Implementation of Supply Chain Management in Iran Construction Industry

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Submitted to the
Institute of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Masters of Science
in
Civil Engineering

Eastern Mediterranean University
June 2016
Gazimağusa, North Cyprus

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ABSTRACT

In the last few decades construction sector in Iran has been developing rapidly compared with other industries in this country. Economically, Iran government has placed a significant emphasis on this industry as a consequent of the escalating social demand of commercial, industrial and residential constructions especially low-cost housing and affordable accommodation. However, this sector is still suffering from low productivity and it is still running on traditional way of doing business. Therefore, a well-organized transformation in order to reduce cost, time and waste in construction sector to cope with this situation seems to be necessary. It is argued that one of the well-thought techniques that possibly could be the solution to construction industry's conflicts and time and cost overruns is the Supply Chain Management (SCM), the concept that has emerged and developed in car manufacturing industry and has brought success to that industry as well. It is believed that supply chain management has the potential to enhance the overall productivity of the construction industry in many ways. Yet, this technique has not been practiced efficiently in many countries particularly in Iran.

The main purpose of this study is to develop an adequate conceptual framework with the aim of implementing SCM in Iran construction industry on the base of an in-depth literature review and analyzing the current performance of the industry throughout a questionnaire survey collected from industries' experts and stakeholders. The collected responds were statistically analyzed and not surprisingly, project quality improvement, site procurement enhancement, project cost and time reduction are the most significant benefits of the construction supply chain

management (CSCM) implementation. Industrialization, BIM (specifically 4D & 5D designs) and advanced technologies (e.g. IT, ERP etc.) are selected as most important variables for implementing CSCM and on the other hand lack of trust, poor subcontractor identification and priced based selection are counted as main barriers in implementing SCM. Subsequently, by implementing this framework it is believed that potential benefits like project cost and time reduction, quality improvement and site procurement management improvement can be achieved.

Keywords: Iran construction industry, supply chain implementation, construction supply chain management, SCM framework, construction management

ÖZ

İran inşaat sektörü, ülkedeki diğer sektörlerle karşılaştırıldığında son on yılda hızla geliştirmektedir. İran hükümeti, ekonomik olarak, özellikle, ticari, endüstriyel ve düşük maliyetli konut inşaatları ve uygun fiyatlı konaklama yerlerine olan artan toplumsal talebin sonucu olarak bu sektöre önem vermiştir. Ancak sektör, düşük üretkenlikte ve geleneksel iş yapma usulleriyle çalışmaktadır. Bu nedenle, bu durumla başa çıkmak için inşaat sektöründe maliyet, zaman ve israfı azaltmak amacıyla iyi bir organizasyonel dönüşüm gerekli gibi görünmektedir. İnşaat sektöründeki çatışmalar, zaman ve maliyet aşımlarına muhtemelen çözüm olabilecek iyi düşünülmüş tekniklerinden biri araç imalat sanayinde ortaya çıkmış bir kavram olan ve geliştirilerek sektörde başarılı olan Tedarik Zinciri Yönetimi (TZY)'nin olduğu ileri sürülmektedir. Tedarik zinciri yönetiminin birçok yönden inşaat sektörünün genel verimliliği artırma potansiyeline sahip olduğuna inanılmaktadır. Oysa, bu teknik, birçok ülkede ve özellikle İran'da etkin bir biçimde ele alınmamıştır.

Bu çalışmanın temel amacı, derinlemesine bir literatür taraması ve bir anket çalışması ile endüstrideki uzman kişi ve paydaşlardan elde edilen sektörün mevcut performans analizine dayanarak inşaat sektöründe Tedarik Zinciri Yönetiminin uygulanması için yeterli bir kavramsal çerçeve geliştirmektir. Toplanan veriler istatistiksel olarak analiz edildi ve şaşırtıcı olmayan bir şekilde, proje kalite geliştirme, saha tedarik geliştirme, proje maliyet ve zaman azaltma inşaat tedarik zinciri yönetimi (İTZY) uygulamasının en önemli faydalarıdır. Endüstrileşme, Yapı Bilgi Modellemesi (YBM) (özellikle 4B ve 5B tasarımlar), ve ileri teknolojiler (Bilişim teknolojileri ve Kurum Kaynak Planlaması) en önemli değişkenler olarak

seçilmiş ve diğer taraftan güven, zayıf taşeron tanımlaması ve fyiyat bazlı seçim TZY uygulamasında başlıca engeller olarak sayılmıştır. Sonrasında, bu çerçeveyi uygulayarak proje maliyeti ve zaman azaltma, kalite iyileştirme ve saha tedarik yönetimi geliştirme gibi potansiyel yararların elde edilebilir olduğuna inanılmaktadır.

Anahtar kelimeler: İran inşaat sektörü, tedarik zinciri uygulaması, inşaat tedarik zinciri yönetimi, TZY çerçevesi, inşaat yönetim

This dissertation is dedicated to my beloved mother Mrs. Narges Khademi and memory of my father Abdolhossein Dastgheibifard

ACKNOWLEDGMENT

I am using this excellent opportunity to express my gratitude to my supervisor Assoc. Prof. Dr. İbrahim Yitmen who helped me throughout the time it took me to complete this research and write the thesis. I am thankful for his guidance, constructive criticisms and advices.

Furthermore, I would also like to express my deep gratitude to Prof. Dr. Tahir Çelik for brightening up the philosophy of construction management throughout his courses and sharing his knowledge and experience.

I would also like to acknowledge my greatest appreciation to my family and friends for loving, supporting and encouraging me to continue my education. I will be grateful endlessly.

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LIST OF ABBREVIATIONS

SC	Supply Chain
SCM	Supply Chain Management
CSC	Construction Supply Chain
CSCM	Construction Supply Chain Management
GSCM	Green Supply Chain Management
BIM	Building Information Modelling
IT	Information Technology
ICT	Information Communication Technology
FM	Facilities management
PM	Project Manager
B2B	Business to business
RM	Relationship Marketing
TSM	Terrain Scanning Method
ERP	Enterprise Resource Planning
SME	Small and Medium Enterprises
GDP	Gross Domestic Product
GNI	Gross National Income
GFCF	Gross Fixed Capital Formation

Chapter 1

INTRODUCTION

1.1 Background

In the last few decades, the idea of globalization has emerged in almost every industry around the world. Many companies to adopt themselves with these modifications, started to change the core strategy of doing business and the structure and process of production by moving toward supply chain management (SCM) strategies. Supply chain (SC) is a theory that generated and rose in the manufacturing industry. SCM was first observed in the so called JIT "Just in Time" method. This delivery method as a piece of the leading car manufacture "Toyota" was first defined in order to manage suppliers to the main Toyota motor factory exclusively in the exact quantity in the exact time (Shingo, 1988). In construction, SC defines the phases through which construction assets (from material to personnel) completely proceed from suppliers to the constructions site. (Javier, et al., 2013)

Many studies and empirical literatures demonstrate that SCM in construction can benefit all stakeholders involved in a project. Additionally, supply chain management has an important impact on increasing the broad output of the construction industry, while it is very new and leftover on the implementation stages (Morledge, et al., 2009). It is believed that the supply chain cooperative activities play a main role in reducing the total cost of the project (Kim, 2014). Compared with other industries (e.g. car manufacturing) major contractors of construction industry

remained relatively at the early levels in their goal to the SC. Many construction companies and suppliers have already tried different methods in case of managing the SC, still a lot is left to do to get benefit from the idea of SCM and whole. Also it is recommended, this phenomenon should be considered more seriously in developing countries where the traditional way of doing business in every industry especially construction is preferred by some major organizations and dictated to the recent or minor contractors.

Iran is enjoying the wealthy and reach natural resources and young educated workforce. Moreover, in the half past century, Iran government has been allocating exceptional focus on construction sector, therefore this industry has become one of the biggest industries in this country. However, this sector in Iran is not as successful as the ones in developed countries. Recently, lots of moves in order to achieve success in Iran construction industry (for instance importing goods heavily from developed countries which faced failure) were made. Likewise, the old-style way of construction does not cover the emerging demand in Iran society. The extreme struggle between construction firms in Iran has directed them to take all proper actions to reduce the expenses as much as they can. Yet, these actions were not successful enough and implementing new techniques should take place.

1.2 Problem Statement

At the moment without a doubt the construction industry's insufficient management can be realized as a factor that holding the construction industry back compared to other industries (Liu, 2014). The construction sector in Tehran (Iran capital) created over $5*10^7$ kilograms of waste everyday just in 2010 (Meibod, et al., 2015). Furthermore, Iran construction industry have some characteristics that may slow the

growth of the economy down, characteristics like construction cost overruns, delays and time issues, construction quality and stakeholder relations and attitude issues etc.

Iran construction industry is traditional based and it is suffering a lot from lack of management and modern technologies (which can be transferred from developed countries) in almost all phases, from early design phase to the latest phase which is delivering the end product to end customer's hand (Hashemi, et al., 2015). Such problems can end up with loss monetary aspects, extension in duration and delivery time, uncontrolled waste production and other undesirable results in projects in Iran construction sector. Additionally, it is said that design-related risks and issues also play an important role as a trouble in the construction project in Iran (Monazam, et al., 2016) and as a consequence of monetary loss and delays in completing projects construction organizations have not be successful to cope with risk and other critical aspects of industry. (Samarghandi, et al., 2016)

In order to manage such difficulties, this study has an in-depth look into literature related to supply chain overall especially in construction industry, result of practicing this technique in developed countries, current condition of the Iranian construction industry and implementation of SCM in Iran construction industry, since this technique has brought success in other industries globally. Initially the implementation of supply chain management requires a study around different factors that can make the implementation process faster and more accurate or, on the other hand, stay as a barrier in the way of implementation of SCM in Iran construction industry.

1.3 Scope and Objectives

The main objective of this study is to find the best way of implementing SCM in Iran construction industry by observing the strengths and weaknesses of this industry through an extensive literature review, construct a questionnaire survey and develop a proper framework by understanding the main points of the related literature from the benefits of SCM in construction industry, barriers in the way of implementation and factors that strengthen the implementation, and finally evaluate the framework in a case study. All in all the main process of the research is summarized in the following:

- To Study the current performance of the construction industry, national and international wise
- To comprehend types and nature of the supplementary elements to the implementation of the SCM and their benefits to the industry
- To discovery the causes that lead to break the supply chain and the consequent result of those barriers on construction projects
- The elaboration of the methodology of resolving the SCM issues and provide possible alternatives.
- And over all, design a conceptual yet proper framework for SCM implementation in Iran construction industry

1.4 Methodology

With the aim of finding a proper way of implementation of SCM in Iran construction industry, after reviewing related literature, a questionnaire survey as a quantitative investigation source in Iran is prepared. The methodology of this piece of work is based on 3 major steps.

- The first step is to design a well-organized questionnaire survey based on the reviewed literatures (subjects and questions are collected from SCM & CSCM globally and Iran construction industry states related studies aiming to have an complete, effectual and detailed literature review that can be useful in survey design).
- The second step is to distribute the prepared questionnaire within experts who are involved directly in Iran construction industry (e.g. Civil engineers, contractors, construction project managers, etc.).
- At the end, collected data has been analyzed statistically (sample reliability test namely Cronbach's Alpha, correlation test in order to have a sufficient and homogenous framework and the hypothesis test specifically t-test for understanding the interaction of the subset with the main issue) the final results are discussed and a proper framework is prepared in order to achieve a sufficient implementation of CSCM in Iran.

1.5 Thesis Outline

This study is divided into 6 chapters, the first one, introduction, offers several subjects starting from background info about SCM and followed by objective, research problem statement and research survey respectively.

In the second chapter, academic literate view and the earlier studies on SCM and its use in construction is clarified and presented in detail.

Immediately after, in chapter three, the methodology of this study is discussed and efficient procedure to analyze SCM and the implementation of this matter in Iran construction industry is proposed.

In the next chapter (chapter 4), data from the collected questioner are analyzed and regarding to that detailed results are illustrated in graphs and charts then discussions are made.

Finally in chapter five, conclusion of the thesis with comprehensive accomplishments and ultimate deductions subsequently recommendations for further academic works is prepared.

Chapter 2

LITERATURE REVIEW

In this chapter an overview of literatures related to the CSCM and implementation of this phenomenon in Iran construction industry is presented. The review of these studies starts with related definitions of construction and some of its characteristics, then Iran construction industry and its current situation which is the target of this study. After that SCM in other industries studies are observed and then the review is narrowed to construction supply chain implementation and finally ended with its challenges.

2.1 Construction Industry

Between the chief economic sectors, the status of the construction industry is exceptional regardless of whether the country is developing or it is already developed. For illustration, the construction industry is subjected to quarterly and annual statements of national accounts. The construction sector shows up in the national accounts (Gross Domestic Product GDP, gross national income GNI and Gross fixed capital formation GFCF). The measurement of results are done by gross output, added value and capital formation. More than half of GFCF involves construction industry outputs (Olanrewaju & Abdul-Rashid, 2015). Economically the construction industry confidence had increased in the third quarter of 2014, according to Engineering News-Record's Construction Industry Confidence Index survey, just over 50 percent of subcontractors stated a refining market with confidence rising through that year. That amount jumps to as high as 64% when

observing the next year (Gavin, 2015). This industry is a vast subdivision of global economy currently that cope with numerous stages from planning to manufacture and fabrication of construction materials. This sector is a dynamic route, typically present high profits for both contractors and workers, and therefore is definitely attractive. Yet, the cyclical and unequal nature of its process often affects its profitability (Tazehzadeh, 2014).

The construction industry can be exemplified as a factory with short-term manufacturing, considering the construction site as the 'factory' where the contractor is responsible for producing the product. To make this matter possible, the builder demands technicians, plant and goods, which should be very carefully managed so the technicians utilize the appropriate equipment within the best possible situation. Materials should be kept in store house with the purpose of all-time availability also not causing any disturbance in overall circulation of the site, appropriate storage capacity and job site space (Chudley & Greeno, 2006). It is believed that construction industry is a dependent section of the global economy, simultaneously came with complexity in addition to low productivity, Low efficiency, excessive fragmentation, price overruns as well as time and struggles in every single stage (Aloini , et al., 2012).

The UK Standard Industrial Classification (SIC) defined that construction consists of common and particular construction career for both civil and building engineering, installation and accomplishment of the building. It consists of new work, maintenance, assembly of prefabricated rather structures or buildings on the construction site, increments and modifications, and impermanent nature construction (Anon., 2003). It is believed that one of the biggest industries in the

word is construction industry (Horvath, 2004). Just in the U.S, $1,072 billion value was allocated for construction in the year 2008 (Anon., 2009).

However, there are some downwards in this industry, it was indicated that the performance of construction industry is low. Mainly, there is an apprehension on profit boundaries of the industry, a satisfactory level of the client and procurement process fragmentation of the construction (Pryke, 2009). In addition, numerous organizations and professions are associated with the construction industry projects and its expansions. Fearne and Fowler acknowledged that Construction industry is regrettably the last one in all significant industrial sectors (Fearne & Fowler, 2006). While Aloini et al have noticed other characteristics of the construction industry, they defined construction as a multi-organizational procedure that involves designer, supplier, contractor, client, consultant etc. It is also mentioned that construction is a multi-phase process that contains 1st conceptual activity, 2nd design, 3rd construction, 4th maintenance, 5th replacement, and 6th decommission (Aloini , et al., 2012).

2.2 Current Status of Iran Construction Industry

Iran construction sector is seeing a stable yearly development of 4.2% which is estimated to reach over 8% in coming years, especially in the end of 2016 where the sector is planned to touch a marketplace size of 154.4$ billion (ifpinfo, 2015). The Iran construction industry is a very broad haven for innovation and technology where the increasing needs in the Iran construction sector is growing rapidly. However this industry in Iran suffers from low productivity, in the last few decades, lots of efforts in order to achieve success in Iran construction industry (for instance importing goods heavily from developed countries which faced failure) were made. Likewise, the traditional way of construction does not cover the emerging demand in Iran

society. The extreme struggle between construction companies in Iran has directed them to take all proper actions to reduce the expenses as much as they can (Ghoddousi, et al., 2010). Particularly increasing for housing and accommodation on one hand, and the construction on the basis of wrong habits in the country, lack of motivation, invention and innovation on the other hand, all together strengthen the demand for systematic transformation and implementation of modern techniques in Iran construction industry more than ever. The construction industry in city of Tehran (Iran capital) created over $5*10^4$ tons of waste everyday just in 2010 (Meibod, et al., 2015) Consequently, a major part of Iranian construction companies by means of fairly practicing such new management techniques (e.g. Supply Chain, Risk, Total Quality Management etc.) Try to find their persistence in magnifying the efficiency of their activities.

Iran government has announced new monetary policies that approximately more than doubled the weight of the share of construction sector in the economy. Officially it is said that this sector's share of the total budget of the country in 2003, '06 and '08, respectively has been amplified from 17.5 to 24 and 28.8 percent.

Regardless of this significant quantity of capital devoted to Iran construction sector, Studies show that there is a total loss of 51 percent (hr./operative/site/week) and the investigation demonstrates 24 to 46 percent inefficiency time variation alternation on studies sites (Hosseini & Ghoddousi, 2012). Therefore, a lot of work needs to be done in order to reduce such a huge amount of waste, and supply chain management (SCM) could be one of these solutions for a part of this amount of job.

2.3 Supply Chain Management (SCM) in General

Supply chain management has been defined as “the network of organizations that are involved, through upstream and downstream relationships, in the different procedures and activities that produce value in the form of products and services in the hands of the ultimate customer” (Wickens, 1992). Moreover the increase in the global rivalry, in addition to an emerging need for healthier client service has significantly amplified the essentiality for incorporation among companies. Accordingly, SC integration, intended to direct procedures lengthwise the SC flawlessly, these days this issue is deliberated as a substantial element to retain a competitiveness privilege over the competition (Danese & Romano, 2011). For better understanding of the concept of SCM the In figure 2.1 the basics of general SCM is illustrated

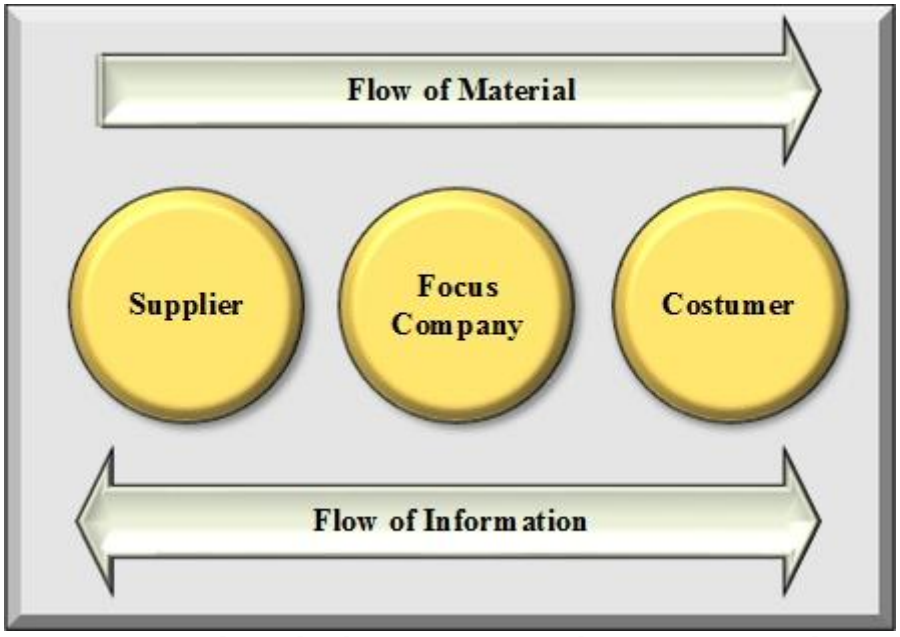

Figure 2.1. General supply chain management basics (Meng, et al., 2011)

Generally, the term SCM is about to manage the relationship process of Supply Chain which grafts the maker and the client (Meng, et al., 2011). Managing and

controlling a particular kind of value is another duty of SC. Starting with creating activities by Supply collaboration in enterprise phase and continuing by Chain phase standing for cross-enterprise partnership, which is indeed the stage that construction industry insufficient administration investment or, at least, poor management at the moment can be realized (Liu, 2014).

Nonetheless, the improvement of SCM in this industry achieved more consideration and independent position. SCM has developed an innovative management way to boost the key proficiency of enterprises. However, the awareness of SCM is more about the partnership in the middle of the participants in the resource networking (He, et al., 2008).

According to Song, et al. SCM is a well-organized and impressive tactic that seems to be feasible for reaching purchaser's highest satisfactory level in the claim of service or product (Song, et al., 2010).

The SCM developed as an idea when profits of a partnership between and far of the capabilities of solo companies were observed. Accordingly it is believed that the cooperative actions in dropping the total cost of the supply chain in fragmented SC were effective (Kim, 2014). What is more, the excellence of SC has become a fundamental stimulus to endorse both enterprise worth and most enterprise competitiveness (Kuang, et al., 2014).

The idea of supply chain demonstrates a linear procedure. Yet, the existence of this linear procedure is just at the top level of concept. There is a linearity limitation at the practical level, once the managing of supply nature and process is explored,

supplier clustering joining together in dyadic exchanges sequence. Public market place swapping a technical and social structure that in one go, are remarked as sustainable systems of relationship (Pryke, 2009).

The implementation of SCM can be achieved by a well-organized involvement of every participant (such as supplier, maker, vendors, etc.) in encountering the customer needs. Some of greatest fundamental aims of the SCM theory are about defining and satisfying the end user demand, company profit improvement and waste reduction relating in three elementary ideologies, one of which is time and the other two are expense and quality (Jalbani, 2010). Such rearrangement may perhaps emphasis on the requirements of the coexisting plan and making procedure. Likewise, the idea of partnership was discussed by other authors. It is argued that there is a significant growing attention in both participants and theoretical works for past few years in the incorporation operations among SC partners (Van der Vaart & van Donk, 2008).

2.4 Construction Industry & SCM

The supply chain (SC) is described as a dynasty of processes and flows that are meant to satisfy the ultimate demand of the client. Accordingly different phases may take into consideration throughout the very early stages to end product. Normally the SC takes account of maker and supplier although it relies on marketing, flows, client & etc. Consequently, it is possible to say that SC includes not just maker and supplier but new SC can be considered in instance developing fresh artifact, client service and marketing. The SC is also described as a linkage of wholesaler, providers, transporters, delivery, production supplier, storing services and selling goods to

clients. It is alleged that naturally supply chain contains a bunch of companies which are gathered to synchronize activities to avoid competition (Jingsheng, 2012).

SCM presents a crucial change in the attention of accountability and power within the whole roles of the project network for almost all companies. This structure of developing roles can be found surrounded by a framework of challenging and various administrating templates. A sustainable existence within official, contractual connections that primarily describes nodes and links, and less organized policies of Project Manager (PM) which deals with formalization, for instance associating and job assortments that pair of them eventually form roles and connection between roles of the project. Such directorial tactics produces an essential effect on roles, the character and methods of interplay within these roles (Pryke, 2009).

The construction SCM can be defined as a linkage of many companies or groups and their relationships that contains a stream of data, a stream of goods, product or service, and the steam of capital among the end-user, supplier, planner and contractor in a relation to a construction project (Xue, et al., 2007).

Construction SCM is far novel to this business comparing its success to other ones; consequently, it is believed to be a future of this industry by several lecturers. In 2004 materials and services which were delivered by out-sourced dealings generally took place as 80% of the total budget of the whole projects, referring to Constructing Excellence. Therefore, principle contractors are rapidly expanding the SC as many more jobs are left for sub-contractors (Richard, 2012).

It is said that SCM has an essential impact on developing the general output in the construction industry, although it is very new and leftover on the implementation stages (Morledge, et al., 2009).

In construction we observe clients, consultants, contractors and suppliers in the broadest sense positioned as nodes connected by linkages comprising knowledge transfer, information exchange, directions and monetary and contractual relationships.

Customers, contractors, advisors, and suppliers in construction industry logically, are defined as knots joined by different linkages including information transmission, knowledge exchange, instructions, monetary and contractual relationships. These grids are described as glancing and flows also defined as repetitive (Pryke & Smyth, 2006) (Pryke, 2001) similar to neural networks the figure 2.2 presents the construction supply chain which in that figure the knots are constantly connecting and separating based on the performance of a subordinate of the project. Every single linkage is connecting with streams which make a reply also create a sequence of binary or poly-directorial streams in anticipation of satisfaction of a specific job or certain matters are untangled (Pryke, 2009).

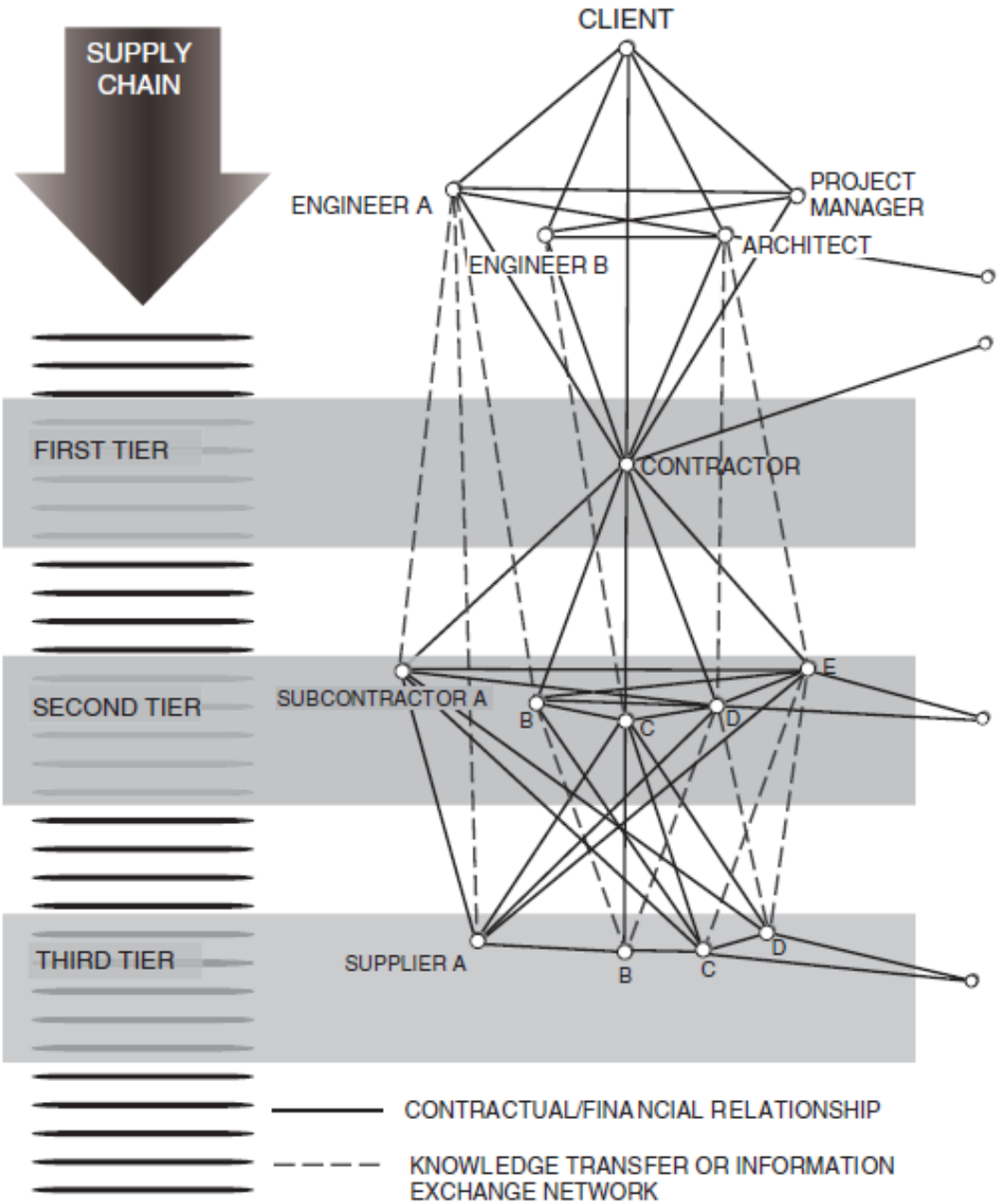

Figure 2.2. Construction supply chain network (Pryke, 2009)

SCM has its own characteristics associated with construction and structural projects. It is believe that Pre-engineering could be a choice in order to reduce construction supply chain (Newman, 1992). Companies associated with construction industry develop their SCM by function procedure standardization and optimization of controlling every linkage by means of efficient gadgets in the SC. Creation of the CSC is the foundation of the total Supply chain method functioning that requires

illustrative assignment for the linkage by having extra attention to the appearances of this trade. (Vrijhoef & Koskela, 2000)

It is believed that almost the whole construction industry is stuck at the starting point of supply chain classification. Although some construction companies are taking SC seriously, still a very small combination of different internal tasks can be seen in organizations. Particularly, management interoperability inside the organization and networks of supplier groups are hard to detect (Pryke, 2009).

Anderson et al. (2007) indicated seven ideologies of SCM which have been tested for seven times and proposed a vale to companies in order to implement SCM. It is said that each of these philosophies is able to deliver three sort of benefit, these benefits are: increase in profits, resource usage and reducing overall cost. These principles suggest that the goal and opportunities of the companies can be reviewed. Reviewing the organization's purposes and chances are indicated by these principles. Additionally through re-engineering the CSCM the revenue increment can be amplified relying on the client requirements. The principles are shown as follow:

- The participation should be based on service needs and customize of the supply chain to get profit. This leads to the revenue growth.
- The customization of logistics network that support the asset utilization.
- The supply chain should be consistent with the forecast and can utilize resources optimally. This supports resource utilization.
- Try to differentiate customer closer products and speed conversion across the supply chain.

- Try to manage sources strategically that could reduce the unseen total cost for purchase material and services. This supports cost reduction strategy.
- Try to develop a supply chain wide that should support the multiple level of decision making and information, services and products should be visible. This supports asset utilization.
- Try to adopt vertical or end to end measures for every channel. This supports multipurpose for example revenue growth, asset utilization and cost reductions (Anderson, et al., 2007).

Despite the increasing demand of the market of the construction industry, competitiveness and productivity remained as unsolved problems. Studies indicated that CSC is extremely fragmented. What's more, this fragmentation grows in construction supply chain managements that are straightly dealing with the on-site work delivery. The consequence of fragmented SC contains a fairly heavy bargain cost, a demand of more management involvement and cooperation of functions on site and less waste and cost reduction chance (ECLLP, 2013).

Another significant character of construction industry that makes the implementation of the SCM difficult is the boundless influence of the client on the end product in terms of both physical and logistical factors such as size, shape, material, delivery time and cost (Akintoye, et al., 2000).

The figure 2.3 is designed to illustrate the overall idea of implementation of supply chain management as a brain-storming stage based on the different reviewed literatures related with construction supply chain motivators, benefits and barriers for the construction projects and its relations with supplier and end costumers.

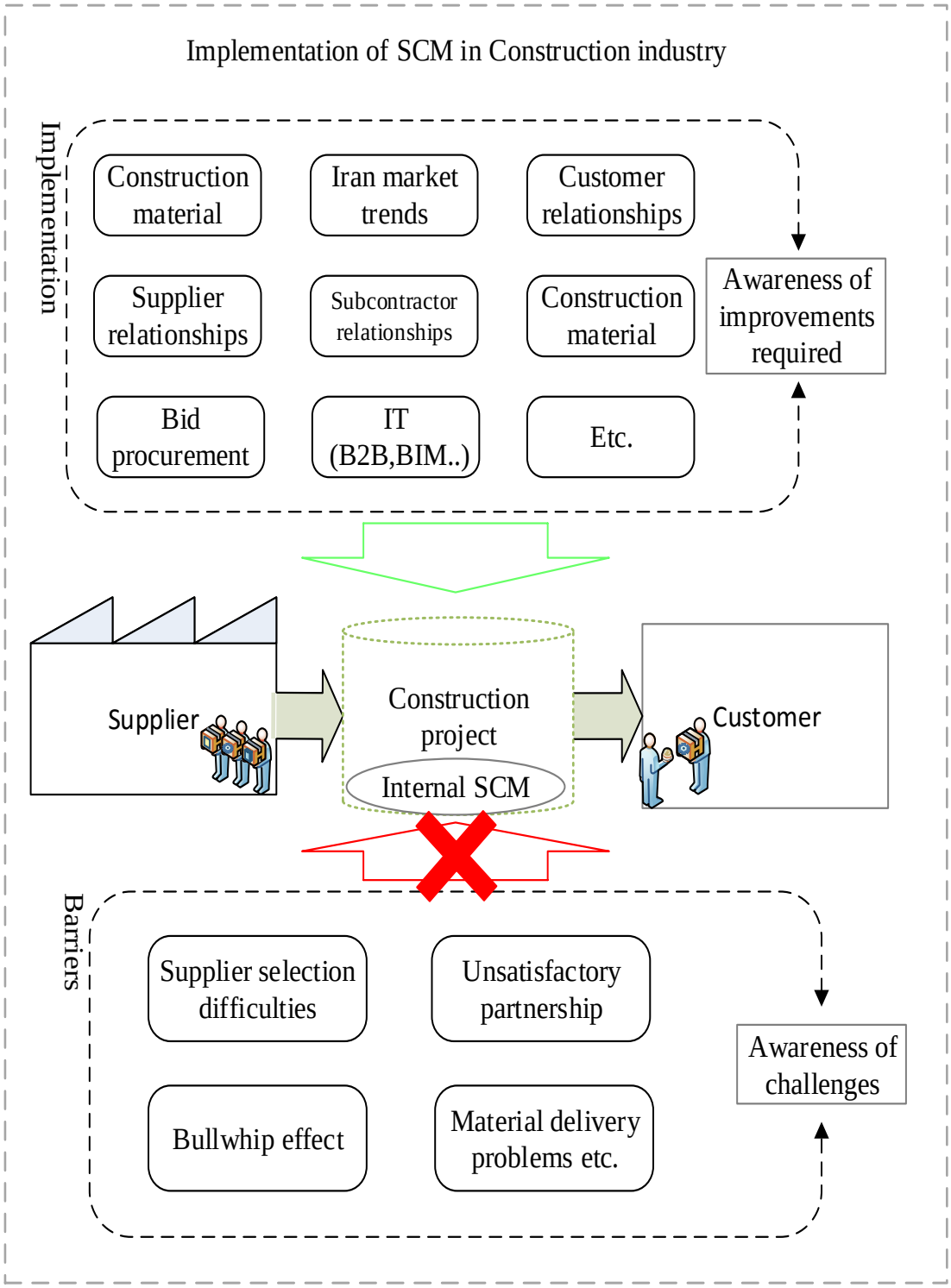

Figure 2.3. SCM implementation overall literature review concept

2.4.1 Construction Material

As a great portion of construction business, materials like asphalt, concrete, bricks etc. are usually deliver from supplier or storage facility to the site ideally at a right

time using delivery vehicles (Davis, et al., 2016). Although this low-cost construction can be ignored by having the all-new costly projects that include tons of energy saving equipment and environmentally friendly engineered materials on the other hand. The complexity of the spreading of a great range of construction materials and advanced linkage of builders' wholesalers cannot be ignored. For instance, inadequate size allotment of a material storing can cause lower efficiency in construction site (e.g. intercepting the flow of material whenever there is a space limitation for depot materials, and spending more capital on discovering and handling construction materials when the storage is overfilled) (RazaviAlavi & AbouRizk, 2015). Traditionally, construction materials selling by sellers are allocated in two different vast categories namely heavy and light side. The first one (the heavy side) contains the fundamental materials which used in traditional category of buildings (e.g. cement, sand, brick etc.). While the other one (the light side) contains materials for decoration, isolation, fixing and etc. Nowadays, the variety of construction materials is remarkably increased. This matter led the market to increase the amount of sellers of a particular material. This makes a vast range of suppliers which in one hand is beneficial in order to get the best fitting material needed, on the other hand, a complex and confusing choice of material that if not taking seriously it might lead to overrun costs.

2.4.2 Market Trends

There is uncertainty about the growth of the prices in high demanded materials in future, this means that in market tend it is possible to say price and demand have vice versa relation and there is an emerging complexity in social trade obligation exposes by international construction firms (Lu, et al., 2015)

2.4.2.1 Construction Material Trader Role in SCM Progress

Merchants or traders have a very significant role in satisfaction level in quality of construction jobs, (Blaževska-Stoilkovska, et al., 2015). A two-month duration credit is prevalent. But not for minor trading companies that are capable of giving a shorter period credit services. However larger dealers are capable of giving a great amount of discount to contractors, moreover, occasionally they are able to offer unusual discounts for their clients. It is believed that this trend is a growing and trading companies are joining together gently. Construction expertise and other related contractors are increasingly requesting discounts and more negotiation in their contract all over the UK. Concerning this, it is possible to say that this might be a key way to have better trading system

2.4.3 Construction Supplier and Customer Relationship

In spite of some changes to improvement, particularly Planning and construction management contracts, unfortunately, construction industry grew through a low-trust structure in the last half century, where the counselors spent most of their working time making sure that their qualified insurance cover was not wide-open to pointless hazard, and both contractors and their subsets accepted the “opportunistic behavior” as a way of improving from unsatisfactorily low proffered turnover limitations in a framework of improperly assigned risks of the construction projects. Most of the primary contractors of the construction industry have moved against exerting the ideology SC partnership, the primary subcontractors who distinguish the significance of SC strategic. Still construction-partnering is a concept that has been approved worldwide without any doubt (Beach, et al., 2005).

Customer-supplier relationship is the sprite of construction management procedure. Its eventual target is the well-organized conveyance of the finest value to the client, which can be attained by boosting efficient partnership among the involved groups in the SC. By means of lessons learned from these sectors, the practice of cooperative SC can be increased in this industry (Akintoye, et al., 2000). Construction sector includes numerous components of a variety of different expertise. Huge construction companies have production subsets for materials and since they have purchasing power, it is possibility for such companies to have direct contact with manufacturers, industrial units, and main traders. Therefore, there is a high chance of laying the traders away. Although, the biggest clients from this industry can be seen within the minor to average size companies who are not able to have such relations.

2.4.4 Lean Supply Chain

In construction industry, lean emphasis on continues improvement, procurement management, supplier and client and cooperative relations (Forgues & Koskela, 2009).

2.5 Implementation SCM in Construction Industry

Undoubtedly the implementation of SCM in construction is not simple, as it includes monitoring and controlling an intricate and dynamic collection of organizations that are functioning aiming to produce countless conflicting industrial targets (Tommelein, et al., 2003).

Policies for construction growth have pointed six principal subject matters in construction supply chain as follow: innovation, IT, job delivery and procurement, site issues, environment and regulative improvement and exports. Almost in all related pieces of literature, there were discussions about the necessity of putting the current fragmented construction industry on the right track by solving key barriers

such as short-term policies or project to project policies (london, 2007). Likewise, some other literatures have observed the importance of the fragmented environment of construction sector (Dainty & Briscoe, 2001). In addition, construction industry is suffering from a separation between different stages and isolation in controls (Egan, 1998).

It is said that the main issues occurred by isolated and separated controls of construction supply chain grow at the junction between different partners or phases involving with the construction supply chain (Love, et al., 2004). These factors are named as the "root causes" in empirical matters (Cox & Ireland, 2002). Moreover the industry is also having problems in SCM to achieve the proper integration advised by literature (Briscoe & Dainty, 2005), in order to cope with such troubles in construction projects Dubois and Gadde have recommended the focus-domination strategy (Dubois & Gadde, 2000). Palaneeswaran et al (2003) have mentioned some of the key issues of the traditional CSCM in the following:

• Inimical relations between clients and contractors

• Inadequate information about sharing risk and profit

• Fragmented strategies

• Emphasis on temporary relationship and "win-lose" encounter

• bridling the authority and repetitive disobedience in contractual responsibilities lead the industry to adversary performance with unsatisfying quality, claims, disagreements, and eventually fights.

• Emphasis on initial bidding price offers with insufficient attention on life cycle expenses and final cost

• Inadequate knowledge swap and defective debates plus uncompleted steps that had been taken toward communication

• Smaller number of relationships that yield strong, sustainable and long-term correlations in construction industry (Palaneeswaran, et al., 2003).

Apart from that, some other factors such as nonexistence of collaboration and strong communication structure between copartners, contractual relationships with on side benefit, lack of customer-supplier relation, price-based selection, and lack of technology employment. While it is believed that lack of top management commitment, lake of appropriate knowledge about the idea of SCM, improper organizational structure and partners' low obligation, respectively are some of the most important barriers to implementing construction supply chain management (Akintoye, et al., 2000).

In addition to mentioned factors, there are other aspects that the effect of them on the implementation of SCM may be unclear in practice although they have been pointed out as effective ones in some literature. These factors will be reviewed in the fallowing.

2.5.1 Commitment

The Commitment was first recognized by (Grönroos, 1996) as an aspect that invented a sustainable relationship. Some other literature indicated that Supply Chain Management is made from either between organizations'' or within a specific organization's relations; needing a specific strategic method, at the mercy of links and should have patronage from out-sources; in the need for persistent commitment and knowledge acquisition from the top manager.

2.5.2 Trust

When improvement in relationships is considered, the significance of discussion around elements like trust and commitment, during the focus group in practice and literatures in academic world are first things that are brought up to the respondents' thought. While the subject seems to be simple, the solution for implementation the trust based system is not that much simple. To measure trust in relations in Davis literature respondents were requested to grade apparent trust as a character from upstream to downstream relations. In general, it was indicated that the whole model showed great expectation that with trust; their businesses with other parties would be ensured. (Davis, 2008)

2.5.3 Quality

In construction supply chain, quality plays a key role. The scope of a moot point, mostly its economic significance, is familiar to the industry. Also the charge of quality implementation or re-engineering the quality of SC still is a major problem (Thomas, et al., 2002).

2.5.4 Facilities Management (FM)

Karan and Irizarry recently indicated that this phenomenon is able to solve problems that are related to the delivery of the services, it is said that the facility management has a great impact on the economical scale and client satisfaction of projects (Karan & Irizarry, 2014). Facility management gathers a vast variety of assets and subordinates associated with users in order to advantage the company, clients and owners (Lehtonen & Salonen, 2005). Change management, Real estate management and building maintenance are decent examples for FM in the construction industry.

2.5.5 Relationship Marketing (RM)

Relationship Management's correlation to CSCM is divided into two oppose mechanisms; the old marketing fails to identify significant inter-relationships inside its mixture, while RM's relations to service industries that undoubtedly have developed in last few decades. Relationship Management investigations expanded heavily in the field of both industrial and services sectors; meanwhile, some of them have been suggesting that the RM is applicable in construction Industry (Davis, 2008).

2.5.6 Subcontractor Selection

Khalid et al indicated that an important point of SC which is missed in other art crafts is a focus on subcontractors selection. While the majority of the job is completed by subcontractors, construction projects rely heavily on numerous subcontractors. About ninety per cent (90%) of the work sit jobs are accomplished by a great number of subcontractors. This occurrence is done while the main contractors are focusing on managing and coordinating subcontractors. What makes it more significant, a great deal of companies that usually play the subcontractors roles are minor ones since the contractors are keen to have pyramid shaped contracting work distribution by means of compound categories of subcontractors (Khalid, et al., 2006)

2.5.7 IT

For communication between organizations needed by the industry, The Information Communication Technology (ICT) strategies' implementation, industrial and organizational wise is recommended. The communication between project managers and customers can be achieved through the organization level of implementation of the ICT policies. While the industrial implementation of ICT needs collaboration,

knowledge and supporting employs, stakeholders, and governmental related organizations. Communication protocols advance in IT has the duty of addressing technological, administrative, public and lexicon matters necessary for implementation at every stage of either construction industry or organization internal communication (Ahuja, et al., 2010).

"Protocol" is described as an acceptable treatment, principle or action (Oxford, 2007). IT improved communication or the use of ICT, including producing, programming, processing, keeping and communicating info. Therefore, IT-enhanced protocols are necessary to describe acceptable approaches of leading these procedures. At every single phase of construction projects, information is made, kept and connected by all members of supply chain. Thus, to have efficient cooperation, all the SC members must obey the established approaches or the communication protocols. Correspondingly, at whatever time, each organization is involved in more than one assignment and could be a part of more than one SC (Dainty, et al., 2001). This exclusive essence of the construction industry requires that the communication protocols should be adopted by the entire industry and do not persist project specific. Moreover, companies require a development in their competencies in order to be in the level of preparedness to professionally implement IT into real-time practices (Hassan Issa & Abu Bakar, 2013).

2.5.7.1 Business-to-Business (B2B)

The expansion and growth of the business-to-business (B2B) market in the construction industry already have eased the business for buyers and suppliers in many countries. In the last decade, construction organizations have been leading their business using web-based communicating tools. Electronic commerce has expanded

the market that suppliers and customers are able to communicate straightly, allowing them to do business at a sustainable price that is specified in harmony with the guidelines of the exchange (Castro-Lacouture, et al., 2007). B2B E-markets act as digital mediator which focus on precise commercial functions and set up virtual marketplaces where firms participate in buying and selling actions once they acquire membership. (Dai & Kauffman, 2001). However, E-business has its own difficulties which soon or after should be resolved. In an e-business market atmosphere, the sale manager is expected to solve problems through the usage of the SC optimization gizmo such as early bidding price, material quantity, bid prices tradeoff and bidding sensitivity to factors that the product requires (Castro-Lacouture, et al., 2007).

2.5.7.2 BIM (Building Information Modeling)

The most important use of BIM gadget is the swapping and shifting of information, that is the straight look of advanced technologies in construction industry (Zhang & Hu, 2011). “BIM is a digital representation of physical and functional characteristics of a facility” defined by American National Institute of Building Sciences (NIBS) (Anon., 2012). Therefore, it renders service as a source of shared information about an ease of creating a trustworthy resource for determinations through the building lifecycle from the very early steps. BIM is also a beneficial tool for construction management by using the integration of parametric model of BIM and diversity of data in associated with the building. The data can be shared and transferred throughout the entire life-cycle of the construction. Subsequently, the workforce or any other stakeholders are able to understand the process and make the right decisions in order to have efficient building process.

The delivery time and amount of material are two main factors that can be arranged by BIM and came in hands of suppliers before ward. Not only that but also BIM can give a root of the job together for the construction manager, constructor, Supplier and other main stockholders. Moreover, BIM makes sure that the data can be successfully controlled and tracked in the building life-cycle. Energy-saving, cost reduction, decreases in pollution and increase effectiveness throughout the whole construction process especially supply chain are main benefits of BIM (Wu & Xu, 2014).

2.5.8 Green Supply Chain Management (GSCM)

The formation of eco-friendly standards and rules marks the green management as a must for the industry's enterprises. With the purpose of realizing sustainable growth, some governments have broadcasted a package of rules and principles to specify a severe penalty for organizations using extreme resources and polluting the region. This makes a cost for the organizations who do not implement green management. The incensement of client's consciousness of global warming, greenhouse gasses and etc. is an external demand for organizations to implement green management in every possible part of the industry. Today's clients request a high-quality commodity with minimum effect on the environment and harmless. Consequently, it is believed that to win clients and maintain competitiveness, companies should implement GSCM. Thus, in the procedure of selecting suppliers, as well as the old-style supplier evaluation standards, the environmentally friendly elements are considered. Specifically, the level of eco-friendly product, recyclability, releasing of perilous and poisonous waste and other appraisal standards of ecological management performance. Choosing an appropriate supplier is about to convert to an important factor for organizations and companies in order to implement Green supply chain

management and to achieve economically benefit and grow in social and competitive environment (He, et al., 2008).

2.5.9 Risk Management

The CSC is very intricate while dynamic that may enhance risk excessively. A Manager needs to recognize and handle suck risks in an attempt to administer the SC successfully. By having this aim, risk management philosophies are of appreciated assistance in order to implement the Supply chain magnet tactics in the construction industry (Aloini , et al., 2012). Some of these SC managerial tactics are presented in the following:

- Monetary schedules: payment confidence; prompt or immediate payment. It is defined as trust establishment and inspiring compatibility in the SC. Contrariwise, downscale disbursement performance prevents optional activities by the SC.
- Design management: Unfinished design, change in design and late conversions are known as a foundation of substantial dissipation; these items disrupt the procedure of the every task involve, decrease effectiveness and swell the site manager's amount of work.
- General Management: competent communication skills, well-planned scheme, crew relation management, on-site communication can be outlined as the most important managerial elements that should be emphasized on.
- Value designation: in the other word "realistic pricing". Realistic levels can be recognized by project members to remain competitive in the market.
- SC integration: efficiently coordinating and using resources; (ECLLP, 2013)

2.5.10 Terrain Scanning Method

Applying TSM can deliver vision into SC implementation. Generally, it considers separate business procedures and the entire SC. the TSM targets to decrease the resources required in solving problems and at the same time, authorizing a high grade of scope. The main goal of the terrain scanning method is to take a complete and procedure orientated vision of the SC, in an impartial, logical method, with a least of human and time source. Main principals of TSM is mentioned in following:

- Identify and classify the business partners least activities related to their SC (the way of their cooperation).
- Identify the pointes that should be improved in works been done individually and procedures within the company, among business SC jointing levels, TSM yields affecting the construction industry.
- Supporting and promoting the standardized outcomes related to components SC developments.
- Deliver fundamental and innovational “quick hits not quick fixes” and theories in changing programs for permanent benefit. (Barker, et al., 2000)

2.5.11 Enterprise Resource Planning (ERP)

Numerous SCM applications such as ERP methods are reachable in market for supporting organization integration. Yet, such gadgets are typically made for large organizations in the manufacturing industry and may not be suitable for CSCM, because of the fragmentation and project form character of CSC and usually small to medium scale of construction companies. Furthermore, ERP methods that are a prevalent key to SC incorporation suffer from many of barriers and limits (Cheng, et al., 2010). The theories and strategies of Briscoe & Dainty litreture for achiving a better construction supply chain integration is summerised in tabel 2.1:

Table 2.1. (Briscoe & Dainty, 2005) SC Definitions

Subject	Definition
Managing communication	Some companies prefer long tender consultation times for their leading projects. However by using contractors in this phase, the customer could be able to make the negotiations stronger.
Customer secure commitment and project aim	Insisting on having a long-term relationship with costumer over several projects or contracts can grow a strong allegiance to contractor that ends in better performance and dependable work in long duration.
Managing information flow	When there is a lack of confidence in customer-contractor relationship, having an efficient flow of info is very challenging while it is known as an essential to effective SC incorporation for construction projects.
Workmanship for solving problems	In order to reduce SC problems at initial steps quick move is needed, lunching a protocol to face contentions and other issues is an indispensable aspect of the foundation of high efficiency SC in construction projects.
Alignment of supply chain systems	It is believed that having supplier and customer's managerial systems in project line is a key factor in an efficient SC. It is indicated that almost all of companies related to any project have their own dissimilar managerial framework and procedure.

Engineering additional values	Some believed that enough proficiency already exist in the commercial direction sector, if the involvement happen in the early stages of construction it is possible to get the most out of it. Moreover there are claims related to integration tactics while adding extra works to the project.
High-quality standard	Improving quality have been always a goal, however it could be costly for a minor companies, so some managers depend on their customers to involve and fund many of these enterprises in quality.

2.6 Common CSC Implementation Challenges

In implementation and development of every single new philosophy, challenges and barriers arise. Undoubtedly identification and classification of these barriers at initial levels can smooth the way more efficiently. Accordingly number of barriers can be faced while the many stages of managing the material procedures comprising: procurement (bid and material), storage the material and its distribution. In the following these problems will be brightened up.

- Bid procurement troubles: in negotiating for budget, the constructor might be enforced to reduce the costs in order to please owner's budget limits, while the scope of the project remains untouched. Therefore, to reduce some of the construction costs, mainly number of least tasks will get under the pressure and finally it might cost quality for the whole project.

- Supplier selection difficulties: In some cases the supplier selection for any reason should be changed, experiencing new supplier can increase the risk in delivery time, quality, quantity and cost of procurement
- Material purchase difficulties: when a supplier is chosen, the manager practically has to pursuer the grade of particular material to make sure that the material reaches the site in specified quantity and time.
- Jobsite storage difficulties: A great number of sub-contractors have the experience of facing storage problems in the jobsite while there is no tension from the main contractor to take care of sub-contractors delivered materials however this kind of problems have been experienced with sub-contractors that are for small or least tasks (e.g. electrical contractors). (Misra, 2012)

2.6.1 Construction SC Integration Difficulties

From other literatures' case studies three of the key challenges (from other authors' point of view) are pulled out and argued bellow:

- Exchange and flow challenges: lack of effective development of communication systems within the elements of SC and reliable mechanism for problem solution for added values into the construction tasks.
- Systems and process challenges: lack of knowledge or insufficient knowledge distribution among all members of the chain.
- Collaboration challenges: Ignoring the necessity of coordination and secure commitment within the supply chain. (Briscoe & Dainty, 2005)

2.6.2 Small and Medium Enterprises (SME)

Industrial organizations in SME category are known as a significant barrier for evolutions from traditional business to developed ones. Particularly, SME struggles with difficulties to reach the same sources which large companies have access to,

such as proper data sources to make proportional decisions. In such organizations, collaboration with other companies (either small or big) in their SC is a preferable substitute that allows them to maintain competitive in the market. Methodologies and applications also characterize SME difference with large enterprises; as an illustration, for the implementation of electric interfaces within the performers in the Supply Chain. While large enterprises have the capital and other necessary resources to implement “e-business & e-supply” methodologies, SME struggles with resource limitations. (Capó-Vicedo, et al., 2001)

2.6.3 Bullwhip Effect

In SCM, a “Bullwhip Effect” has concerned extensive business leaders. Prof. Hau L. Lee was one of the first to bring up the ideology of Bullwhip Effect. Even though there is no noticeable transformation in clients’ need of specific product, but it can cause a pretty large oscillation in roster and transport delays. It occurs when data cannot be successfully shared and overbrowned in the progress of conduction from the customer to the main suppliers, which causes fluctuation of demand information in a large scale (Song, et al., 2010)

2.6.4 Material Delivery Challenges

Recent techniques that solves that traditional strategy downwards through making construction projects’ execution phase flexible, created extra problems to the progress of material delivery. These methods accept the difficulty of making a precise calendar earlier for an enormous, complex project. However, such approaches are based on nonstop scheduling on a single construction run.

The solution presented by Ala-Risku and Kärkkäinen depends on a tracking-based method for building inventory clearness of the inventory of the construction for

temporary SC, also a pro-active pattern for delivery of materials for defined project function. It is believed that this model is a novel notion for construction SC, however it is suggested that more case studies should be observed so that the practicality of this ideology being experienced as well as the academic solution. (Ala-Risku & Kärkkäinen, 2006)

Chapter 3

METHODOLOGY

3.1 General

Doing research is an improvement through discovering causes and effects in a methodical and well-ordered manner (Philip E., et al., 2005). In order to have an effectual implementation of CSCM among Iran organizations and companies, selecting an appropriate method is indispensable. Therefore, a proper designed survey questionnaire based on the literature review achievements, questioning the industry's experts and data collection based on the current culture and needs of Iran construction industry is proposed in this piece of work. Since this is a quantitative survey and collected data without an in-depth analysis is worthless, therefore in order to have an effective analysis first the reliability of the survey is done by SPSS then correlation analysis is done using Microsoft Excel spread sheet in order to find the relation between valuables and finally hypothesis testing using t-test method by SPSS program to find the significance of the factors is done.

The Microsoft speared sheet has various benefits to the user, the pre-defined statistical formals which can be found in analysis tool Pak was used for the correlation analysis in this research.

3.2 Proposed Survey

The literature review has come up with elements that are counted as either strength or threat for supply chain management in different sectors but generally in construction industry. Although a survey has verity of advantages such as

practicality, ease of understanding the statistical society that is under study and many other benefits, it should be considered that the questionnaire design should be well-thought in order to have precise analysis and more importantly useful framework and future needs.

Therefore, in this study based on the reviewed literature in implementation of supply chain management in Iran construction industry, the questionnaire is a combination of 5 sections that each of them designed to discussed a unique topic as follow:

- General information
- Construction relationships and its subsets in SCM
- Influence of different factors helping the CSCM implementation
- Benefits of an efficient implementation of CSCM
- SCM implementation barriers or difficulties

Each of these sections contains number of questions that finalizes the needed information in detail. Moreover, beside section one's questions that are about the respondent's profile and related general information, questions in other sections are designed based on the impact level and necessity of subsets that will be discussed later on. In order to simplify process of implementation of CSCM in this piece of work, in figure below (figure 3.1) the main framework of design and purpose of the questionnaire is illustrated.

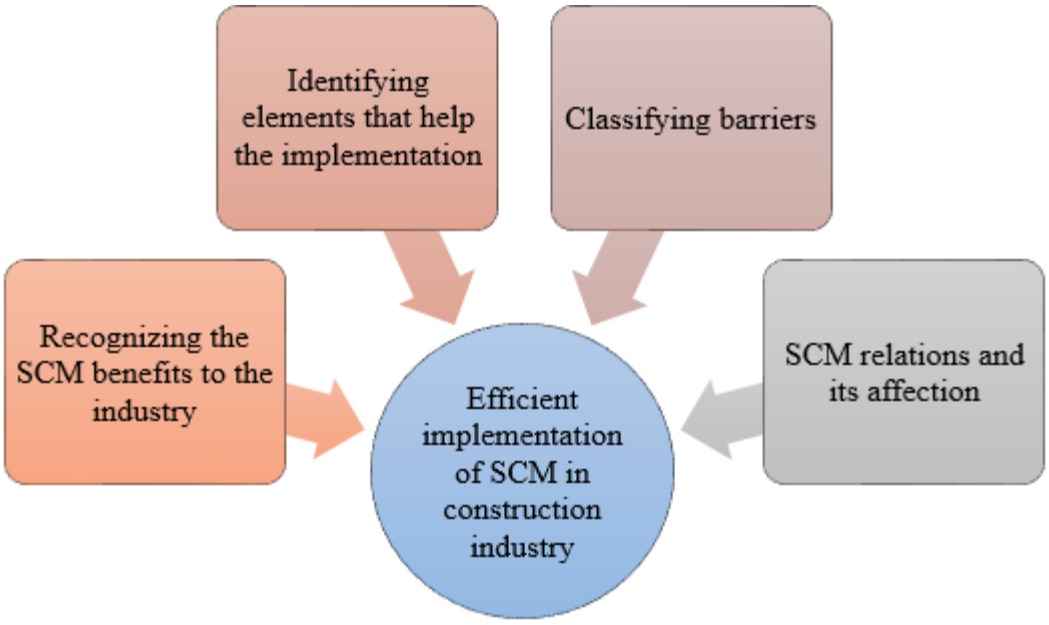

Figure 3.1. Implementation's elements clustering

Throughout the literature review from the construction industry whether globally or in-house to supply chain in construction and other industries, lots of factors that have either positive or negative impact on implementation of supply chain management have been carefully studied and the most important ones where discussed in this piece of work. In the table 3.1 the key factors in the literature review is narrowed down into questions in order to use in the survey to analyze the Iran construction current state of affairs.

Table 3.1. Questionnaire reference table

	Question topic	**Resource**
	What is the significance of the long-term relationship with customers (and what are the benefits)	(Akintoye, et al., 2000), (Briscoe & Dainty, 2005)

	What is the significance of the long-term relationship with suppliers (and what are the benefits)	(Akintoye, et al., 2000)
Impact of different factors on implementation	Understanding the concept and Significance of the implementation of SCM	(Morledge, et al., 2009),
	Transportation and Service delivery problem studies	(Vrijhoef & Koskela, 2000)
	Industrialization, especially pre-fabrication	(Warszawski, 1990)
	Inventory	(Song, et al., 2010)
	Lean production management	(Forgues & Koskela, 2009)
	BIM (Building Information Modeling) generally 4D and 5D BIM designs	(Zhang & Hu, 2011)
	Appling advanced technologies like TSM (train scanning methodology), ERP (Enterprise resource planning), IT, etc.	(Barker, et al., 2000), (Cheng, et al., 2010)
	Concept of Green Supply Chain Management (GSCM) (since the environmental standards makes the production under pressure.)	(He, et al., 2008)
	Direct relation between supplier and customer using web based trading	(Castro-Lacouture, et

	mechanism (business to business or B2B)	al., 2007)
	Proper Risk identification and studies at early stages	(Pryke, 2009)
benefits of an efficient implementation	Overall project cost reduction	(Vrijhoef & Koskela, 2000),
	Decrease the duration (time) of projects	(Vrijhoef & Koskela, 2000),
	Quality improvement	(Thomas, et al., 2002)
	Able to solve low productivity	(Aloini , et al., 2012)
	Reducing waste creation	(ECLLP, 2013), (Jalbani, 2010)
	Significant improve in labor management	(Vrijhoef & Koskela, 2000)
	Overall improvement in site internal difficulties (Basically procurement problems e.g. Job site storage and material handling problems etc.)	(Misra, 2012)
Barriers	Lack of trust	(Davis, 2008)
	Lack of top management commitment	(Grönroos, 1996)
	Customer-supplier nonexistence or poor communication	(Akintoye, et al., 2000)
	Economic systems based on small and	(Capó-Vicedo, et al.,

	medium sized enterprises (SME)	2001)
	Lake of focus on subcontractor identification	(Khalid, et al., 2006)
	Priced-based selection	(Capó-Vicedo, et al., 2001)
	Loss of tendency to implement new technologies (e.g. IT, BIM, Online Vehicle Tracking etc.)	(Zhang & Hu, 2011), (Hassan Issa & Abu Bakar, 2013)
	Uncertainty in benefits	(Anderson, et al., 2007), (Akintoye, et al., 2000)
	Lack of sequential procedure (Building interior decisions postponements)	(Newman, 1992)
	Fragmented characteristics of the construction projects	(Love, et al., 2004)

As declared before, each of stated sections is made from aspects that narrow the survey to smallest detachable elements which assists to make the complex process of CSCM implementation straightforward and efficient. However, not necessarily each of these components has equal impact (comparing with other elements) on SCM implementation. Therefore, the impact level of each question is asked from the respondents as it is demonstrated in table 3.2.

Table 3.2. Impact level definition

Impact level	Description
1:Very low	The item have almost NO effect on the aspect.
2:Low	The element have little influence on the subject.
3:Moderate	There is a 50/50 chance of having effect on the issue.
4:High	The element is lucky to have an effect on the subject.
5:Very High	There is a strong belief that the remarked item have an complete influence on the subject

3.3 Data Collection & Analyses

The prepared questionnaire is distributed by email among the Iran construction experts, engineers and some other stakeholders. In order to have an inclusive investigation the respondents chosen where directly in touch with the industry at the time and have faced Iran construction industry upwards and downwards and asked about the threats and strengths of implementation and current situation of construction relationships.

The filled forms are collect in the same way of distribution and analyzed by the IBM SPSS (Statistical Package for the Social Sciences) software for analyzing the reliability of the test and other statistical issues and for better data analysis illustration, preparing figures and charts, Microsoft Excel and Microsoft Visio 2013 are used. There might be other common programs out in the market as well, nevertheless, professional programs such as SPSS are able to make the job more accurate and as it offers wide range of charts which by visualizing the outputs it make the data analysis more understandable.

3.4 Analyzing Method

Statistically, there are various ways of analyzing the reliability and relevancy and closeness of collected data and SPSS program is a proper software that offers clean and screen techniques for such evaluations. SPSS is programmed to leave no doubt that the output is analyzed by different means.

In this research different analysis are done; for determining the importance of the factors RII (relative importance index) method is used, also factor analysis and reliability test have been done in addition to correlation between factors test (Pearson correlation analysis) , and hypothesis testing (T-test).

3.4.1 Reliability Test

As the name speaks for itself this testing method is able to do the reliability check of the stability and consistency of the collected data. This theory apply the Cronbach's alpha that generally measures an interaction among a data set (Yitmen, et al., 2011). The range of Cronbach's alpha (α) is from zero to 1 which shows the interaction or consistency of data set by enlarging from zero to one and the acceptable point is equal or bigger than 0.7 . This test can be simply done by SPSS however it is wort to know the meaning the results of this test, the table below illustrates the Cronbach's alpha and the consistency relations (see table 3.3).

Table 3.3. Cronbach's alpha consistency (George & Mallery, 2003)

Cronbach's α (alpha)	Internal Consistency rank
$\alpha < 0.5$	Unacceptable
$0.5 \leq \alpha < 0.6$	Poor
$0.6 \leq \alpha < 0.7$	Questionable
$0.7 \leq \alpha < 0.8$	Acceptable

3.4.2 Correlation Analysis

Correlation analysis is through the determination the linear relationship and correlation between variables can be measured by this tool. The achieved values can be somewhere between ±1, where they relatively show the negative and positive correlation. The figure 3.2 demonstrates the relations of Pearson Correlation Analysis.

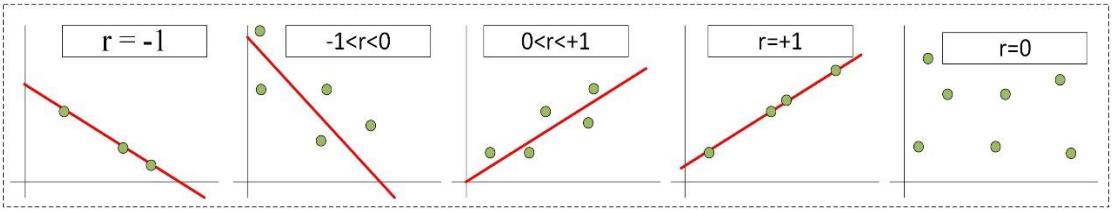

Figure 3.2. Factor correlations illustration (Cohen, et al., 2013)

Undoubtedly there is also defined acceptance boundaries for the correlation values just like the other tools that mentioned previously. These limits are illustrated in table 3.4:

Table 3.4. Correlation value range strength (Cohen, et al., 2013)

correlation coefficient	Acceptance level
-0.3 ≤ r ≤ 0.3	Weak
-0.7 ≤ r < -0.3 or 0.3 < r ≤ 0.7	Moderate
-1 ≤ r < -0.7 or 0.7 < r ≤ 1	Strong

As it is shown in the table 3.3 the strong relation range of r is above between -1 to -0.7 and +0.7 to +1 where the negative value illustrates a strong divers relation, otherwise the value correlation might be moderate and weak.

3.4.3 T-Test Method for Hypothesis Testing

In order to find the significant level of each factor the hypothesis testing should be done, one of the best ways to do such testing is the T-test which can be done by SPSS program. In this method the null hypothesis is acceptable if $\rho \leq 0.05$ (As the *significant value* is a dependent of **ρ**) and unquestionably it will be rejected if $\rho \geq 0.05$. Generally all these presented tools for statistical analysis are pre-assumed in the program but it is worth to check in the program settings in order to avoid faulty results. Montgomery has defined T-test in the way described below:

y1, y2, y3 … yi: a sample (a response)

n: size of the sample

D_f : Degrees of freedom

$\bar{y}$: mean of sample

S: Standard deviation

$SE_{\bar{y}}$: Standard error mean

μ: Hypothesized mean

Mean $=\frac{\sum_i^n y_i}{n}$ S$=\sqrt{\frac{\sum_i^n (y_i-\bar{y})}{n-1}}$ $SE_{\bar{y}}=\frac{S}{\sqrt{n}}$ t$=\frac{\bar{y}-\mu}{SE_{\bar{y}}}$:

From the table 3.5 if the given t (with the alpha and calculated standard deviation) is smaller than the calculated t then the hypothesis is proven right and the factor is significant. (Montgomery, 2001)

Table 3.5. Percentage Points of the t Distribution *(Montgomery, 2001)*

ν \ α	.40	.25	.10	.05	.025	.01	.005	.0025	.001	.0005
1	.325	1.000	3.078	6.314	12.706	31.821	63.657	127.32	318.31	636.62
2	.289	.816	1.886	2.920	4.303	6.965	9.925	14.089	23.326	31.598
3	.277	.765	1.638	2.353	3.182	4.541	5.841	7.453	10.213	12.924
4	.271	.741	1.533	2.132	2.776	3.747	4.604	5.598	7.173	8.610
5	.267	.727	1.476	2.015	2.571	3.365	4.032	4.773	5.893	6.869
6	.265	.727	1.440	1.943	2.447	3.143	3.707	4.317	5.208	5.959
7	.263	.711	1.415	1.895	2.365	2.998	3.499	4.019	4.785	5.408
8	.262	.706	1.397	1.860	2.306	2.896	3.355	3.833	4.501	5.041
9	.261	.703	1.383	1.833	2.262	2.821	3.250	3.690	4.297	4.781
10	.260	.700	1.372	1.812	2.228	2.764	3.169	3.581	4.144	4.587
11	.260	.697	1.363	1.796	2.201	2.718	3.106	3.497	4.025	4.437
12	.259	.695	1.356	1.782	2.179	2.681	3.055	3.428	3.930	4.318
13	.259	.694	1.350	1.771	2.160	2.650	3.012	3.372	3.852	4.221
14	.258	.692	1.345	1.761	2.145	2.624	2.977	3.326	3.787	4.140
15	.258	.691	1.341	1.753	2.131	2.602	2.947	3.286	3.733	4.073
16	.258	.690	1.337	1.746	2.120	2.583	2.921	3.252	3.686	4.015
17	.257	.689	1.333	1.740	2.110	2.567	2.898	3.222	3.646	3.965
18	.257	.688	1.330	1.734	2.101	2.552	2.878	3.197	3.610	3.922
19	.257	.688	1.328	1.729	2.093	2.539	2.861	3.174	3.579	3.883
20	.257	.687	1.325	1.725	2.086	2.528	2.845	3.153	3.552	3.850
21	.257	.686	1.323	1.721	2.080	2.518	2.831	3.135	3.527	3.819
22	.256	.686	1.321	1.717	2.074	2.508	2.819	3.119	3.505	3.792
23	.256	.685	1.319	1.714	2.069	2.500	2.807	3.104	3.485	3.767
24	.256	.685	1.318	1.711	2.064	2.492	2.797	3.091	3.467	3.745
25	.256	.684	1.316	1.708	2.060	2.485	2.787	3.078	3.450	3.725
26	.256	.684	1.315	1.706	2.056	2.479	2.779	3.067	3.435	3.707
27	.256	.684	1.314	1.703	2.052	2.473	2.771	3.057	3.421	3.690
28	.256	.683	1.313	1.701	2.048	2.467	2.763	3.047	3.408	3.674
29	.256	.683	1.311	1.699	2.045	2.462	2.756	3.038	3.396	3.659
30	.256	.683	1.310	1.697	2.042	2.457	2.750	3.030	3.385	3.646
40	.255	.681	1.303	1.684	2.021	2.423	2.704	2.971	3.307	3.551
60	.254	.679	1.296	1.671	2.000	2.390	2.660	2.915	3.232	3.460
120	.254	.677	1.289	1.658	1.980	2.358	2.617	2.860	3.160	3.373
∞	.253	.674	1.282	1.645	1.960	2.326	2.576	2.807	3.090	3.291

ν = degrees of freedom.

[a] Adapted with permission from *Biometrika Tables for Statisticians*, Vol. 1, 3rd edition, by E. S. Pearson and H. O. Hartley, Cambridge University Press, Cambridge, 1966.

Chapter 4

SURVEY ANALYSIS AND RESULT

4.1 General

In this part the analysis and discussions about the survey outcomes are made. In order to have an efficient co-operation in implementation of SCM in construction industry, the survey questioner file was sent by E-mail to over 200 construction experts (e.g. civil engineers, architectures, contractors etc.) who was selected within the survey described limitations. Luckily 103 of respondents replied and they have accomplished the survey completely. The statistics was analyzed with IBM SPSS program and by equal to 0.765 Cronbach's Alpha, the survey was successfully reliable. (See the appendix)

4.2 Analysis of Respondents' Profile

In the survey the first eight questions are allocated to the respondents profile and his or her background information. The organization type of most of the respondents was Civil Engineering Contractor (69%) by having big difference with other types (the closest type is the investment companies that are 10 percent of the population) of companies in construction industry are shown in the chart below (figure4.1):

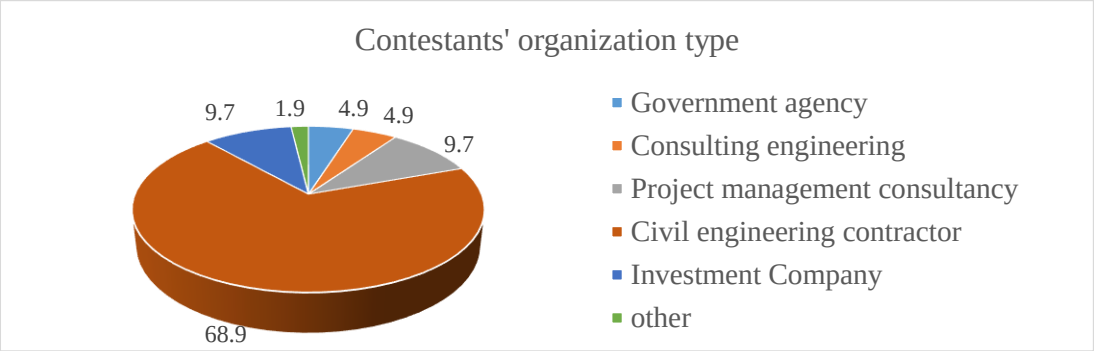

Figure 4.1. Respondents' organization type

And from the chart 4.2, specialization or the field of study of each respondent can be seen. As it was predictable from organization chart, the biggest group of respondents are civil engineers and the rest are shown below.

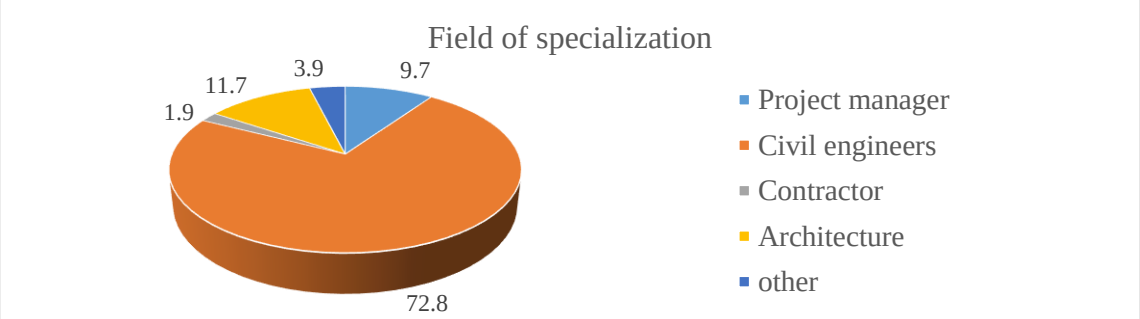

Figure 4.2. Field of specialization

Additionally the respondents were asked about their experience in their career, the most common years of experience was 4 to 6 years however the second big cluster of respondents' years of experience were 7 to 10 years which is noticeably helpful to use in the survey. The pie chart below (chart 4.3) shows the proportion of the respondents in this content.

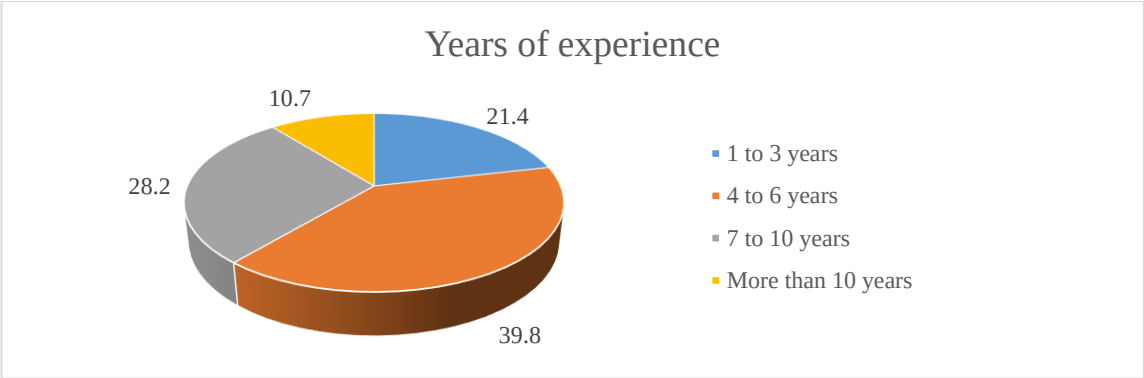

Figure 4.3. Respondents' years of experience

Also the number of projects that each of respondents was involved in the last 5 years is illustrated in chart 4.4. Approximately just under 40% of the respondents have been working in 10 to 15 projects in last 5 years and almost 30 percent of them have experienced more than 15 projects in that period.

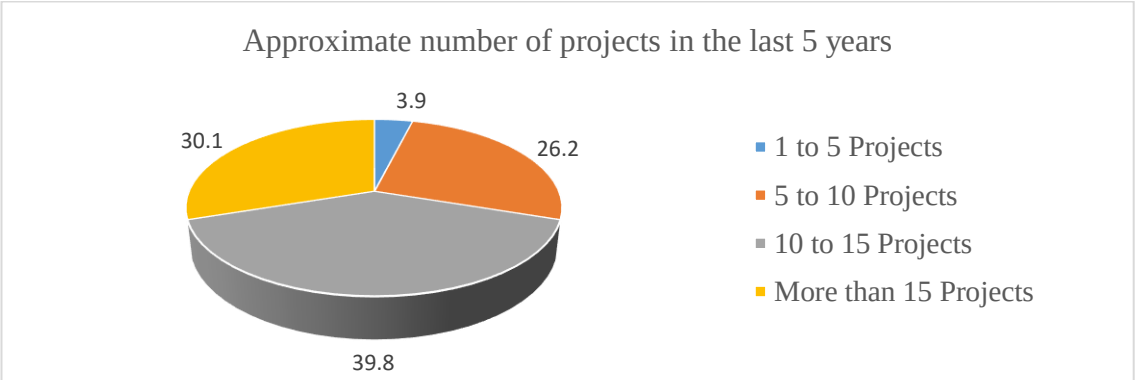

Figure 4.4. Approximate projects in last 5 years

The approximate number of employees was mostly selected as 30 to 45 (by almost 36% of respondents) followed by 15 to 30 (selected by 30.1% of respondents) as it is illustrated in the pie chart below (chart 4.5).

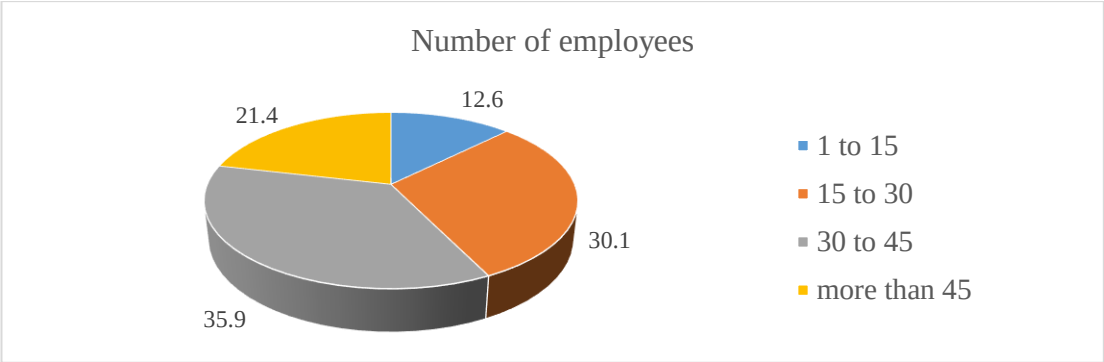

Figure 4.5. Number of workers/employees

The number of subcontractors was also questioned and like the projects it is decided to be in the last five years which seems to be important period. The results are shown in the pie chart below (chart 4.6). Two main clusters that were selected were less than fifty and between 50 to 100 sub-contractors, with almost same share of 41 percent.

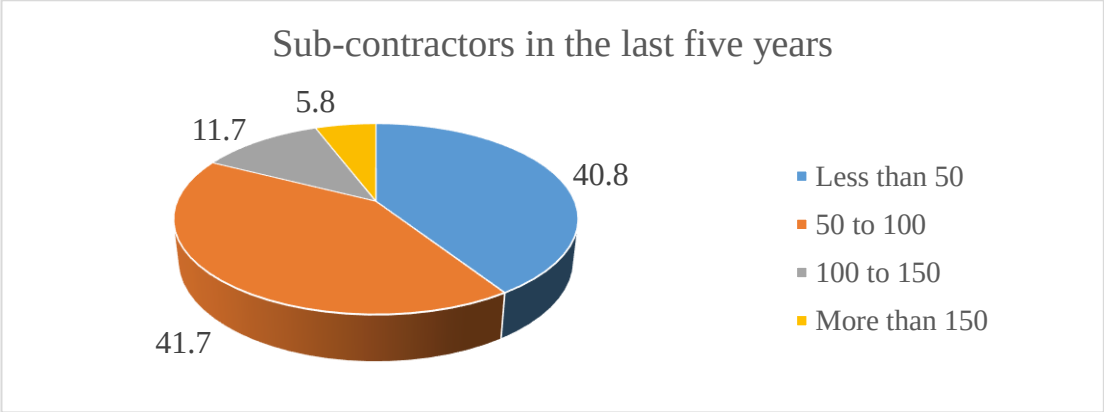

Figure 4.6. Number of sub-contractors

Finally the last question that was asked in first section about the respondents' professional background was the annual revenue of their company which was surprisingly answered generously by all of the respondents. With big difference to the second choice (27% Approx.), the 0.5$ to 1$ million piece with 60% of the population stands out and other information is illustrated in the chart 4.7.

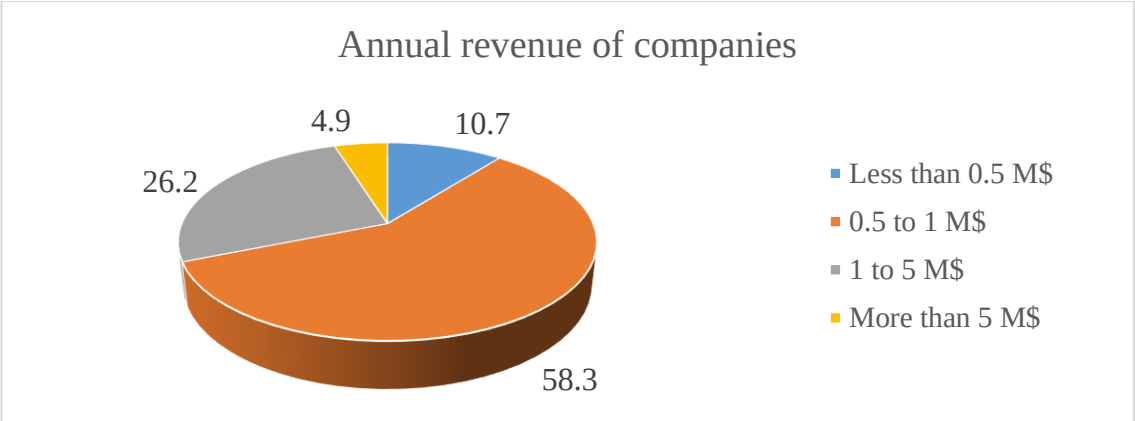

Figure 4.7. Approximate annual revenue

4.3 Correlation Analysis

Since the purpose of this thesis is to develop a proper framework in order to implement SCM in Iran construction industry, therefore a very strong correlation between all variables taking a part in that framework is necessary. The design of this test is to recognize the relation between the drivers or barriers, which is essential for this type of survey. The comparison between variables is made to find whether the survey questions were homogenous or not, or what is the statement of the correlation of the factors. The meaning of correlation numbers are clarified in previous chapter, according to that we are looking for numbers above (+0.7) since the statement of this number strong and it illustrates direct relation between factors. Before the analysis table (table 4.2) the legend table (table 4.1) is prepared to simplify the understanding of the factors. Moreover in fallowing the average of the responds to each of valuables are indicated in table 4.3.

Table 4.1. Variables legend

Legend		Variable
SCM relationships	Q9	Customer long-term relationship
	Q10.1	Competitiveness enhancement
	Q10.2	Better client service
	Q10.3	Supply chain reduction
	Q11	Suppliers long-term relationship
	Q12.1	streamline the construction process
	Q12.2	streamline the purchasing process
	Q12.3	Simplify paper works
SCM drivers	Q13.1	Understanding the concept of SCM
	Q13.2	Transportation and Service delivery problem studies
	Q13.3	Industrialization, especially pre-fabrication
	Q13.4	Inventory
	Q13.5	Lean production management
	Q13.6	BIM generally 4D and 5D BIM designs.
	Q13.7	Applying advanced technologies like TSM, ERP, IT, etc.
	Q13.8	Concept of GSCM
	Q13.9	Web based direct relation between supplier and customer
	Q13.10	Proper Risk identification and studies at early stages
Benefits of SCM	Q14.1	Project cost reduction
	Q14.2	Decrease the duration (time) of projects
	Q14.3	Quality improvement
	Q14.4	Solve low productivity issues
	Q14.5	Reducing waste creation
	Q14.6	Labor management significant improvement
	Q14.7	Site internal difficulties (Basically procurement) improvement
SCM implementation barrier	Q15.1	Lack of trust
	Q15.2	Lack of top management commitment
	Q15.3	Customer-supplier nonexistence or poor communication
	Q15.4	Lake of focus on subcontractor identification
	Q15.5	Economic systems based on small and medium sized enterprises

	Q15.6	Priced-based selection
	Q15.7	Loss of tendency to implement new technologies
	Q15.8	Uncertainty in benefits
	Q15.9	Lack of sequential procedure
	Q15.10	Fragmented characteristics of the construction projects

Table 4.2. Survey average respond results

(%)	Q9	Q10.1	Q10.2	Q10.3	Q11	Q12.1	Q12.2	Q12.3	Q13.1	Q13.2	Q13.3	Q13.4	Q13.5	Q13.6	Q13.7	Q13.8	Q13.9	Q13.10
very	29	0	7.7	0	1.9	7.7	0	1	1	1	0	3.9	1	0	0	1.9	0	6.8
low	1.9	0	0	1.9	0	0	1	1	1	0	0	4.9	1.9	0	0	10.7	1	1.9
modera	1.9	6	5	2.9	0	4.9	0	10.	3.9	6	6	8.7	7.8	2.9	1	3.9	5.1	1.9
high	11.7	7.9	9.6	11.7	6.8	14	10.8	14.	15.	19.6	8.7	22.	24.	5.8	10.	20.4	4.9	4.9
very	81.5	86.	77.	83.5	91.	76	88.2	72.	78.	73.2	85.	60.	65	91.	88.	63.1	92	84.
TOTAL	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**

(%)	Q14.1	Q14.2	Q14.3	Q14.4	Q14.5	Q14.6	Q14.7	Q15.1	Q15.2	Q15.3	Q15.4	Q15.5	Q15.6	Q15.7	Q15.8	Q15.9	Q15.10	
very	2.9	0	7.7	0	1.9	7.7	0	1	1	1	0	3.9	1	0	0	1.9	0	
low	1.9	0	0	1.9	0	0	1	1	1	0	0	4.9	1.9	0	0	10.7	1	
modera	1.9	1	1	2.9	0	4.9	0	10.	3.9	5.8	1	8.7	7.8	2.9	1	3.9	0	
high	11.7	7.9	13.	11.7	6.8	14	6.8	14.	15.	19.4	8.7	22.	24.	5.8	10.	20.4	14.	
very	81.6	91.	77.	83.5	91.	76	92.2	72.	78.	73.8	90.	60.	65	91.	88.	63.1	87.	
TOTAL	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**	**103**	

Table 4.3. Correlation test results

	Q9	Q10.1	Q10.2	Q10.3	Q11	Q12.1	Q12.2	Q12.3	Q13.1	Q13.2	Q13.3	Q13.4	Q13.5	Q13.6	Q13.7	Q13.8	Q13.9	Q13.10	Q14.1	Q14.2	Q14.3	Q14.4	Q14.5	Q14.6	Q14.7	Q15.1	Q15.2	Q15.3	Q15.4	Q15.5	Q15.6	Q15.7	Q15.8	Q15.9	Q15.10
Q9	1.00																																		
Q10.1	0.97	1.00																																	
Q10.2	0.94	0.99	1.00																																
Q10.3	0.98	0.99	0.97	1.00																															
Q11	0.89	0.93	0.96	0.95	1.00																														
Q12.1	0.98	0.99	0.92	0.97	0.99	1.00																													
Q12.2	0.88	0.96	0.94	0.97	0.93	0.95	1.00																												
Q12.3	0.97	0.95	0.98	0.93	0.95	0.96	0.99	1.00																											
Q13.1	0.95	0.93	0.94	0.96	0.95	0.96	0.99	0.95	1.00																										
Q13.2	0.94	0.97	0.93	0.93	0.98	0.99	0.98	0.93	0.90	1.00																									
Q13.3	0.98	0.89	0.92	0.97	0.90	0.95	0.98	0.99	0.95	0.99	1.00																								
Q13.4	0.97	0.95	0.88	0.98	0.88	0.97	0.96	0.98	0.91	0.99	0.97	1.00																							
Q13.5	0.89	0.93	0.97	0.97	0.83	0.94	0.96	0.93	0.98	0.92	0.96	0.94	1.00																						
Q13.6	0.97	0.95	0.94	0.93	0.97	0.92	0.91	0.99	0.99	0.98	0.90	0.92	0.95	1.00																					
Q13.7	0.90	0.94	0.98	0.93	0.93	0.90	0.98	0.95	0.96	0.92	0.93	0.97	0.97	0.95	1.00																				
Q13.8	0.94	0.89	0.97	0.98	0.90	0.97	0.97	0.93	0.92	0.98	0.97	0.99	0.98	0.96	0.98	1.00																			
Q13.9	0.89	0.95	0.88	0.95	0.93	0.95	0.92	0.98	0.88	0.98	0.96	0.95	0.95	0.88	0.95	0.96	1.00																		
Q13.10	0.92	0.95	0.90	0.93	0.88	0.89	0.95	0.98	0.98	0.93	0.88	0.92	0.89	0.92	0.91	0.95	0.93	1.00																	
Q14.1	0.97	0.93	0.92	0.96	0.92	0.92	0.89	0.95	0.92	0.96	0.96	0.96	0.95	1.00	0.94	0.96	0.99	0.90	1.00																
Q14.2	0.88	0.95	0.94	0.90	0.95	0.99	0.94	0.98	0.91	0.89	0.97	0.95	0.95	0.90	0.92	0.96	0.92	0.99	0.93	1.00															
Q14.3	0.97	0.96	0.93	0.92	0.95	0.96	0.92	0.94	0.93	0.94	0.96	0.96	0.96	0.88	0.90	0.97	0.98	0.88	0.94	0.97	1.00														
Q14.4	0.98	0.96	0.94	0.98	0.97	0.97	0.94	0.97	0.98	0.98	0.97	0.92	0.98	0.89	0.98	0.93	0.96	0.95	0.97	0.85	0.94	1.00													
Q14.5	0.96	0.93	0.91	0.99	0.98	0.99	0.92	0.93	0.95	0.97	0.91	0.93	0.93	0.90	0.92	0.93	0.95	0.95	0.98	0.98	0.94	0.93	1.00												
Q14.6	0.93	0.89	0.98	0.99	0.97	0.98	0.97	0.92	0.94	0.98	0.98	0.88	0.89	0.97	0.98	0.91	0.97	0.96	0.97	0.91	0.97	0.99	0.95	1.00											
Q14.7	0.97	0.95	0.94	0.90	0.89	0.94	0.88	0.93	0.92	0.98	0.94	0.97	0.96	0.90	0.96	0.97	0.92	0.91	0.95	0.94	0.90	0.93	0.92	0.98	1.00										
Q15.1	0.96	0.93	0.97	0.92	0.96	0.93	0.98	0.93	0.99	0.94	0.98	0.96	0.95	0.90	0.92	0.96	0.97	0.90	0.93	0.88	0.92	0.96	0.98	0.97	0.90	1.00									
Q15.2	0.96	0.93	0.95	0.96	0.94	0.92	0.94	0.97	0.90	0.97	0.95	0.91	0.93	0.94	0.95	0.98	0.93	0.97	0.94	0.93	0.94	0.98	0.98	0.97	0.95	0.93	1.00								
Q15.3	0.89	0.89	0.91	0.99	0.98	0.99	0.98	0.99	0.88	0.89	0.93	0.94	0.99	0.98	0.93	0.92	0.98	0.97	0.98	0.97	0.98	0.91	0.95	0.99	0.98	0.98	0.99	1.00							
Q15.4	0.96	0.93	0.92	0.94	0.95	0.95	0.96	0.99	0.95	0.99	0.93	0.97	0.89	0.92	0.93	0.97	0.95	0.88	0.97	0.98	0.88	0.97	0.99	0.98	0.88	1.00	0.95	0.93	1.00						
Q15.5	0.99	0.97	0.99	0.99	0.98	0.99	0.92	0.89	0.96	0.96	0.91	0.99	0.99	0.98	0.99	0.99	0.92	0.97	0.98	0.89	0.93	0.96	0.92	0.96	0.91	0.98	0.91	0.97	0.98	1.00					
Q15.6	0.97	0.93	0.93	0.91	0.99	0.92	1.00	**0.99**	0.95	0.93	0.94	0.91	0.96	0.97	0.98	0.97	0.98	0.94	0.97	0.97	0.98	0.97	0.93	0.98	0.97	0.96	0.95	0.99	0.95	0.98	1.00				
Q15.7	0.89	0.96	0.97	0.92	0.97	0.97	0.91	0.93	0.96	0.96	0.94	0.97	0.97	0.93	0.96	0.98	0.90	0.99	0.97	0.93	0.93	0.98	0.99	0.98	0.95	0.96	0.92	0.90	0.92	0.93	0.92	1.00			
Q15.8	0.95	0.93	**0.83**	0.96	0.95	0.94	0.94	0.91	0.96	0.97	0.89	0.98	0.97	0.94	0.95	0.92	0.93	0.85	0.94	0.93	0.85	0.97	0.97	0.99	0.94	0.94	0.98	0.97	0.89	0.97	0.94	0.95	1.00		
Q15.9	0.96	0.9	0.91	1.00	0.98	0.93	0.95	0.99	0.99	0.98	0.90	0.96	0.96	0.88	0.95	0.97	0.9	0.88	0.98	0.93	0.95	0.97	0.93	0.98	0.97	0.96	0.94	0.98	0.88	0.98	0.88	0.90	0.94	1.00	
Q15.10	0.93	0.93	0.91	0.95	0.92	0.96	0.97	0.90	0.95	0.89	0.90	0.98	0.98	0.93	0.91	0.98	0.92	0.95	0.97	0.95	0.96	0.98	0.90	0.97	0.95	0.96	0.97	0.99	0.97	0.89	0.90	0.92	0.96	0.91	1.00

Table 4.2 illustrates the percentage of responds to each question of the survey and by having the quick look it can be assumed that by utilizing this table (table 4.2) the analysis for the correlation test could be run which resulted in table 4.3. The result of the correlation test in table 4.3 indicates a very accurate and homogenous survey where the least correlation between the variables is 0.83 which is over the lower limit (0.7) for strong correlation between them and also all the correlation numbers are positive values which illustrates the direct relationship among the survey questions and factors.

4.4 Relationships in CSCM

In this part for the t-test the hypothesis based on the relations are made. As suppliers and customers are two of the most important stockholders of construction industry and construction projects therefore theses stakeholders relations were took under investigation. The first null hypothesis is H_1: there is a significant interaction between customer relations and SCM success. The table 4.4 illustrates the t-test.

Table 4.4. T-test results for Q9

	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Customer long-term relationship	4.6505	.94670	.09328	17.694	103	.000

As it can be seen in the table 4.4, t=17.694 and $p= 0.000 < 0.005$, and since the hypothesis cannot be rejected therefore it can be concluded that this factor is significantly affecting the construction supply chain management improvement.

Since construction customer long-term relation have an effect on the construction supply chain process, then the factors that strengthen by customer relationship should

be evaluated. The first variable is competitiveness enhancement, the H_1 is described as if the customer long-term relation have a noteworthy effect on competitiveness enhancement. The table 4.5 illustrates the result.

Table 4.5. T-test results for Q10.1

	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
competitiveness enhancement	4.9515	.25739	.02536	76.947	103	.000

The long-term customer relationship has a great effect on competitiveness enhancement since t=76.947 and $p= 0.000 < 0.005$ which represents a very significant interaction between this two issues.

Better client service is believed to be influenced by the customer relations. The H_1 will be described as: the better customer relations affect the client service. The table 4.6 indicates a very significant interaction between the client service and long term customer relationship (t=11.544 & $p= 0.000 < 0.005$)

Table 4.6. T-test results for Q10.2

	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Better client service	4.4757	1.29739	.12784	11.544	103	.000

Third variable that questioned from the respondents was the supply chain reduction as the result of the customer long-term relation. The H_1: the supply chain reduction does have a vital effect on the customer relations since the hypothesis (t=30.016, p=

$0.000 < 0.005$) cannot be rejected (table 4.7), it can be conclude that this variable have a strong positive interaction with the subject.

Table 4.7. T-test results for Q10.3

	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Supply chain reduction	4.7670	.59744	.05887	30.016	103	.000

The other type of relations in construction process that was considered is supplier long term relations. The hypothesis H_1 is: the supplier long-term relations does have an impact on the SCM implementation in construction industry, the results of the t-test in table 4.8 ($t= 25.549$ & $p= 0.000 < 0.005$) indicates that the hypothesis cannot be rejected and the supplier long-term relations have a very significant on the CSCM implementation. Additionally by comparing the means of this variable with the customer long-term relations ($Q11= 4.7670 > 4.6505 = Q9$) it can be deduced that there is an agreement that this variable have more influence on CSCM than customer relations.

Table 4.8. T-test results for Q11

	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Supplier long term relations	4.8350	.72891	.07182	25.549	103	.000

As it mentioned before the long term supplier relation is a very significant factor in construction SCM implementation the valuables that are related to this issue were asked from respondents. The first valuable that is affected by this manner is

streamlining the construction process. The H_1 is: the long-term supplier relation streamlines the construction process. The t-test results (t= 12.133 & p= 0.000 < 0.005) shows a strong relation between this factor and the long-term supplier relation as the table 4.9 illustrates the results.

Table 4.9. T-test results for Q12.1

	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Streamline construction process	4.4369	1.20188	.11842	12.133	103	.000

The second valuable that is affected by the construction supplier long-term relation is streamline the purchasing process. The H_1: purchasing process may be affected by the supplier long-term cannot be rejected therefore long-term relations have a great impact on the purchasing process (table4.10) (t=50.312 and p= 0.000 < 0.005).

Table 4.10. T-test results for Q12.2

	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Streamline purchasing process	4.9029	.38385	.03782	50.312	103	.000

4.5 Impact of Different Drivers on SCM

This part will discuss the t-test result of the integration of the drivers of the implementation of supply chain management in construction industry which is done by SPSS program. Factors and drivers for an efficient implementation that were extracted from the literature review by the writer are subjected to question from the respondents. In the following the results will be discussed.

The first factor that were asked was understanding the concept and significance of the implementation of SCM. The null hypothesis was H_1 = the understanding of the concept have a significant effect on the implementation which was not rejected by the test ($t=25.223$ & $p= 0.000 < 0.005$). Therefore, from the results (table 4.11) it can be deduced that the understanding the concept and significance of the implementation of SCM has a very strong integration with the effective supply chain implementation.

Table 4.11. T-test results for Q13.1

	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Understanding the concept of SCM	4.6990	.68363	.06736	25.223	103	.000

The transportation and service delivery problem studies was suggested by many literature therefore this driver was asked from the contestants and the test results ($t=24.568$ & $p= 0.000 < 0.005$). Shows the very significant correlation between transportation and service delivery problem studies and success in the SCM implementation the table 4.12 shows the t-test results.

Table 4.12. T-test results for Q13.2

	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
transportation and service delivery problem studies	4.6505	.68182	.06718	24.568	103	.000

In order to have an efficient SCM implementation and proper framework Industrialization, especially pre-fabrication is highly recommended. Since the

hypothesis (H_1: the industrialization, essentially does have an effect on the SCM implementation) cannot rejected by t= 56.430 & p= $0.000 < 0.005$ in table 4.13 and it can be said that industrialization is an unescapable step to achieve a proper implementation.

Table 4.13. T-test result for Q13.3

	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Industrialization, especially pre-fabrication	4.8932	.34049	.03355	56.430	103	.000

Lean production management is believed as one of the important factors that have an integration with the SCM. This belief is supported by testing the hypothesis of H_1 = supply chain management is affected by the lean production management with t=19.023 & p= $0.000 < 0.005$ (see table 4.14). Therefor it can be concluded that this item has a very significant integration with the subject.

Table 4.14. T-test result for Q13.5

	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Lean Production management	4.5049	.80286	.07911	19.023	103	.000

BIM (Building Information Modeling) generally 4D and 5D BIM designs were one of the subjects that discussed widely and the results deduce a very immense interaction between this issue and supply chain management implementation and proposing an efficient framework. The t-test hypothesis ($H_{1=}$ there is an interaction between BIM and the successful implementation of CSCM) has accepted with t=

47.381 & p= 0.000 < 0.005 (see table 4.15). Consequently BIM and it subsets have significant interaction with the CSCM success.

Table 4.15. The t-test results for Q13.6

	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
BIM, generally 4D and 5D	4.8835	.40344	.03975	47.381	103	.000

The other drivers for the CSCM implementation were Applying advanced technologies like TSM (train scanning methodology), ERP (Enterprise resource planning), IT, etc. the hypothesis was H_1: advanced techs does have an interaction with CSCM implementation. The t-test results in table 14.16 illustrates the accepting the hypothesis (t=52.547 & p= 0.000 < 0.005) so these technologies have a significant interaction with CSCM implementation framework.

Table 4.16. T-test results for Q13.7

	Mean	Std. Deviation	Std. Error Mean	t	df	Sig. (2-tailed)
Advanced techs. IT, ERP, TSM, etc.	4.8738	.36190	.03566	52.547	103	.000

Direct relation between supplier and customer using web based trading mechanism (business to business or B2B) have been tested to see whether this factor have impact on the implementation or not. The hypothesis of H_1 = B2B does have a considerable interaction with the CSCM implementation have been tested by SPSS and the t-test results in table 4.17 (t=53.869 & p= 0.000 < 0.005) indicates a very strong

interaction between direct relation between supplier and customer using web based trading mechanism and supply chain implementation.

Table 4.17. T-test result for Q13.9

Direct relation between supplier and customer using web based trading mechanism	Mean	Std. Deviation	Std. Error Mean	t	d_f	Sig. (2-tailed)
	4.8223	.36216	.03569	53.869	103	.000

The analysis of proper risk identification and studies at early stages as the last factor that can be benefit the implementation is done. The H_1: risk identification have an extensive correlation with the CSCM implementation ($t=11.516$ & $p= 0.000 < 0.005$). It is deduced that risk identification plays a very significant role in implementing CSCM. (See table 4.18)

Table 4.18. T-test results for Q13.10

Proper Risk identification and studies at early stages	Mean	Std. Deviation	Std. Error Mean	t	d_f	Sig. (2-tailed)
	4.5146	1.33478	.13152	11.516	103	.000

4.6 Benefits of SCM in Construction Companies

This section discuss about the benefits that can be gained through the construction SCM implementation for the construction companies. In this part also t-test method has done with the SPSS program and deliberations are made in the following. The table 4.19 contains the the results of the hypothesis test of the benefits that can be achived by the implementation CSCM. The hypothesis that were made in order to

prove the benefits of implementing SCM to construction companies is provided in fallowing:

- H_1 CSCM decreases the construction overal cost
- H_2 Implementation of CSCM reduces the duration (time of the project)
- H_3 There is a significant quality improvement in implementatio of CSCM
- H_4 Low productivity issues can be solved by implementin SCM
- H_5 Construction SCM implementation have impact on waste mangement
- H_6 Lobor management and CSC have a significant interaction
- H_7 CSCM can benefit the overall improvement in site internal difficulties (Basically procurement problems e.g. Job site storage and material handling problems etc.)

The table 4.19 deduce the result of the t-test of all hypothesis mentioned respectively. As it can be see from the table, all of the hypothesises were rejected and this proves the benefits of implementation of SCM in construction industry. Moreover, the significant (2-tailed) of all of these hypothesis are $p = 0.000 < 0.005$ which indicates a very significant interaction between each of these advantages and the SCM implementation. However, means of these advantages are a little different from each other. By comparison the means, it can realize there is a strong believe that the possibility of achieving cost and time reduction, quality improvement and site procurement management is more realistic than waste reduction and other advantages.

Table 4.19. T-test analysis for survey section 4

	Mean	Std. Deviation	Std. Error Mean	t	d_f	Sig. (2-tailed)
Overall project cost reduction	4.9223	.30323	.02988	64.339	103	.000
Decrease the duration (time) of projects	4.8932	.44087	.04344	43.582	103	.000
Quality improvement	4.8835	.54774	.05397	34.899	103	.000
Able to solve low productivity	4.1359	1.33614	.13165	8.628	103	.000
Reducing waste creation	4.4660	1.04615	.10308	14.222	103	.000
Significant improve in labor management	4.4660	.86109	.08485	17.279	103	.000
Overall improvement in site procurement difficulties	4.8641	.42122	.04150	44.914	103	.000

4.7 SCM Implementation Barriers

Without any doubt in implementing any concept in any industry, there will be difficulties and barriers and construction supply chain management implementation is not an exception. According to that in the literature review the possible barriers and difficulties were extracted and questioned from the respondents. The statistical analysis had been done by SPSS program and the t-test results will be discussed in following. One of the main barriers in implementation CSCM in Iran construction industry is lack of trust. In the T-test the hypothesis the H_1: there is no interaction between lack of trust and implementation barriers. As the t-test results in table 4.20 illustrates ($t= 56.095$ & $p= 0.000 < 0.005$) the hypothesis is rejected. It can be concluded that lack of trust in Iran construction industry plays very significant role.

Therefore studies around lack of trust as constrain in SCM management or construction stockholders should be done in order to remove this barrier.

Table 4.20. T-test results for Q1501

	Mean	Std. Deviation	Std. Error Mean	t	d_f	Sig. (2-tailed)
Lack of trust	4.9126	.34604	.03410	56.095	103	.000

Lack of top management commitment also was indicated as a barrier in related literatures therefore this item was asked and the respondents' answers are analyzed. H_1: lack of commitment does not have any negative affect on the SCM implementation. Table 4.21 deduce the results of the t-test which is not rejected ($t=15.132$ & $p= 0.000 < 0.005$). However although this valuable is accepted by the hypothesis testing, comparing the means of top management commitment and the trust shows the significance of the lack of trust (mean=4.9126) as a barrier comparing with top management commitment (mean= 4.3689)

Table 4.21. T-test results for Q15.2

	Mean	Std. Deviation	Std. Error Mean	t	d_f	Sig. (2-tailed)
Lack of top management commitment	4.3689	.91812	.09047	15.132	103	.000

Another factor that was tested with SPSS is communication, whether there is no communication through customer and supplier or there is a poor one. In the test the H_1: there is correlation between Customer-supplier nonexistence or poor communication with the negative impact on the supply chain implementation was not

rejected with t= 27.076 & p= 0.000 < 0.005. Consequently, this factor is also a very significant barrier in the implementation (see the results in table 4.22).

Table 4.22. T-test results for 15.3

between Customer-supplier nonexistence or poor communication	Mean	Std. Deviation	Std. Error Mean	t	d_f	Sig. (2-tailed)
	4.6796	.62956	.06203	27.076	103	.000

Lake of focus on subcontractor identification is believed as the next barrier in implementing supply chain management in the literature, therefore construction experts were asked whether they are agree with this subject. The hypothesis H_1: Having no subcontractor identification does expressively affect the implementation was made and cannot rejected by SPSS t-test (see table4.23) (t= 56.430 & p= 0.000 < 0.005). Thus the lack of subcontractor identification can be counted as a very significant barrier and there should be an investment on this type of work.

Table 4.23. T-test results for Q15.4

Lack of subcontractor identification	Mean	Std. Deviation	Std. Error Mean	t	d_f	Sig. (2-tailed)
	4.8932	.34049	.03355	56.430	103	.000

When it comes to choose between suppliers usually the sort of selection comes out as a trouble. Priced based selection is another item that was asked from the respondents and the test results (t=56.430 & p= 0.000 < 0.005) shows the accepting in table 4.24 the H_1: the price based selection have impact on the implementation. Accordingly selecting suppliers based only on the price is believed to make trouble in further collaboration and experts should avoid such behavior.

Table 4.24. T-test result for Q15.6

	Mean	Std. Deviation	Std. Error Mean	t	d_f	Sig. (2-tailed)
Priced based selection	4.8932	.34049	.03355	56.430	103	.000

As SCM implementation barrier uncertainty in benefits of stockholders is another problem that holds the implementation back. Therefore this item was asked from the industry experts. Hypothesis of H_1: uncertainty in benefits holds back the implementation is tested and as the table 4.25 illustrates the results the ($t= 10.310$ & $p= 0.000 < 0.005$) telling that this item also have a significant impact on the implementation. Undoubtedly, the benefits of this technique can be brighten up to the stakeholders by studies like this one proven to Pessimists in the long term run.

Table 4.25. T-test results for Q15.8

	Mean	Std. Deviation	Std. Error Mean	t	d_f	Sig. (2-tailed)
Uncertainty in benefits	4.1262	1.10861	.10923	10.310	103	.000

Lack of sequential procedure (Building interior decisions postponements) is another issue which is practicing in large scales in Iran construction industry, and it is believed that this matter have an effect on the construction supply chain management implementation, the hypothesis H_1: there will be problems in CSCM implementation if there is a lack of sequential procedure. The SPSS t-test results in table 4.26 ($t=58.731$& $p= 0.000 < 0.005$) illustrates the hypothesis cannot be rejected and constructors should be aware of such problems and try to finalize the design

decisions in the beginning of the work so that the chain of the does not break in the idle of the construction.

Table 4.26. T–test result for Q15.9

	Mean	Std. Deviation	Std. Error Mean	t	d_f	Sig. (2-tailed)
Lack of sequential procedure	4.9029	.32883	.03240	58.731	103	.000

The last item that was believed as a barrier in implementing SCM in Iran construction industry is the fragmented characteristics of the construction projects which was asked by the survey and the statistical analysis deduce a correctness of the H_1 : fragmented characteristics of the construction projects does interfere with the implementation of SCM (t= 13.958 & p= $0.000 < 0.005$). From the table 4.27 it can be see that the mean of this variable is not as high as others but still there is an agreement on the importance of the impact of this factor on implementation and it is worth to be attentive to such barriers.

Table 4.27. T-test results for Q15.10

	Mean	Std. Deviation	Std. Error Mean	t	d_f	Sig. (2-tailed)
fragmented characteristics of the construction projects	4.4369	1.04478	.10395	13.958	103	.007

4.8 Proposing a Framework

In the literature review many items related to CSCM have been studied and a conceptual framework was developed however, through the survey questionnaire these studies have been discussed with the construction experts. In addition, each of

these discussions covers an area related to the SCM implementation from the drivers, to barriers. Therefore, as tests have proven the reliability, correlation between variables and to the subjects, it can said that a reliable framework can be developed in order to have an efficient SCM in Iran construction industry.

As it can be seen in the framework (figure 4.8) there are four major concerns related to construction supply chain management implementation from the top of the framework to bottom these areas respectively are: drivers, construction relations (divided into supplier and costumer relations), barriers and benefits and each of them are narrowed to smallest elements that have highest impact in the implementation.

These Drivers namely are: “understanding the SCM concept”, “Industrialization”, “Procurement management”, “BIM”, “Advanced technologies”, “Initial risk identification” and “B2B web based direct costumer supplier relations”. The logic of these drivers are employed from previous researches as follow: (Morledge, et al., 2009), (Warszawski, 1990), (Zhang & Hu, 2011), (Cheng, et al., 2010), (Pryke, 2009), and the long-term relationship for suppliers’ elements are: “Simplifying the construction process” and “Simplifying the purchasing process” and for long-term costumer relationship factors are: “Competitive enhancement”, “Better client service” and “Supply chain reduction”. Also the idea of construction relationship factors and benefits are from (Akintoye, et al., 2000) and (Briscoe & Dainty, 2005) researches. The barriers that should be putted aside from the industry are: “Lake of trust”, “Priced based selection”, “Lake of top management commitment”, “Uncertainty in benefits”, “Non-existence or poor customer supplier relations”, “Fragmented characteristics of construction projects”, “Lake of sequential procedure”, “Transportation and service delivery problems” and “ Lake of

subcontractor identification". Like the other two areas of the research the concept of barriers section is gained from (Davis, 2008), (Khalid, et al., 2006), (Anderson, et al., 2007), (Love, et al., 2004), (Hassan Issa & Abu Bakar, 2013) researches. Consequently, by taking the mentioned steps the achievements will be: "Time and cost reduction", "Solving the low productivity problems", "Quality improvement"' and "Site procurement improvement". (Vrijhoef & Koskela, 2000) (Aloini , et al., 2012) (Jalbani, 2010) (Misra, 2012). Additionally the shape and formation of the framework is designed by the writer by getting the idea and combining (Olsson, 2000), (Vrijhoef, et al., 2005) and (Behera, et al., 2015) literatures and applying the mentioned titles into the framework.

The input of the framework is the "traditional construction supply chain" and by having the "SCM control unit" the drivers will be correctly implemented and relations will be controlled and correct decisions will be made by the SCM team and necessary actions will be taken. However in order to achieve the mentioned benefits (outputs) of CSCM implementation at the end of the framework in Iran construction industry the barriers should be considered and excluded from the business habits. However, some of the barriers like lack of trust cannot be removed by the SCM control unit overnight and it might take longer time than implementing the drivers or filtering other barriers (for instance transportation delivery problems) and rapid practice, continues study and analysis of the industry status is recommended in order to achieve the maximum advantage from this framework.

The general idea of the proposed framework was developed after getting assistance from other frameworks that were in the same field like (Vaidyanathan & Howell, 2007) and (Samaranayake, 2005).

4.8.1 Main Benefits of Proposed Framework and How to Achieve Them

Although every variable in the framework has its own value, in order to recognize how the proposed framework will work the fallowing context explains the most important benefits and how to achieve them. The analysis of the results illustrate that some of the variables are more important than the others since the mean of them was ranked higher than the others. Four of main benefits of the implementation of CSCM respectively are: Quality improvement, Project Time reduction, Project Cost reduction and site procurement improvement.

The long-term supplier relations is ranked a key factor in the CSC implementation, the clear understand of the contractor needs, construction site condition, the amount and the specification of the material needed can be result of this factor. The mentioned benefits can be counted as quality characteristics of the finished product or more importantly the project quality. Long-term relations also can help to reduce lack of Trust in a long term.

Despite the benefits of BIM in time reduction in construction projects as a whole, project early stage sub-contractor identification reduces the risk of having delays during the construction process and customer long-term relation gives the contractor or manager a clear understand of the needs so that the reworks and changes will be minimum moreover this would help the sequential procedure and all in all the duration or time of the project will be reduced.

The co-operation of BIM, RFID, Pre-fabrication, lean production and service delivery management are believed to benefit project cost, by means of analyzing the project cost with BIM and send the information to cloud system, allow to

manufacturer to use updated information with the aim of pre-fabricate the materials as much as possible and managing to deliver right amount of material at the right time by getting benefit from lean production management and advanced technologies (RFID) at construction site.

The procurement management itself is vast area of study, many variables have either direct or indirect effect of the procurement and procurement itself have effects on other benefits on construction project. Mainly web based direct relation of supplier and project manager with assistance of on time service delivery can minimize the site storage area, duration and related waste production since these factor can help to remove the unnecessary storage areas. As an illustration the long term metal storage can cause corrosion and strength failure despite the site area that is left over to finish after the storage have got empty. Therefor the procurement as one of the most important factors and be improved.

Nonetheless these implementations without controlling cannot be successful, therefore it is recommended to have an active SCM control unit by the framework. This control unit based on the size of the project can differ, in Small or Medium size enterprises the unit can be defined as duties to the construction management office by clearly identifying the concept to the managers and employees or in the large scale projects it can be a SCM control team in addition to the existing construction management head office. Overall the duties are the same and applying drivers, controlling the relations and filtering barriers should be done by this unit.

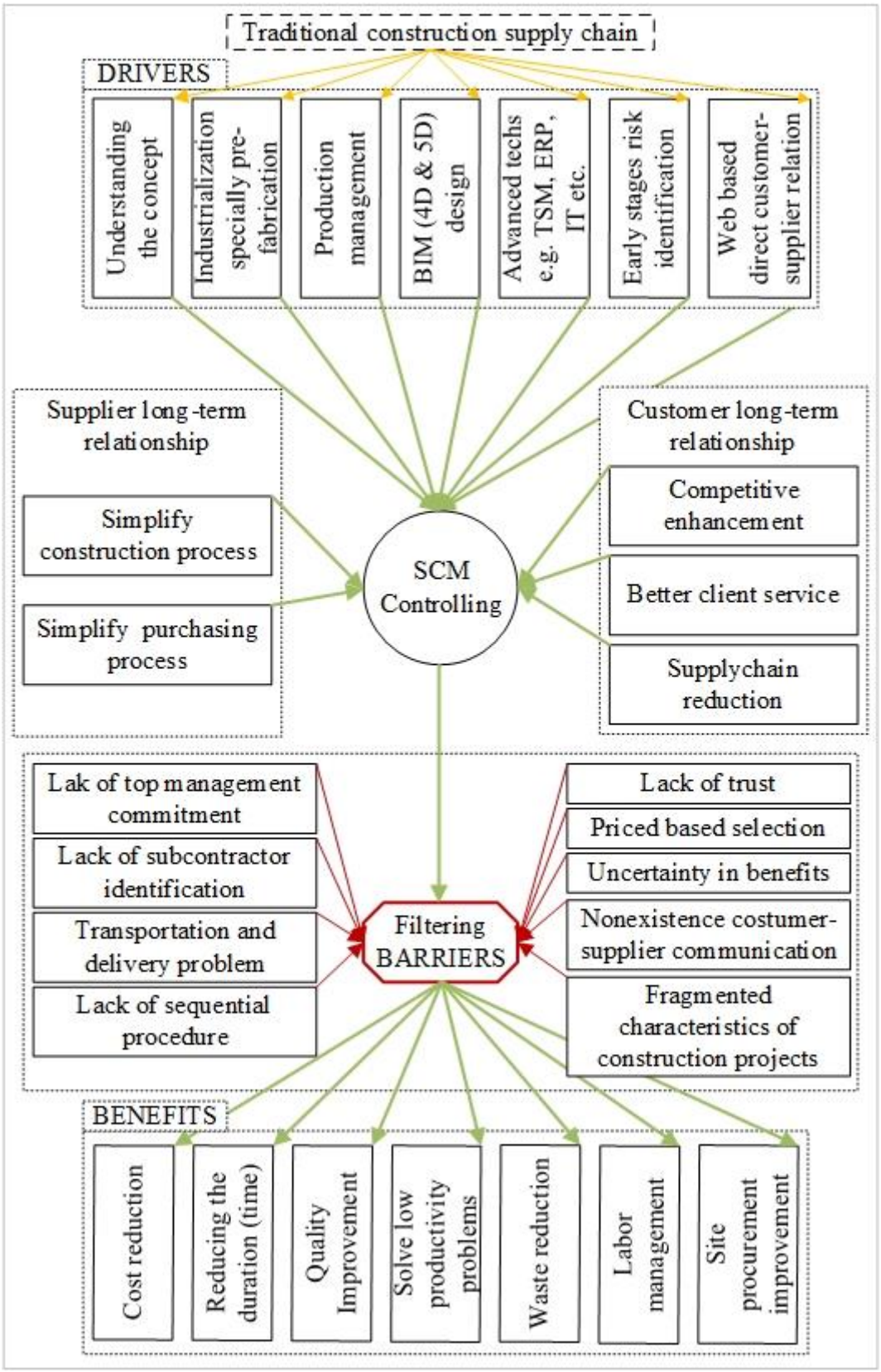

Figure 4.8. Supply chain management implementation proposed framework

4.9 Case Study and Evaluation of Framework

To do the evaluation of the frame work and the applicability of it, first study the current condition and overall specifications of a project situated in Iran is done. The construction is situated near a very critical highway (Afarinesh highway) in Shiraz, Iran. Figure 4.9 illustrates the condition of the case study project.

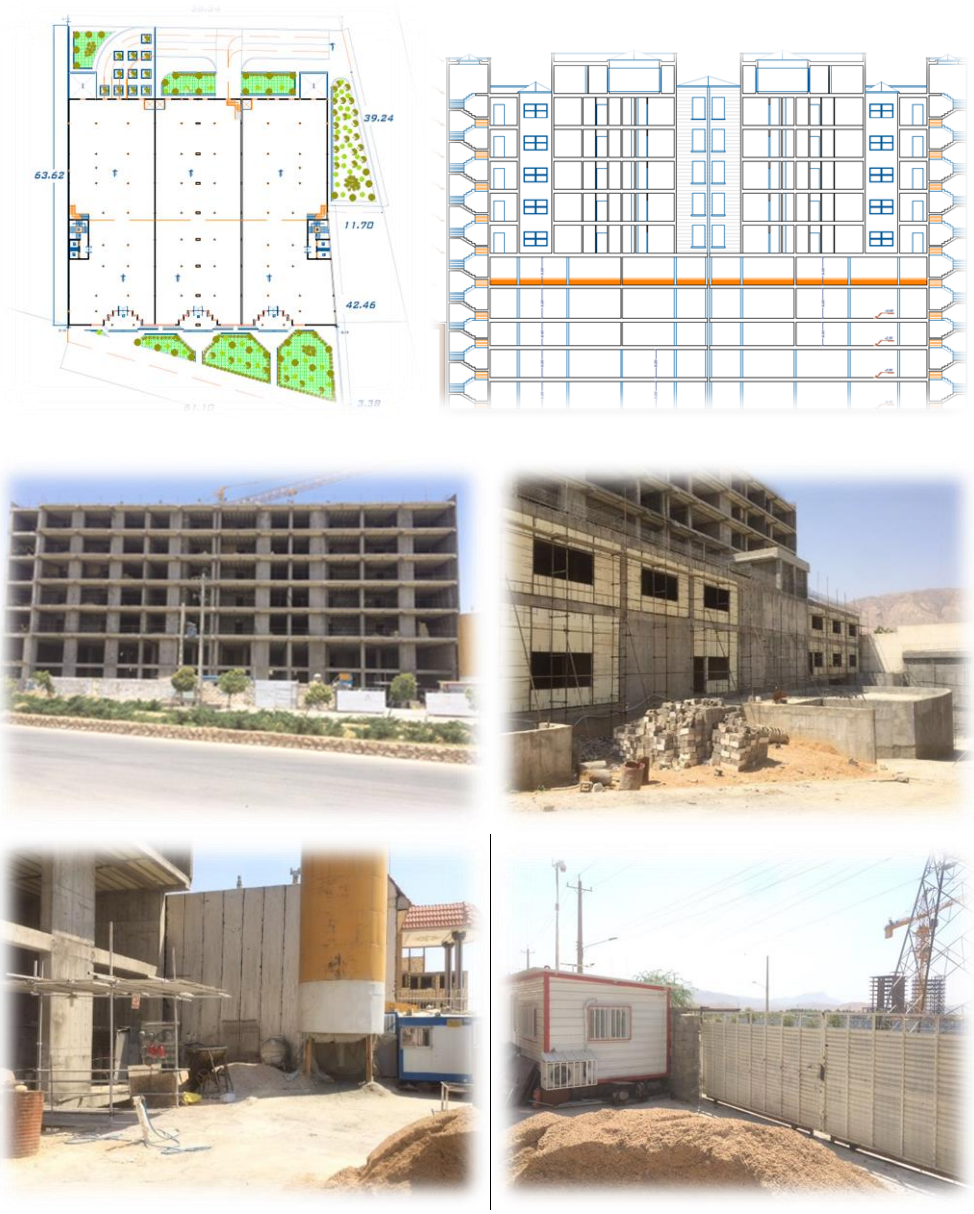

Figure 4.9. Case study illustration

The project structure is concrete and it is founded on 4900 m^2 land. The overall construction area is 24000 m^2 distributed in ground floor (as commercial) and 82 residential apartments in 9 floors above with their parking lots located in underground floors. The construction process has taken over three years and it has made almost 40% progress and it belongs to private sector Despite some minor new techniques in constructing walls and using precast concrete in making columns and roofs, this project is identified as traditional based since there is no foot print of new techniques like PM scheduling, 4D and 5D in BIM, IT, etc.

The manager claims that due to site soil behavior, the 12meters excavation could be done by using the soil nailing technique in order to prevent soil collapse in neighbors land. To do so the project was stopped for couple of months to find a proper subcontractor and to wait for specified sub-contractor to finish other work in another project and come to this site to do the soil nailing job. This delay can be resulting due to lack of early stage and appropriate sub-contractor identification web based direct relations and SC separation. On the other hand the project applied precast concrete (which can be categorized as part of industrialization or pre-fabrication) in roofs and columns therefore the process duration reduced and stakeholders achieved predicted homogenous quality all around the structure for specified job.

Moreover, since over 80% of the land is under construction and despite the concrete structure other jobs are done in-house, procurement and storage management is a very critical issue in this projects. Additionally, common problems like neighborhood claims as result of sound and other pollutions, uncertainty stockholders of the progress made and extended duration and some other problems that are believed to be able to solve by implementing SC have been identified.

4.9.1 Framework Evaluation

The case study have been done and some problems regarding the project progress have been identified. In order to analyze and evaluate the study proposed framework, the case study project manager have been questioned and asked about the impact level of applying the most important factors of CSC and the key benefits that may achieved by implementation. The table 4.28 illustrates how the project manager have ranked the key problems and their potential solutions.

Table 4.28. Interview results

Question No.		1:Very low	2:Low	3:Moderate	4:High	5:Very High
1	To what extend do you believe the proper application and integration of BIM, Pre-fabrication, lean production and service delivery management can benefit the project **cost** of the project?	**1**	**2**	**3**	**4**	**5** **X**
2	To what extend do you believe the supplier long-term relation can benefit the trust and specified **quality** of material that you required?	**1**	**2**	**3**	**4**	**5** **X**
3	Despite the benefits of BIM to **time** reduction, to what extent do you believe early stage risk and Sub-contractor identification may reduce the **duration** of the project?	**1**	**2**	**3**	**4**	**5** **X**
4	To what extent Do you believe Direct relations with supplier in addition to a proper flow of information can benefit the site **procurement** management and site **storage** difficulties?	**1**	**2**	**3**	**4** **X**	**5**
5	By hiring a **SCM control team** or clearing the concept to your team and applying the framework how much do you think it can help the mentioned difficulties?	**1**	**2**	**3**	**4**	**5** **X**

As a result of the discussion (table 4.28) the project manager agreed that even in the current condition of the project (with the jobs that have been done and futures works to do), the application of the mentioned techniques in a right way by getting assistance from the SC control unit can reduce project cost and duration in addition to quality and site procurement improvement. Therefore, the evaluation of the framework for the case study illustrates that the implementation of supply chain in construction framework is feasible and it could assist the construction process.

Chapter 5

CONCLUSION AND RECOMMENDATION

5.1 General

The aim of this research was about the implementation of supply chain management in Iran construction industry by analyzing the responsiveness of Iranian construction experts through the survey and within the explained limitations and develop a framework. The effort of this chapter is to response to the research questions extensively, summarize the achievements and recommend further works which, from the writer point of view are beneficial for the management of the construction industry.

5.2 Discussion and Conclusion

Since this study was mainly covering all aspects of the supply chain management in Iran construction industry, therefore, in this part to ease the understanding for readers the items will be clustered in the order of: first the importance of implementing this phenomena in construction relationship (In Iran); second, main substances or drivers and their influence on the implementation; third, key benefits of efficient implementation of construction supply chain management; and forth, highest difficulties and barriers in implementation of supply chain management in this sector.

5.2.1 Construction Relations Effect on SCM Implementation

Construction relations in this study is divided in to two main portions the first one is the supplier relations and the second one is construction clients or customers

relationship. Although, as both suppliers and customers are very significant elements of construction relation that supply chain management has direct influence on them, the supplier relationships appears to be more significant from industry's experts' responds. So far the most sensitive substances that possibly will get benefit from the implementation of SC in supplier relationships are simplifying the material purchasing progress from the providers and easing the construction process which seems to have arduous situation in traditional situation of industry. Moreover, supply chain management's impact on the clients' and costumers' relationships cannot be ignored where the end product is sold or rented to.

Accordingly, CSCM have the capability to wave consumer relationship variables as well, three of the most significant costumer's relation elements that will be influenced by this framework, respectively are: development in market competition, better client service and supply chain reduction.

5.2.2 SCM Implementation Contributory Elements or Drivers

In construction industry many different factors are involved which might have influence on the SCM implementation. From the literature review the most important drivers that are related to CSC were selected, these drivers are believed as the key elements of the implementation of SC in Iran construction industry:

- Understanding the concept of SCM
- Industrialization, especially pre-fabrication
- Lean production management
- BIM generally 4D and 5D BIM designs.
- Applying advanced technologies like TSM, ERP, IT, etc.
- Web based direct relation between supplier and customer

- Proper Risk identification and studies at early stages

5.2.3 Advantages and Output of SCM Framework Implementation

The application Supply chain management implementation framework brings changes and challenges to every related sector from smallest enterprises in the industry to the political decision makers. Hence, SCM should be acknowledged and recognized by almost every party in the industry in addition to the majority in the society who are directly or indirectly connected to this business. In order to achieve this acceptance, the benefits of implementing SCM implementation occurrence should be clarified to stated population. In this this study have extracted the major benefits of SC to Iran construction industry:

- Project cost reduction
- Reducing the duration (time) of projects
- Quality improvement
- Solve low productivity issues
- Reducing waste creation
- Labor management significant improvement
- Site internal difficulties (Basically procurement) improvement

5.2.4 Barriers and Obstacles in SCM Implementation

Implementing unprecedented techniques is not a stress-free practice, it might brought challenges and difficulties. One of the methods that can simplify such progresses, is reviewing previous literature, experiences, lessons-learned and recommendations made by experts. Subsequently, based on such measures, prediction the possible barriers is proposed and take a correct actions is required. Thus, in this study the possible threats and obstacles were questioned from the experts and finally, after the

survey analysis these barriers in implementing SC in Iran construction industry are narrowed to:

- Lack of trust
- Lack of top management commitment
- Customer-supplier nonexistence or poor communication
- Lake of focus on subcontractor identification
- Transportation and service delivery problems
- Priced-based selection
- Uncertainty in benefits
- Lack of sequential procedure
- Fragmented characteristics of the construction projects

Understanding these key barriers, reviewing them in problem-solving sections in different stages of construction, settle them by control unit and synchronizing them with other subsets of construction industry (mainly drivers, relations and benefits) in the framework, makes the implementation of an efficient supply chain management, achievable.

As a result this study have responded the research questions by proposing the best possible conceptual framework with reliable and correlated subsets in order to implement SCM in Iran construction industry. (See Figure 4.8)

5.3 Recommendation for Future Studies

Basically this study has brighten up the application of SCM technique in general, proposed a framework and viewed different aspects of CSCM in Iran construction industry. Therefore, for further works it is recommended to narrow studies to:

- BIM implementation in construction supply chain management specially in supplier relationships
- Real-time cost analysis of SCM implementation as a standard in construction sector
- Integration of the construction supply chain costumer relationships with real state studies.
- Study and analysis the role of different sectors (private, governmental, etc.) of the industry in making the SC more beneficial.
- Procurement management integration with RFID technologies to benefit supply chain management studies especially in urban areas.
- Construction industrialization application and its limits in Iran.

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APPENDICES

Appendix A: sample of the questionnaire general information

Section1, general information

1. Contact info

Name and Surname	
Company Name	
Email Address	

2. What type of organization you work in?

- Government agency
- Consulting engineering
- Project management consultancy
- Civil engineering contractor
- Investment Company
- Manufacturer
- Other

3. What is your education or field of specialization in construction industry?

- Project manager
- Civil engineers
- Other
- Contractor
- Architecture

4. How many years of experience do you have in this field?

- 1 to 3 years
- 4 to 6 years
- 7 to 10 years
- More than 10 years

5. What is the approximate number of projects you were involved?

- o 1 to 5 Projects
- o 5 to 10 Projects
- o 10 to 15 Projects
- o More than 15 Projects

6. What is the approximate number of employees/workers you have?

- o 1 to 15
- o 15 to 30
- o 30 to 45
- o More than 45

7. How many subcontractor did you have in your recent projects? (Last 5 years)

- o Less than 50
- o 50 to 100
- o 100 to 150
- o More than 150

8. What is the approximate annual revenue of your company in million dollars? (If possible)

- o Less than 0.5 M$
- o 0.5 to 1 M$
- o 1 to 5 M$
- o More than 5 M$

Appendix B: sample of the questionnaire, construction relationship

Section 2, relations in SCM

9. What is the significance of the long-term relationship with customers? [19]

○ **Very low** ○ **Low** ○ **Moderate** ○ **High** ○ **Very High**

10. What are the benefits of long term relationship with customer? And how much they influence they have.

Question No.		**Not sure**	**1:Very low**	**2:Low**	**3:Moderate**	**4:High**	**5:Very High**
10.1	Competitiveness enhancement		**1**	**2**	**3**	**4**	**5**
10.2	Better client service		**1**	**2**	**3**	**4**	**5**
10.3	Supply chain reduction		**1**	**2**	**3**	**4**	**5**

(If any other please mention in question 16)

11. What is the significance of the long-term relationship with suppliers? And how much influence they have.

○ **Very low** ○ **Low** ○ **Moderate** ○ **High** ○ **Very High**

12. What are the benefits of long term relationship with supplier?

Question No.		Not sure	1:Very low	2:Low	3:Moderate	4:High	5:Very High
12.1	streamline the process of construction		**1**	**2**	**3**	**4**	**5**
12.2	streamline the process of purchasing		**1**	**2**	**3**	**4**	**5**
12.3	Simplify the paper work		**1**	**2**	**3**	**4**	**5**

(If any other please mention in question 16)

Appendix C: sample of the questionnaire. Influence of different factors on the CSCM

Section 3, Impact of different factors on SCM

13. What is the influence of mentioned factors on implementing supply chain management in Iran construction industry?

Question No.		Not sure	1:Very low	2:Low	3:Moderate	4:High	5:Very High
13.1	Understanding the concept and Significance of the implementation of SCM		**1**	**2**	**3**	**4**	**5**
13.2	Transportation and Service delivery problem studies		**1**	**2**	**3**	**4**	**5**
13.3	Industrialization, especially pre-fabrication		**1**	**2**	**3**	**4**	**5**
13.4	Inventory		**1**	**2**	**3**	**4**	**5**
13.5	Lean production management		**1**	**2**	**3**	**4**	**5**
13.6	BIM (Building Information Modeling) generally 4D and 5D BIM designs.		**1**	**2**	**3**	**4**	**5**
13.7	Applying advanced technologies like TSM (train scanning methodology), ERP (Enterprise resource planning), IT, etc.		**1**	**2**	**3**	**4**	**5**
13.8	Concept of Green Supply Chain Management (GSCM) (since the environmental standards makes the production under pressure.)		**1**	**2**	**3**	**4**	**5**
13.9	Direct relation between supplier and customer using web based trading mechanism (business		**1**	**2**	**3**	**4**	**5**

	to business or B2B)						
13.10	Proper Risk identification and studies at early stages		**1**	**2**	**3**	**4**	**5**

Appendix D: sample of the questionnaire, SCM benefits to the industry

Section 4, benefits of an efficient implementation of SCM in construction companies.

14. Benefits that could be achieved by implementation of SC in Iran construction industry.

Question No.		Not sure	1:Very low	2:Low	3:Moderate	4:High	5:Very High
14.1	Overall project cost reduction?		**1**	**2**	**3**	**4**	**5**
14.2	Decrease the duration (time) of projects?		**1**	**2**	**3**	**4**	**5**
14.3	Quality improvement		**1**	**2**	**3**	**4**	**5**
14.4	Able to solve low productivity		**1**	**2**	**3**	**4**	**5**
14.5	Reducing waste creation		**1**	**2**	**3**	**4**	**5**
14.6	Significant improve in labor management		**1**	**2**	**3**	**4**	**5**
14.7	Overall improvement in site internal difficulties (Basically procurement problems e.g. Job site storage and material handling problems etc.)		**1**	**2**	**3**	**4**	**5**

Appendix E: sample of the questionnaire, SCM barriers

Section 5, obstacles on the way of SCM implementation

15. Influence of the key barriers in Implementing SCM in Iran construction industry

		Not sure	1:Very low	2:Low	3:Moderate	4:High	5:Very High
15.1	Lack of trust		**1**	**2**	**3**	**4**	**5**
15.2	Lack of top management commitment		**1**	**2**	**3**	**4**	**5**
15.3	Customer-supplier nonexistence or poor communication		**1**	**2**	**3**	**4**	**5**
15.4	Lake of focus on subcontractor identification		**1**	**2**	**3**	**4**	**5**
15.5	Economic systems based on small and medium sized enterprises (SME)		**1**	**2**	**3**	**4**	**5**
15.6	Priced-based selection		**1**	**2**	**3**	**4**	**5**
15.7	Loss of tendency to implement new technologies (e.g. IT, BIM, Online Vehicle Tracking etc.)		**1**	**2**	**3**	**4**	**5**
15.8	Uncertainty in benefits		**1**	**2**	**3**	**4**	**5**
15.9	Lack of sequential procedure (Building interior decisions postponements)		**1**	**2**	**3**	**4**	**5**
15.10	Fragmented characteristics of the construction projects		**1**	**2**	**3**	**4**	**5**

16. If there is any other factor(s) that you believe it could have influence (either positive or negative) on implementation of CSCM please mention.

Appendix F: IBM SPSS reliability test results

```
RELIABILITY
  /VARIABLES=Q9 Q10.1 Q10.2 Q10.3 Q11 Q12.1 Q12.2 Q12.3 Q13.1 Q13.2
Q13.3 Q13.4 Q13.5 Q13.6 Q13.7
    Q13.8 Q13.9 Q13.10 Q14.1 Q14.2 Q14.3 Q14.4 Q14.5 Q14.6 Q14.7 Q15.1 Q15.2
Q15.3 Q15.4 Q15.5 Q15.6
    Q15.7 Q15.8 Q15.9 Q15.10
  /SCALE('ALL VARIABLES') ALL
  /MODEL=ALPHA
  /STATISTICS=DESCRIPTIVE SCALE
  /SUMMARY=TOTAL.
```

Reliability

Notes		
Output Created		17-APR-2016 18:10:59
Comments		
Input	Data	C:\Users\adaphone1\Documents\thesis.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	103
	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=Q9 Q10.1 Q10.2 Q10.3 Q11 Q12.1 Q12.2 Q12.3 Q13.1 Q13.2 Q13.3 Q13.4 Q13.5 Q13.6 Q13.7 Q13.8 Q13.9 Q13.10 Q14.1 Q14.2 Q14.3 Q14.4 Q14.5 Q14.6 Q14.7 Q15.1 Q15.2 Q15.3 Q15.4 Q15.5 Q15.6 Q15.7 Q15.8 Q15.9 Q15.10 /SCALE('ALL VARIABLES') ALL /MODEL=ALPHA /STATISTICS=DESCRIPTIVE SCALE /SUMMARY=TOTAL.
Resources	Processor Time	00:00:00.03
	Elapsed Time	00:00:00.05

Scale: ALL VARIABLES

Case Processing Summary

		N	%
Cases	Valid	103	100.0
	Excluded[a]	0	.0
	Total	103	100.0

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

Reliability Statistics

Cronbach's Alpha	N of Items
.769	35

Item Statistics

	Mean	Std. Deviation	N
Q9	4.6505	.94670	103
Q10.1	4.9515	.25739	103
Q10.2	4.4757	1.29739	103
Q10.3	4.7670	.59744	103
Q11	4.8350	.72891	103
Q12.1	4.4369	1.20188	103
Q12.2	4.9029	.38385	103
Q12.3	4.5728	.79953	103
Q13.1	4.6990	.68363	103
Q13.2	4.6505	.68182	103
Q13.3	4.8932	.34049	103
Q13.4	4.2621	1.20425	103
Q13.5	4.5049	.80286	103
Q13.6	4.8835	.40344	103
Q13.7	4.8738	.36190	103
Q13.8	4.3204	1.08658	103
Q13.9	4.9223	.36216	103
Q13.10	4.5146	1.33478	103

Q14.1	4.9223	.30323	103
Q14.2	4.8932	.44087	103
Q14.3	4.8835	.54774	103
Q14.4	4.1359	1.33614	103
Q14.5	4.4660	1.04615	103
Q14.6	4.4660	.86109	103
Q14.7	4.8641	.42122	103
Q15.1	4.9126	.34604	103
Q15.2	4.3689	.91812	103
Q15.3	4.6796	.62956	103
Q15.4	4.8932	.34049	103
Q15.5	4.4272	1.02519	103
Q15.6	4.8932	.34049	103
Q15.7	4.8447	.45927	103
Q15.8	4.1262	1.10861	103
Q15.9	4.9029	.32883	103
Q15.10	4.4369	1.04478	103

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Q9	158.5825	84.755	.074	.774
Q10.1	158.2816	85.361	.319	.766
Q10.2	158.7573	80.950	.185	.772
Q10.3	158.4660	82.467	.380	.760
Q11	158.3981	85.654	.056	.773
Q12.1	158.7961	81.752	.172	.772

Q12.2	158.3301	84.263	.360	.764
Q12.3	158.6602	81.423	.338	.760
Q13.1	158.5340	81.918	.368	.760
Q13.2	158.5825	80.304	.505	.754
Q13.3	158.3398	84.442	.381	.764
Q13.4	158.9709	77.695	.367	.758
Q13.5	158.7282	79.239	.494	.753
Q13.6	158.3495	84.132	.358	.763
Q13.7	158.3592	84.370	.368	.764
Q13.8	158.9126	81.492	.218	.768
Q13.9	158.3107	85.157	.248	.766
Q13.10	158.7184	80.694	.186	.773
Q14.1	158.3107	84.157	.485	.763
Q14.2	158.3398	82.834	.488	.760
Q14.3	158.3495	83.426	.322	.763
Q14.4	159.0971	80.932	.176	.773
Q14.5	158.7670	79.063	.365	.758
Q14.6	158.7670	80.239	.387	.758
Q14.7	158.3689	83.157	.470	.760
Q15.1	158.3204	83.926	.457	.762
Q15.2	158.8641	83.903	.131	.771
Q15.3	158.5534	84.916	.141	.769
Q15.4	158.3398	84.266	.410	.763
Q15.5	158.8058	77.942	.439	.754
Q15.6	158.3398	84.893	.309	.765
Q15.7	158.3883	83.808	.348	.763
Q15.8	159.1068	82.410	.164	.771
Q15.9	158.3301	85.263	.259	.766
Q15.10	158.7961	79.948	.316	.761

Scale Statistics			
Mean	Variance	Std. Deviation	N of Items
163.2330	86.945	9.32444	35