3	5	15	15	25	4	4	4	5	16	16	20
	Late involvement of parts	Relationship development	4	4	4	2	16	16	8	4	5	4	3	20	16	12
		Strategic alliances	4	4	4	2	16	16	8	4	5	4	3	20	16	12
		Concurrent engineering	4	4	4	2	16	16	8	4	5	4	3	20	16	12
		Lean thinking	3	4	4	2	12	12	6	4	5	4	3	20	16	12
	Inadequate selection of suppliers	Strategic Sourcing / Purchasing	3	2	4	5	6	12	15	4	3	3	4	12	12	16
	Absence of performance measurement system	Partnership performance	2	3	3	5	6	6	10	1	3	3	4	3	3	4
		Cost reduction	2	3	3	5	6	6	10	1	3	3	4	3	3	4
		Communication	2	3	3	5	6	6	10	1	2	2	4	2	2	4
		Contract management	2	3	3	5	6	6	10	1	2	2	4	2	2	4
	Absence of a conflict resolution procedure	Trust	3	5	3	2	15	9	6	2	4	4	3	8	8	6
		Relationships development	3	5	3	2	15	9	6	2	5	4	3	10	8	6
		Organisational culture	3	5	3	2	15	9	6	2	5	4	3	10	8	6

Type of Risk	Risk factor	SCM* sub-context	Respondent 5							Respondent 6						
			Probability	Impact			Risk Score			Probability	Impact			Risk Score		
				Time	Cost	Quality	Time	Cost	Quality		Time	Cost	Quality	Time	Cost	Quality
Strategic	Lack of awareness of SCM benefits	Strategic networks	1	3	2	2	3	2	2	2	3	3	3	6	6	6
		Relationships development	1	3	2	2	3	2	2	2	3	3	3	6	6	6
		Cost reduction	2	3	2	2	6	4	4	2	3	3	3	6	6	6
		Communication	1	3	2	2	3	2	2	2	3	3	3	6	6	6
	Old culture	Organisational culture	2	4	3	3	8	6	6	2	3	3	3	6	6	6
		Communication	1	4	3	3	4	3	3	2	3	3	3	6	6	6
		Capability development	1	4	3	3	4	3	3	2	3	3	3	6	6	6
		Strategic alliances	2	3	3	3	6	6	6	2	2	2	2	4	4	4
		Trust	1	3	3	3	3	3	3	2	2	2	2	4	4	4
	Inadequate change management	Change management	3	4	3	3	12	9	9	3	3	2	1	9	6	3
	Inadequate BPR**	Strategic alliances	2	3	4	2	6	8	4	2	2	4	2	4	8	4
		Strategic networks	2	3	4	2	6	8	4	2	2	4	2	4	8	4
Operation	Lack of concurrent design	Concurrent engineering	4	5	4	4	20	16	16	3	4	4	3	12	12	9
	Inadequate IT system	Integration of materials and information flows	4	5	5	4	20	20	16	3	4	4	3	12	12	9
		Communication	4	3	4	4	12	16	16	3	3	4	4	9	12	12
		VMI***	3	4	4	4	12	12	12	4	3	4	3	12	16	12
	Inadequate training and instruction	Organisational culture	2	5	4	2	10	8	4	2	4	3	3	8	6	6
		Knowledge transfer	2	5	4	2	10	8	4	2	4	3	3	8	6	6
		Capability development	1	5	4	2	5	4	2	2	4	3	3	8	6	6
	Myopic control	Contract management	1	2	3	3	2	3	3	2	2	3	3	4	6	6
		Trust	1	3	2	2	3	2	2	2	2	2	2	4	4	4
Supply	Inadequate communication	Communication	3	5	4	3	15	12	9	3	4	4	3	12	12	9
		Partnership performance	3	5	4	3	15	12	9	4	5	4	3	20	16	12
		VMI	3	5	4	4	15	12	12	3	4	4	3	12	12	9
		Knowledge transfer	3	5	4	4	15	12	12	3	4	4	3	12	12	9
		Integration of material and information flows	4	3	5	4	12	20	16	4	4	5	4	16	20	16
	Late involvement of parts	Relationship development	3	4	3	2	12	9	6	5	5	4	3	25	20	15
		Strategic alliances	3	4	3	2	12	9	6	5	5	4	3	25	20	15
		Concurrent engineering	3	4	2	2	12	6	6	4	5	4	3	20	16	12
		Lean thinking	3	4	3	2	12	9	6	3	4	4	4	12	12	12
	Inadequate selection of suppliers	Strategic Sourcing / Purchasing	5	3	3	5	15	15	25	5	2	3	5	10	15	25
	Absence of performance measurement system	Partnership performance	2	2	2	3	4	4	6	2	3	3	4	6	6	8
		Cost reduction	2	2	2	3	4	4	6	2	3	3	4	6	6	8
		Communication	1	2	2	3	2	2	3	1	3	3	3	3	3	3
		Contract management	1	2	2	3	2	2	3	2	3	3	4	6	6	8
	Absence of a conflict resolution procedure	Trust	1	4	4	2	4	4	2	2	5	3	1	10	6	2
		Relationships development	1	4	4	2	4	4	2	2	5	3	1	10	6	2
		Organisational culture	1	4	4	2	4	4	2	1	4	3	1	4	3	1

Type of Risk	Risk factor	SCM* sub-context	Respondent 7							Respondent 8						
			Probability	Impact			Risk Score			Probability	Impact			Risk Score		
				Time	Cost	Quality	Time	Cost	Quality		Time	Cost	Quality	Time	Cost	Quality
Strategic	Lack of awareness of SCM benefits	Strategic networks	1	3	2	2	3	2	2	1	3	3	3	3	3	3
		Relationships development	2	3	2	2	6	4	4	1	3	3	3	3	3	3
		Cost reduction	2	3	2	2	6	4	4	1	3	3	3	3	3	3
		Communication	1	3	2	1	3	2	1	1	2	2	2	2	2	2
	Old culture	Organisational culture	2	3	3	4	6	6	8	1	3	3	3	3	3	3
		Communication	2	3	3	4	6	6	8	1	3	3	3	3	3	3
		Capability development	1	3	3	4	3	3	4	1	3	3	3	3	3	3
		Strategic alliances	2	3	3	4	6	6	8	1	3	3	3	3	3	3
		Trust	1	3	3	4	3	3	4	1	3	3	3	3	3	3
	Inadequate change management	Change management	2	4	2	2	8	4	4	3	3	3	2	9	9	6
	Inadequate BPR**	Strategic alliances	3	2	3	1	6	9	3	2	3	5	3	6	10	6
		Strategic networks	3	2	3	1	6	9	3	2	3	5	3	6	10	6
Operation	Lack of concurrent design	Concurrent engineering	5	4	4	2	20	20	10	4	5	4	4	20	16	16
	Inadequate IT system	Integration of materials and information flows	4	3	4	3	12	16	12	4	3	3	3	12	12	12
		Communication	4	5	3	4	20	12	16	3	3	4	3	9	12	9
		VMI***	4	5	4	4	20	16	16	4	3	4	3	12	16	12
	Inadequate training and instruction	Organisational culture	2	5	4	3	10	8	6	2	5	4	2	10	8	4
		Knowledge transfer	1	4	3	3	4	3	3	2	5	4	2	10	8	4
		Capability development	1	4	3	3	4	3	3	2	5	3	2	10	6	4
	Myopic control	Contract management	1	3	4	4	3	4	4	1	3	4	3	3	4	3
		Trust	1	3	2	2	3	2	2	1	2	2	2	2	2	2
Supply	Inadequate communication	Communication	3	3	3	4	9	9	12	3	4	4	3	12	12	9
		Partnership performance	3	4	4	4	12	12	12	4	5	5	4	20	20	16
		VMI	3	4	4	4	12	12	12	4	4	4	3	16	16	12
		Knowledge transfer	3	4	4	4	12	12	12	4	5	5	4	20	20	16
		Integration of material and information flows	3	4	4	4	12	12	12	5	4	5	5	20	25	25
	Late involvement of parts	Relationship development	3	4	4	2	12	12	6	4	5	4	3	20	16	12
		Strategic alliances	3	4	4	2	12	12	6	4	5	4	3	20	16	12
		Concurrent engineering	3	4	4	2	12	12	6	3	5	4	3	15	12	9
		Lean thinking	3	4	4	2	12	12	6	3	5	4	3	15	12	9
	Inadequate selection of suppliers	Strategic Sourcing / Purchasing	4	2	2	4	8	8	16	3	1	3	4	3	9	12
	Absence of performance measurement system	Partnership performance	3	3	3	4	9	9	12	2	2	2	4	4	4	8
		Cost reduction	3	3	3	4	9	9	12	1	2	2	4	2	2	4
		Communication	3	3	3	4	9	9	12	1	2	2	4	2	2	4
		Contract management	3	3	3	4	9	9	12	2	2	2	4	4	4	8
	Absence of a conflict resolution procedure	Trust	3	3	2	2	9	6	6	2	4	2	2	8	4	4
		Relationships development	2	3	2	2	6	4	4	2	4	2	2	8	4	4
		Organisational culture	2	3	2	2	6	4	4	2	3	2	2	6	4	4

Type of Risk	Risk factor	SCM* sub-context	Respondent 9							Respondent 10						
			Probability	Impact			Risk Score			Probability	Impact			Risk Score		
				Time	Cost	Quality	Time	Cost	Quality		Time	Cost	Quality	Time	Cost	Quality
Strategic	Lack of awareness of SCM benefits	Strategic networks	1	3	3	2	3	3	2	1	4	4	3	4	4	3
		Relationships development	1	3	3	2	3	3	2	1	4	4	3	4	4	3
		Cost reduction	1	3	3	2	3	3	2	1	4	4	3	4	4	3
		Communication	1	3	3	2	3	3	2	1	3	3	2	3	3	2
	Old culture	Organisational culture	1	4	4	3	4	4	3	2	3	3	3	6	6	6
		Communication	1	4	4	3	4	4	3	2	2	2	2	4	4	4
		Capability development	1	4	4	3	4	4	3	2	3	3	3	6	6	6
		Strategic alliances	1	4	4	3	4	4	3	2	2	2	2	4	4	4
		Trust	1	4	4	3	4	4	3	2	2	2	2	4	4	4
	Inadequate change management	Change management	2	3	2	2	6	4	4	3	3	2	1	9	6	3
	Inadequate BPR**	Strategic alliances	3	2	4	3	6	12	9	2	2	4	2	4	8	4
		Strategic networks	3	2	4	3	6	12	9	2	2	4	2	4	8	4
Operation	Lack of concurrent design	Concurrent engineering	4	4	3	3	16	12	12	5	4	4	3	20	20	15
	Inadequate IT system	Integration of materials and information flows	3	3	3	3	9	9	9	4	3	4	3	12	16	12
		Communication	4	4	3	3	16	12	12	3	4	3	3	12	9	9
		VMI***	4	4	3	3	16	12	12	4	4	3	3	16	12	12
	Inadequate training and instruction	Organisational culture	2	5	5	3	10	10	6	2	4	4	2	8	8	4
		Knowledge transfer	1	5	5	3	5	5	3	2	4	4	2	8	8	4
		Capability development	2	5	5	3	10	10	6	2	4	4	2	8	8	4
	Myopic control	Contract management	1	3	4	4	3	4	4	2	2	4	3	4	8	6
		Trust	1	2	2	3	2	2	3	2	2	2	2	4	4	4
Supply	Inadequate communication	Communication	4	4	4	3	16	16	12	3	4	4	4	12	12	12
		Partnership performance	4	4	4	3	16	16	12	3	4	4	4	12	12	12
		VMI	4	4	4	3	16	16	12	3	4	3	4	12	9	12
		Knowledge transfer	4	4	4	3	16	16	12	3	4	3	4	12	9	12
		Integration of material and information flows	5	4	4	5	20	20	25	4	4	5	4	16	20	16
	Late involvement of parts	Relationship development	5	4	5	4	20	25	20	3	4	3	2	12	9	6
		Strategic alliances	4	4	5	4	16	20	16	3	4	3	2	12	9	6
		Concurrent engineering	4	4	5	4	16	20	16	3	4	3	2	12	9	6
		Lean thinking	4	4	5	4	16	20	16	3	4	3	2	12	9	6
	Inadequate selection of suppliers	Strategic Sourcing / Purchasing	3	1	2	5	3	6	15	4	2	2	4	8	8	16
	Absence of performance measurement system	Partnership performance	1	2	3	3	2	3	3	2	2	2	5	4	4	10
		Cost reduction	1	2	3	3	2	3	3	2	2	2	5	4	4	10
		Communication	1	2	3	3	2	3	3	1	1	2	4	1	2	4
		Contract management	1	2	3	3	2	3	3	2	2	2	5	4	4	10
	Absence of a conflict resolution procedure	Trust	1	4	3	3	4	3	3	2	5	2	2	10	4	4
		Relationships development	1	4	3	3	4	3	3	1	4	2	1	4	2	1
		Organisational culture	1	4	3	3	4	3	3	1	4	2	1	4	2	1

Type of Risk	Risk factor	SCM* sub-context	Respondent 11							Respondent 12						
			Probability	Impact			Risk Score			Probability	Impact			Risk Score		
				Time	Cost	Quality	Time	Cost	Quality		Time	Cost	Quality	Time	Cost	Quality
Strategic	Lack of awareness of SCM benefits	Strategic networks	2	4	4	3	8	8	6	1	3	3	2	3	3	2
		Relationships development	2	4	4	3	8	8	6	1	3	3	2	3	3	2
		Cost reduction	1	4	4	3	4	4	3	1	2	2	2	2	2	2
		Communication	1	4	4	3	4	4	3	1	2	2	2	2	2	2
	Old culture	Organisational culture	1	3	2	3	3	2	3	2	4	4	4	8	8	8
		Communication	1	3	2	3	3	2	3	2	4	4	4	8	8	8
		Capability development	2	3	2	3	6	4	6	2	4	4	4	8	8	8
		Strategic alliances	1	3	2	3	3	2	3	2	4	4	4	8	8	8
		Trust	1	2	3	3	2	3	3	2	4	4	4	8	8	8
	Inadequate change management	Change management	3	4	2	2	12	6	6	3	3	1	1	9	3	3
	Inadequate BPR**	Strategic alliances	2	2	3	2	4	6	4	1	2	3	2	2	3	2
		Strategic networks	2	2	3	2	4	6	4	1	2	3	2	2	3	2
Operation	Lack of concurrent design	Concurrent engineering	3	4	4	3	12	12	9	4	4	4	3	16	16	12
	Inadequate IT system	Integration of materials and information flows	4	4	4	3	16	16	12	3	3	3	3	9	9	9
		Communication	4	5	4	3	20	16	12	3	3	3	3	9	9	9
		VMI***	4	5	4	3	20	16	12	4	3	4	3	12	16	12
	Inadequate training and instruction	Organisational culture	1	5	3	3	5	3	3	2	5	4	2	10	8	4
		Knowledge transfer	1	4	3	3	4	3	3	2	4	4	3	8	8	6
		Capability development	2	5	3	3	10	6	6	2	5	4	3	10	8	6
	Myopic control	Contract management	2	2	3	4	4	6	8	2	3	4	4	6	8	8
		Trust	2	3	3	2	6	6	4	2	2	2	2	4	4	4
Supply	Inadequate communication	Communication	4	4	4	4	16	16	16	3	4	3	3	12	9	9
		Partnership performance	4	4	4	4	16	16	16	3	4	3	3	12	9	9
		VMI	4	3	3	3	12	12	12	3	4	3	4	12	9	12
		Knowledge transfer	4	4	4	4	16	16	16	3	4	3	4	12	9	12
		Integration of material and information flows	4	3	4	5	12	16	20	5	4	4	4	20	20	20
	Late involvement of parts	Relationship development	5	5	5	4	25	25	20	4	4	5	2	16	20	8
		Strategic alliances	5	4	5	4	20	25	20	4	4	5	2	16	20	8
		Concurrent engineering	5	4	5	4	20	25	20	3	4	4	2	12	12	6
		Lean thinking	4	5	5	4	20	20	16	2	4	5	3	8	10	6
	Inadequate selection of suppliers	Strategic Sourcing / Purchasing	4	3	3	5	12	12	20	5	2	3	5	10	15	25
	Absence of performance measurement system	Partnership performance	3	3	3	4	9	9	12	2	2	2	4	4	4	8
		Cost reduction	3	3	3	4	9	9	12	1	2	2	4	2	2	4
		Communication	3	3	3	3	9	9	9	1	2	2	4	2	2	4
		Contract management	3	3	3	4	9	9	12	1	2	2	4	2	2	4
	Absence of a conflict resolution procedure	Trust	2	4	2	2	8	4	4	3	4	3	2	12	9	6
		Relationships development	2	4	2	2	8	4	4	3	4	3	2	12	9	6
		Organisational culture	1	4	1	2	4	1	2	3	4	3	2	12	9	6

Type of Risk	Risk factor	SCM* sub-context	Respondent 13							Respondent 14						
			Probability	Impact			Risk Score			Probability	Impact			Risk Score		
				Time	Cost	Quality	Time	Cost	Quality		Time	Cost	Quality	Time	Cost	Quality
Strategic	Lack of awareness of SCM benefits	Strategic networks	1	3	3	3	3	3	3	2	4	4	3	8	8	6
		Relationships development	1	3	3	3	3	3	3	2	4	4	3	8	8	6
		Cost reduction	1	3	3	3	3	3	3	2	4	4	3	8	8	6
		Communication	1	2	2	3	2	2	3	2	4	4	3	8	8	6
	Old culture	Organisational culture	1	3	3	3	3	3	3	2	4	4	3	8	8	6
		Communication	1	3	3	3	3	3	3	2	4	4	3	8	8	6
		Capability development	1	3	3	3	3	3	3	2	4	4	3	8	8	6
		Strategic alliances	2	3	3	3	6	6	6	2	3	3	3	6	6	6
		Trust	2	3	3	3	6	6	6	2	3	3	3	6	6	6
	Inadequate change management	Change management	2	4	2	2	8	4	4	3	3	3	2	9	9	6
	Inadequate BPR**	Strategic alliances	2	3	4	3	6	8	6	1	2	5	3	2	5	3
		Strategic networks	2	3	4	3	6	8	6	1	2	5	3	2	5	3
Operation	Lack of concurrent design	Concurrent engineering	3	4	5	2	12	15	6	5	4	4	3	20	20	15
	Inadequate IT system	Integration of materials and information flows	4	4	3	3	16	12	12	4	4	4	3	16	16	12
		Communication	3	4	3	3	12	9	9	4	4	4	3	16	16	12
		VMI***	3	4	3	3	12	9	9	4	4	4	3	16	16	12
	Inadequate training and instruction	Organisational culture	2	4	3	2	8	6	4	2	5	3	2	10	6	4
		Knowledge transfer	2	4	3	2	8	6	4	2	5	4	1	10	8	2
		Capability development	2	4	3	2	8	6	4	2	4	3	1	8	6	2
	Myopic control	Contract management	2	2	3	3	4	6	6	2	3	3	4	6	6	8
		Trust	2	2	3	3	4	6	6	2	3	2	3	6	4	6
Supply	Inadequate communication	Communication	3	4	4	4	12	12	12	3	4	5	4	12	15	12
		Partnership performance	3	4	4	4	12	12	12	3	3	5	4	9	15	12
		VMI	3	4	4	5	12	12	15	4	4	4	4	16	16	16
		Knowledge transfer	3	4	4	5	12	12	15	4	3	4	4	12	16	16
		Integration of material and information flows	5	4	5	5	20	25	25	4	4	4	4	16	16	16
	Late involvement of parts	Relationship development	5	4	5	3	20	25	15	5	5	5	2	25	25	10
		Strategic alliances	3	4	5	3	12	15	9	4	5	5	2	20	20	8
		Concurrent engineering	4	4	5	3	16	20	12	4	5	5	2	20	20	8
		Lean thinking	4	4	5	3	16	20	12	4	5	5	2	20	20	8
	Inadequate selection of suppliers	Strategic Sourcing / Purchasing	5	4	4	5	20	20	25	4	3	5	5	12	20	20
	Absence of performance measurement system	Partnership performance	2	2	2	5	4	4	10	1	2	1	3	2	1	3
		Cost reduction	2	2	2	5	4	4	10	1	2	1	3	2	1	3
		Communication	2	2	2	5	4	4	10	1	2	1	3	2	1	3
		Contract management	2	2	2	5	4	4	10	1	2	1	3	2	1	3
	Absence of a conflict resolution procedure	Trust	2	5	2	2	10	4	4	1	4	3	2	4	3	2
		Relationships development	2	5	2	2	10	4	4	1	4	3	2	4	3	2
		Organisational culture	2	5	2	2	10	4	4	1	4	3	2	4	3	2

Type of Risk	Risk factor	SCM* sub-context	Respondent 15							Respondent 16						
			Probability	Impact			Risk Score			Probability	Impact			Risk Score		
				Time	Cost	Quality	Time	Cost	Quality		Time	Cost	Quality	Time	Cost	Quality
Strategic	Lack of awareness of SCM benefits	Strategic networks	1	3	3	3	3	3	3	2	4	4	3	8	8	6
		Relationships development	1	3	3	3	3	3	3	2	4	4	3	8	8	6
		Cost reduction	1	3	3	3	3	3	3	2	4	4	3	8	8	6
		Communication	1	3	3	3	3	3	3	2	3	3	2	6	6	4
	Old culture	Organisational culture	1	4	3	3	4	3	3	2	4	3	4	8	6	8
		Communication	2	4	3	3	8	6	6	2	4	3	4	8	6	8
		Capability development	2	4	3	3	8	6	6	2	4	3	4	8	6	8
		Strategic alliances	1	4	3	3	4	3	3	2	4	3	3	8	6	6
		Trust	2	3	3	3	6	6	6	2	4	3	3	8	6	6
	Inadequate change management	Change management	2	3	2	2	6	4	4	2	4	2	3	8	4	6
	Inadequate BPR**	Strategic alliances	2	2	3	2	4	6	4	2	3	4	3	6	8	6
		Strategic networks	2	2	3	2	4	6	4	2	3	4	3	6	8	6
Operation	Lack of concurrent design	Concurrent engineering	4	4	5	3	16	20	12	4	5	5	3	20	20	12
	Inadequate IT system	Integration of materials and information flows	3	4	4	4	12	12	12	4	3	4	3	12	16	12
		Communication	3	4	4	4	12	12	12	4	4	4	3	16	16	12
		VMI***	4	4	4	4	16	16	16	3	4	4	3	12	12	9
	Inadequate training and instruction	Organisational culture	1	4	4	2	4	4	2	1	4	4	3	4	4	3
		Knowledge transfer	1	4	4	2	4	4	2	2	4	4	3	8	8	6
		Capability development	1	4	4	2	4	4	2	2	4	4	3	8	8	6
	Myopic control	Contract management	1	2	3	4	2	3	4	2	3	4	4	6	8	8
		Trust	1	2	2	3	2	2	3	2	2	2	3	4	4	6
Supply	Inadequate communication	Communication	4	5	4	3	20	16	12	3	4	4	4	12	12	12
		Partnership performance	4	5	4	3	20	16	12	4	3	3	3	12	12	12
		VMI	4	5	4	3	20	16	12	4	4	4	4	16	16	16
		Knowledge transfer	4	5	4	4	20	16	16	3	4	4	4	12	12	12
		Integration of material and information flows	4	4	5	5	16	20	20	4	4	4	5	16	16	20
	Late involvement of parts	Relationship development	3	4	5	3	12	15	9	4	5	4	2	20	16	8
		Strategic alliances	3	4	5	3	12	15	9	4	5	4	3	20	16	12
		Concurrent engineering	3	4	5	3	12	15	9	4	4	4	3	16	16	12
		Lean thinking	2	4	5	3	8	10	6	4	5	5	4	20	20	16
	Inadequate selection of suppliers	Strategic Sourcing / Purchasing	4	2	2	4	8	8	16	4	3	3	5	12	12	20
	Absence of performance measurement system	Partnership performance	2	3	3	4	6	6	8	2	2	3	4	4	6	8
		Cost reduction	2	3	3	4	6	6	8	2	2	3	4	4	6	8
		Communication	2	3	3	4	6	6	8	1	2	3	4	2	3	4
		Contract management	2	3	3	4	6	6	8	2	2	3	4	4	6	8
	Absence of a conflict resolution procedure	Trust	2	3	1	1	6	2	2	2	4	3	2	8	6	4
		Relationships development	2	3	1	1	6	2	2	2	4	3	2	8	6	4
		Organisational culture	2	3	1	1	6	2	2	2	4	3	2	8	6	4

Appendix E: Risk Significant Index Formulas

The risk significant index developed by Shen et al. (2001) was used in this research. With respect to the impact on a particular project objective, the significance score for each risk assessed by each respondent can be calculated through Equation (1).

$$r_{ij}^{k} = \alpha_{ij}\beta_{ij}^{k} \qquad \text{Eq (1)}$$

Where:

r_{ij}^{k} = significance score assessed by respondent j for the impact of risk i on project objective k; i = ordinal number of risk, $i \in (1, 38)$; k = ordinal number of project objective, $k \in (1, 3)$; j = ordinal number of valid feedback to risk i , $j \in (1, n)$; n = total number of valid checklist (n = 16), α = likelihood occurrence of risk *i*, assessed by respondent *j;* β = level of impact of risk i on project objective k, assessed by respondent *j*.

The average score for each risk considering its significance on a project objective can be calculated through Equation (2). This average score is called the risk significance index score and will be used to rank among all risks on a particular project objective.

$$R_{i}^{k} = \frac{\sum_{j=1}^{n} r_{ij}^{k}}{n} = \frac{1}{n}\sum_{j=1}^{n} \alpha_{ij}\,\beta_{ij}^{k} \qquad \text{Eq (2)}$$

Where:

R_i^k = significance index score for risk i on project objective k. (Average risk score for risk i on project objective k)

On the other hand, Equation (3) is formulated in order to find percentages of each risks than other ones which is observable below:

$$R_{pi} = \frac{R_i}{\sum R_{tk}} \times 100 \qquad \text{Eq (3)}$$

Where:

R_{pi}= Percentage for risk i on project objective k

$\sum R_{tk}$ = Total significance index score on project objective k (Total Average risk score on project objective k).

With respect to the impact on a particular project objective, the total percentage of risks can be calculated through Equation (4).

$$T_{pr} = \frac{\sum R_{tk}}{\sum(\sum R_{tk})} \times 100 \qquad \text{Eq (4)}$$

Where T_{pr}= Total Percentage of risks; $\sum R_{tk}$ =Total significance index score on project objective k (Total Average risk score on project objective k).

Appendix F: Checklist Reliability by SPSS

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Reliability

Notes

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Case Processing Summary

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	Excluded[a]	0	.0
	Total	16	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
.808	.811	12

Item Statistics

	Mean	Std. Deviation	N
ST1	1.5000	.63246	16
ST2	1.6250	.71880	16
ST3	1.4375	.51235	16
ST4	1.3750	.50000	16
ST5	1.5625	.51235	16
ST6	1.5625	.51235	16
ST7	1.5625	.51235	16
ST8	1.5625	.51235	16
ST9	1.5000	.51640	16
ST10	2.6250	.50000	16
ST11	2.0625	.57373	16
ST12	2.1250	.61914	16

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	1.708	1.375	2.625	1.250	1.909	.137	12

```
RELIABILITY
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  /SUMMARY=MEANS.
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Reliability

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	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=RE13 RE14 RE15 RE16 RE17 RE18 RE19 RE20 RE21 /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /STATISTICS=DESCRIPTIVE /SUMMARY=MEANS.
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Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	16	100.0
	Excluded[a]	0	.0
	Total	16	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
.833	.829	9

Item Statistics

	Mean	Std. Deviation	N
OP1	3.8750	.71880	16
OP2	3.6250	.50000	16
OP3	3.5000	.51640	16
OP4	3.7500	.44721	16
OP5	1.7500	.44721	16
OP6	1.6250	.50000	16
OP7	1.7500	.44721	16
OP8	1.6875	.47871	16
OP9	1.6250	.50000	16

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.576	1.625	3.875	2.250	2.385	1.123	9

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RELIABILITY
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/SUMMARY=MEANS.
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Reliability

Notes

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	Cases Used	Statistics are based on all cases with valid data for all variables in the procedure.
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Scale: ALL VARIABLES

Case Processing Summary

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Cases	Valid	16	100.0
	Excluded[a]	0	.0
	Total	16	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
.820	.817	17

Item Statistics

	Mean	Std. Deviation	N
SU1	3.3125	.47871	16
SU2	3.5000	.51640	16
SU3	3.5625	.51235	16
SU4	3.4375	.51235	16
SU5	4.2500	.57735	16
SU6	4.0000	.81650	16
SU7	3.6875	.70415	16
SU8	3.6250	.61914	16
SU9	3.2500	.68313	16
SU10	4.0000	.73030	16
SU11	1.9375	.57373	16
SU12	1.8125	.65511	16
SU13	1.5000	.73030	16
SU14	1.7500	.68313	16
SU15	2.0000	.63246	16
SU16	1.9375	.68007	16
SU17	1.7500	.68313	16

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.901	1.500	4.250	2.750	2.833	.951	17

```
RELIABILITY
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  /SUMMARY=MEANS.
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Reliability

Notes

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	Matrix Input	C:\Users\Sony\Desktop ima SPSS\Nima Tazehzadeh-Time.sav
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=RE1 RE2 RE3 RE4 RE5 RE6 RE7 RE8 RE9 RE10 RE11 RE12 /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /STATISTICS=DESCRIPTIVE /SUMMARY=MEANS.
Resources	Processor Time	00 00:00:00.016
	Elapsed Time	00 00:00:00.016

```
[DataSet1] C:\Users\Sony\Desktop\nima SPSS\Nima Tazehzadeh-Time.sav
```

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	16	100.0
	Excluded[a]	0	.0
	Total	16	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
.777	.783	12

Item Statistics

	Mean	Std. Deviation	N
ST1	3.2500	.44721	16
ST2	3.1875	.54391	16
ST3	3.1250	.61914	16
ST4	2.8125	.65511	16
ST5	3.3125	.60208	16
ST6	3.1250	.80623	16
ST7	3.1875	.75000	16
ST8	3.0625	.68007	16
ST9	2.8125	.75000	16
ST10	3.4375	.51235	16
ST11	2.3750	.50000	16
ST12	2.4375	.51235	16

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.010	2.375	3.438	1.063	1.447	.112	12

```
RELIABILITY
  /VARIABLES=RE13 RE14 RE15 RE16 RE17 RE18 RE19 RE20 RE21
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE
  /SUMMARY=MEANS.
```

Reliability

Notes

Output Created		24-Jun-2014 11:30:15
Comments		
Input	Data	C:\Users\Sony\Desktop ima SPSS\Nima Tazehzadeh-Time.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	16
	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=RE13 RE14 RE15 RE16 RE17 RE18 RE19 RE20 RE21 /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /STATISTICS=DESCRIPTIVE /SUMMARY=MEANS.
Resources	Processor Time	00 00:00:00.015
	Elapsed Time	00 00:00:00.006

```
[DataSet1] C:\Users\Sony\Desktop\nima SPSS\Nima Tazehzadeh-Time.sav
```

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	16	100.0
	Excluded[a]	0	.0
	Total	16	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
.854	.851	9

Item Statistics

	Mean	Std. Deviation	N
OP1	4.1875	.40311	16
OP2	3.8125	.75000	16
OP3	3.8750	.61914	16
OP4	3.8750	.71880	16
OP5	4.3750	.61914	16
OP6	4.1250	.61914	16
OP7	4.1875	.65511	16
OP8	2.5625	.51235	16
OP9	2.3125	.47871	16

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.701	2.313	4.375	2.063	1.892	.551	9

```
RELIABILITY
  /VARIABLES=RE22 RE23 RE24 RE25 RE26 RE27 RE28 RE29 RE30 RE31 RE32
RE33 RE34 RE35 RE36 RE37 RE38
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE
  /SUMMARY=MEANS.
```

Reliability

Notes

Output Created		24-Jun-2014 11:31:10
Comments		
Input	Data	C:\Users\Sony\Desktop ima SPSS\Nima Tazehzadeh-Time.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	16
	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=RE22 RE23 RE24 RE25 RE26 RE27 RE28 RE29 RE30 RE31 RE32 RE33 RE34 RE35 RE36 RE37 RE38 /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /STATISTICS=DESCRIPTIVE /SUMMARY=MEANS.
Resources	Processor Time	00 00:00:00.016
	Elapsed Time	00 00:00:00.006

```
[DataSet1] C:\Users\Sony\Desktop\nima SPSS\Nima Tazehzadeh-Time.sav
```

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	16	100.0
	Excluded[a]	0	.0
	Total	16	100.0

Case Processing Summary

		N	%
Cases	Valid	16	100.0
	Excluded[a]	0	.0
	Total	16	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
.807	.811	17

Item Statistics

	Mean	Std. Deviation	N
SU1	4.1250	.50000	16
SU2	4.2500	.68313	16
SU3	4.3125	.60208	16
SU4	4.1875	.65511	16
SU5	3.6875	.47871	16
SU6	4.4375	.51235	16
SU7	4.3125	.47871	16
SU8	4.2500	.44721	16
SU9	4.3125	.47871	16
SU10	2.3750	.80623	16
SU11	2.4375	.51235	16
SU12	2.4375	.51235	16
SU13	2.3125	.60208	16
SU14	2.3750	.50000	16
SU15	4.1250	.61914	16
SU16	4.1875	.65511	16
SU17	4.0000	.63246	16

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.654	2.313	4.438	2.125	1.919	.737	17

```
RELIABILITY
  /VARIABLES=RE1 RE2 RE3 RE4 RE5 RE6 RE7 RE8 RE9 RE10 RE11 RE12
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE
  /SUMMARY=MEANS.
```

Reliability

Notes

Output Created		24-Jun-2014 11:33:14
Comments		
Input	Data	C:\Users\Sony\Desktop ima SPSS\Nima Tazehzadeh-Cost.sav
	Active Dataset	DataSet2
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	16
	Matrix Input	C:\Users\Sony\Desktop ima SPSS\Nima Tazehzadeh-Cost.sav
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=RE1 RE2 RE3 RE4 RE5 RE6 RE7 RE8 RE9 RE10 RE11 RE12 /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /STATISTICS=DESCRIPTIVE /SUMMARY=MEANS.
Resources	Processor Time	00 00:00:00.000
	Elapsed Time	00 00:00:00.004

```
[DataSet2] C:\Users\Sony\Desktop\nima SPSS\Nima Tazehzadeh-Cost.sav
```

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	16	100.0
	Excluded[a]	0	.0
	Total	16	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
.776	.773	12

Item Statistics

	Mean	Std. Deviation	N
ST1	3.0625	.68007	16
ST2	2.9375	.77190	16
ST3	2.9375	.77190	16
ST4	2.6250	.71880	16
ST5	3.0625	.57373	16
ST6	3.0000	.63246	16
ST7	3.0625	.57373	16
ST8	2.7500	.68313	16
ST9	2.7500	.77460	16
ST10	2.2500	.57735	16
ST11	3.8125	.65511	16
ST12	3.8125	.65511	16

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.005	2.250	3.813	1.563	1.694	.197	12

```
RELIABILITY
  /VARIABLES=RE13 RE14 RE15 RE16 RE17 RE18 RE19 RE20 RE21
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
```

```
/STATISTICS=DESCRIPTIVE
/SUMMARY=MEANS.
```

Reliability

Notes

Output Created		24-Jun-2014 11:33:39
Comments		
Input	Data	C:\Users\Sony\Desktop ima SPSS\Nima Tazehzadeh-Cost.sav
	Active Dataset	DataSet2
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	16
	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=RE13 RE14 RE15 RE16 RE17 RE18 RE19 RE20 RE21 /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /STATISTICS=DESCRIPTIVE /SUMMARY=MEANS.
Resources	Processor Time	00 00:00:00.016
	Elapsed Time	00 00:00:00.005

```
[DataSet2] C:\Users\Sony\Desktop\nima SPSS\Nima Tazehzadeh-Cost.sav
```

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	16	100.0
	Excluded[a]	0	.0
	Total	16	100.0

Case Processing Summary

		N	%
Cases	Valid	16	100.0
	Excluded[a]	0	.0
	Total	16	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
.866	.862	9

Item Statistics

	Mean	Std. Deviation	N
OP1	4.2500	.57735	16
OP2	3.7500	.57735	16
OP3	3.6250	.61914	16
OP4	3.6875	.47871	16
OP5	3.6875	.60208	16
OP6	3.6875	.60208	16
OP7	3.5625	.62915	16
OP8	3.5000	.51640	16
OP9	2.1875	.40311	16

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.549	2.188	4.250	2.063	1.943	.306	9

```
RELIABILITY
  /VARIABLES=RE22 RE23 RE24 RE25 RE26 RE27 RE28 RE29 RE30 RE31 RE32
RE33 RE34 RE35 RE36 RE37 RE38
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE
  /SUMMARY=MEANS.
```

Reliability

Notes

Output Created		24-Jun-2014 11:34:15
Comments		
Input	Data	C:\Users\Sony\Desktop ima SPSS\Nima Tazehzadeh-Cost.sav
	Active Dataset	DataSet2
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	16
	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=RE22 RE23 RE24 RE25 RE26 RE27 RE28 RE29 RE30 RE31 RE32 RE33 RE34 RE35 RE36 RE37 RE38 /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /STATISTICS=DESCRIPTIVE /SUMMARY=MEANS.
Resources	Processor Time	00 00:00:00.000
	Elapsed Time	00 00:00:00.005

```
[DataSet2] C:\Users\Sony\Desktop\nima SPSS\Nima Tazehzadeh-Cost.sav
```

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	16	100.0
	Excluded[a]	0	.0
	Total	16	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
.847	.844	17

Item Statistics

	Mean	Std. Deviation	N
SU1	3.8750	.50000	16
SU2	4.0000	.63246	16
SU3	3.9375	.57373	16
SU4	3.9375	.44253	16
SU5	4.3125	.60208	16
SU6	4.3125	.70415	16
SU7	4.2500	.68313	16
SU8	4.1250	.80623	16
SU9	4.3125	.70415	16
SU10	3.0625	.85391	16
SU11	2.5625	.62915	16
SU12	2.5625	.62915	16
SU13	2.5000	.63246	16
SU14	2.5000	.63246	16
SU15	2.6250	.80623	16
SU16	2.6875	.79320	16
SU17	2.5625	.89209	16

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.419	2.500	4.313	1.813	1.725	.616	17

```
RELIABILITY
  /VARIABLES=RE1 RE2 RE3 RE4 RE5 RE6 RE7 RE8 RE9 RE10 RE11 RE12
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE
  /SUMMARY=MEANS.
```

Reliability

Notes

Output Created		24-Jun-2014 11:36:25
Comments		
Input	Data	C:\Users\Sony\Desktop ima SPSS\Nima Tazehzadeh-Quality.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	16
	Matrix Input	C:\Users\Sony\Desktop ima SPSS\Nima Tazehzadeh-Quality.sav
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=RE1 RE2 RE3 RE4 RE5 RE6 RE7 RE8 RE9 RE10 RE11 RE12 /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /STATISTICS=DESCRIPTIVE /SUMMARY=MEANS.
Resources	Processor Time	00 00:00:00.016
	Elapsed Time	00 00:00:00.014

```
[DataSet1] C:\Users\Sony\Desktop\nima SPSS\Nima Tazehzadeh-Quality.sav
```

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	16	100.0
	Excluded[a]	0	.0
	Total	16	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
.801	.804	12

Item Statistics

	Mean	Std. Deviation	N
ST1	2.5000	.63246	16
ST2	2.4375	.62915	16
ST3	2.5000	.63246	16
ST4	2.1875	.65511	16
ST5	3.0000	.63246	16
ST6	2.9375	.68007	16
ST7	3.0000	.63246	16
ST8	2.7500	.68313	16
ST9	2.6875	.79320	16
ST10	2.0625	.68007	16
ST11	2.3125	.60208	16
ST12	2.3125	.60208	16

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.557	2.063	3.000	.938	1.455	.101	12

```
RELIABILITY
  /VARIABLES=RE13 RE14 RE15 RE16 RE17 RE18 RE19 RE20 RE21
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE
  /SUMMARY=MEANS.
```

Reliability

Notes

Output Created		24-Jun-2014 11:37:00
Comments		
Input	Data	C:\Users\Sony\Desktop ima SPSS\Nima Tazehzadeh-Quality.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	16
	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=RE13 RE14 RE15 RE16 RE17 RE18 RE19 RE20 RE21 /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /STATISTICS=DESCRIPTIVE /SUMMARY=MEANS.
Resources	Processor Time	00 00:00:00.015
	Elapsed Time	00 00:00:00.005

```
[DataSet1] C:\Users\Sony\Desktop\nima SPSS\Nima Tazehzadeh-
Quality.sav
```

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	16	100.0
	Excluded[a]	0	.0
	Total	16	100.0

Case Processing Summary

		N	%
Cases	Valid	16	100.0
	Excluded[a]	0	.0
	Total	16	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
.854	.850	9

Item Statistics

	Mean	Std. Deviation	N
OP1	2.9375	.57373	16
OP2	3.1875	.40311	16
OP3	3.4375	.51235	16
OP4	3.1875	.54391	16
OP5	2.5000	.51640	16
OP6	2.5000	.63246	16
OP7	2.5000	.63246	16
OP8	3.6875	.47871	16
OP9	2.4375	.51235	16

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	2.931	2.438	3.688	1.250	1.513	.220	9

```
RELIABILITY
  /VARIABLES=RE22 RE23 RE24 RE25 RE26 RE27 RE28 RE29 RE30 RE31 RE32
RE33 RE34 RE35 RE36 RE37 RE38
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE
  /SUMMARY=MEANS.
```

Reliability

Notes

Output Created		24-Jun-2014 11:37:39
Comments		
Input	Data	C:\Users\Sony\Desktop ima SPSS\Nima Tazehzadeh-Quality.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	16
	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=RE22 RE23 RE24 RE25 RE26 RE27 RE28 RE29 RE30 RE31 RE32 RE33 RE34 RE35 RE36 RE37 RE38 /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /STATISTICS=DESCRIPTIVE /SUMMARY=MEANS.
Resources	Processor Time	00 00:00:00.000
	Elapsed Time	00 00:00:00.006

```
[DataSet1] C:\Users\Sony\Desktop\nima SPSS\Nima Tazehzadeh-
Quality.sav
```

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	16	100.0
	Excluded[a]	0	.0
	Total	16	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
.777	.779	17

Item Statistics

	Mean	Std. Deviation	N
SU1	3.5000	.51640	16
SU2	3.6250	.50000	16
SU3	3.7500	.57735	16
SU4	3.9375	.57373	16
SU5	4.5000	.51640	16
SU6	2.6250	.71880	16
SU7	2.6875	.70415	16
SU8	2.6875	.70415	16
SU9	2.8750	.80623	16
SU10	4.6250	.50000	16
SU11	4.0000	.63246	16
SU12	4.0000	.63246	16
SU13	3.8125	.65511	16
SU14	4.0000	.63246	16
SU15	1.9375	.57373	16
SU16	1.8750	.61914	16
SU17	1.8750	.61914	16

Summary Item Statistics

	Mean	Minimum	Maximum	Range	Maximum / Minimum	Variance	N of Items
Item Means	3.313	1.875	4.625	2.750	2.467	.812	17