The Impacts of Economic Sanctions on Supply Chain Management

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ABSTRACT

Over the last two decades, supply chains have shown a great tendency of expanding their networks beyond the national boundaries and using the global sourcing strategy. As a result, supply chains have become more complex and dynamic networks that extend over several countries, including multiple tiers of suppliers, each of which may have various entities with different operations, structures and goals. In this situation, any uncertainty in the political and economic relations between countries should be considered as a source of risks. After the rise of unforeseeable political issues, one conceivable response of nations is imposing sanctions which lead to significant problems in seller-buyer relationships.

This study has focused on the Iranian supply chains -which have been suffering from harsh economic and financial sanctions in the recent years- in order to investigate the impact of such sanctions on supply chain risk management (SCRM). After identifying the most significant supply chain risks associated with different flows, namely material, information and financial flows, the identified risks are analyzed via a qualitative method with respect to means of probability, impact and effect of sanctions.

The impact of sanctions on different risk drivers, industries and supply chain performance measures are investigated. The results show that sanctions have the greatest negative impact on financial risks compared to the other risk drivers and all companies regardless of their industries and scopes are found to be vulnerable to sanctions. As to performance criteria however, the analyses disclose that supply chain

cost and cash to cash cycle should receive more attention whenever the supply chain are influenced by sanctions.

The analyses reveal that supply chain risk factors are really triggered by sanctions specifically risks of exchange rate movements, material price fluctuations, supplier bankruptcy, inability to collect all receivables and buying from a single source which should be viewed as the leading risk factor in the presence of sanctions.

In the final stage, the high ranked risks are discussed and appropriate risk management strategies are proposed to deal with them.

Keywords: Supply chain management, Sanctions, Risk management.

ÖZ

Son 20 yılda, tedarik zincirleri ulusal sınırların ötesinde kendi ağlarını genişleterek ve küresel tedarik stratejisi kullanarak büyük bir eğilim göstermiştir. Sonuç olarak, birden fazla katmanda her biri farklı işlemler, yapı ve hedefleri ile çeşitli varlıklara sahip olan tedarik zincirleri birçok ülkede yayılmış daha karmaşk ve dinamik ağlar haline gelmiştir. Bu durumda, ülkeler arasındaki siyasi ve ekonomik ilişkilerdeki herhangi bir belirsizlik risklerin kaynağı olarak kabul edilmelidir. Öngörülemeyen siyasi konuların artmasından sonra, ülkerin ilk tepkisi satıcı-alıcı ilişkilerinde sorunlar yol açacak yaptırımlarda bulunmatıv.

Bu çalışma, son yıllarda sert ekonomik ve mali yaptırımlara uğramış, tedarik zinciri risk yönetimini fonksiyonların etkisini araştırmak için İran tedarik zincirlerine odaklanmıştır (SCRM). Farklı akışları ile en önemli tedarik zinciri risklerini tespit ettikten sonra, yani malzeme, bilgi ve finansal akımlar, belirlenen risklerin olasılık, çarpma ve yaptırımların etkisinin araçlarının açısından nitel yönteme analiz edilir. Farklı risk sürücüleri, sanayi ve tedarik zinciri performans önlemlerinin yaptırımların etkisi araştırılmıştır. Sonuçlar yaptırımlara bakılmaksızın sanayi ve kapsamların diğer risk sürücüleri ve tüm şirketlere kıyasla finansal yaptırımlara karşı savunmasız olarak kabul edilir olduğunu göstermektedir. Performans kriterleri açısından, tedarik zinciri yaptırımları zaman nakit döngüsündeki yaptırımlarda tedarik zinciri bundan etkilenmektedir.

Analizler, özellikle döviz kurundaki hareketlerin riskleri tedarik zinciri risk faktörlerinin yaptırımlar tarafından tetiklendiğini ortaya koymaktadır, materyal fiyat

dalgalanmaları, tedarikçi iflasi, tek bir kaynaktan satın almak için yetersiz tüm alacak toplama ve yaptırımlar lider risk faktörleri olarak görülmelidir.

Son aşamada, yüksek sıradaki riskler tartışıldı ve bunlarla başa çıkabilmek için uygun risk yönetimi stratejileri **önerılmıştır**.

Anahtar Kelimeler: Tedarik zinciri yönetimi, Cezai yaptırımlar, Risk yönetimi.

This thesis is gratefully dedicated to:

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And my late father

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LIST OF ABBREVIATIONS

C 2 C   Cash To Cash

EU   European Union

FMEA   Failure Mode and Effects Analysis

FTA   Fault Tree Analysis

GDP   Gross Domestic Product

IS   Information System

IT   Information Technology

MBD   Million Barrels Per Day

P+1 countries   Britain, Russia, France, United States, China and Germany

RCA   Root Cause Analysis

RPN   Risk Priority Number

SCM   Supply Chain Management

SCRM   Supply Chain Risk Management

SPSS   Statistical Package for the Social Sciences

UN   United Nations

Chapter 1

INTRODUCTION

1.1 Background

Nowadays, business communities are becoming more complex and facing an increased exposure to risks. In the field of supply chain, the trends towards globalization , the adoption of outsourcing and offshoring policies (Lockamy and McCormack, 2009), the tendency to lean supply chain (Thun and Hoenig, 2011) and the reduction of product life cycles (Punniyamoorthy, Thamaraiselvan, and Manikandan, 2013) are just the few factors that contribute to such risk exposure. According to Thun and Hoenig (2011) two main supply chain risk drivers are complexity and efficiency. In today's high competitive business environment, firms are increasingly adopting globalization and out sourcing strategies to reach or maintain their competitiveness by cost reduction and enhancement responsiveness (Lockamy and McCormack, 2009). As a consequence, the supply chain network is moving toward more complication and extension which may lead to various sources of uncertainty (Ceryno, Scavarda, and Klingebiel, 2014). Furthermore, many organizations have adopted just-in-time and lean concepts which intend to improve efficiency via removing "wastes" from a supply chain, for example, by decreasing the inventory level. However, it could also lead to high vulnerability because without safety stock the supply chain disruptions can barely be compensated (Thun and Hoenig, 2011). These facts show the reason behind the increment interest of researchers and practitioners in supply chain risk management

(SCRM) over the past decade (O. Tang and Nurmaya Musa, 2011), but this field is still in its nascency (Thun and Hoenig, 2011) and needs more research.

Modern supply chain systems are complex and dynamic networks that extended over several geographical districts, including multiple tiers of suppliers, each of them may have various entities with different operations, structures and goals. Such systems are vulnerable to a wide range of risks which make risk managing become a challenging duty for supply chain decision makers (Aqlan and Lam, 2015; Teresa Wu, Blackhurst, and Chidambaram, 2006).

The aim of SCRM is to develop a proper approach to identify, assess, analyze and treat areas of uncertainties within a supply chain in order to increase its resilience (Neiger, Rotaru, and Churilov, 2009). One common example which illustrates the importance of SCRM is Ericsson's crisis in 2000. At that time Ericsson applied the single-source strategy; as a result, the fire that only lasted for 10 minutes in one of its supplier's plant (Philips Electronics) produced electronic chips for mobile phones caused an estimated $400 million loss and hugely affected Ericsson's choice to leave mobile telephone business (Norrman and Jansson, 2004). Meanwhile, Nokia which used the same supplier reacted very differently. Nokia was proactive and had been prepared for such situations. Nokia not only cooperated with Philips to get back to business rapidly but also used different suppliers to quickly switch to alternative sources (Sheffi, 2007).

Over the last two decades, due to the globalization, managers have been facing with unknown conditions and new risks. Having enhanced competitive advantage, supply chains have shown a great tendency of expanding their networks beyond national boundaries and use global sourcing strategy. There are many motivations that trigger

global sourcing such as accessing to goods with lower prices, better accessibility to new technologies and greater chance to enter new markets. However, this phenomenon leads supply chains to become more complex and imposes them to higher uncertainties and vulnerabilities (e.g. local political instability, exchange rate fluctuations) that may decrease supply chains performance if they are not handled appropriately (Danese, Romano, and Formentini, 2013; Golini and Kalchschmidt, 2011). In addition, the internationalization of suppliers highlights the role of economic and political relationships between countries. Thus, any political or military conflicts between nations has a huge impact on the firm's business performance. With the escalation of conflicts, one expected action of governments is to institute sanctions. Barriers on imports and exports, financial-related issues, including limitations on financial transactions and reductions in the collaborations with foreign countries are only some of the difficulties which are caused by sanctions. According to Eyler (2007) economic sanctions are "diplomatic acts used to change a foreign government's political policies, where sanctions act as if they are macroeconomic policies transmitting coercive economic effects from senders to targets." (p.19).

However usually sanctions have been imposed against specific activities and entities, due to the multilateral communications between different organizations and industries, in addition to the predetermined goals, other sectors and industries are also affected. For example sanctions against Iran are generally focused on nuclear activities, while their negative effects on other industries like the automotive industry have been reported (H. Davarzani, Zegordi, and Norrman, 2011).

From SCRM point of view, economic sanctions are considered as a source of disruptions (unplanned and unanticipated events) which can interrupt the flow of materials, information and cash, leading delays for customers and loos in sales and revenues (Bode and Wagner, 2015). Several authors have referred to the supply chain disruptions in different ways, e.g. Kleindorfer and Saad (2005) provided a conceptual framework to assess and mitigate disruptions in a supply chain, C. S. Tang (2006b) introduced "robust" strategies to manage supply chain disruptions, Craighead et al. (2007) investigated the severity of disruptions and the supply chain structure, Wilson (2007) studied the impacts of transportation disruption on the supply chain performance, K. Chen and Xiao (2009) introduced models to coordinate the supply chain after the occurrence of demand disruptions, Stecke and Kumar (2009) developed a disruption classification framework that matched several kinds of disruptions in the supply chain, Sawik (2013) studied the optimal supplier selection by considering disruption risks and He, Huang, and Yuan (2015) investigated different procurement policies to find the proper policy in order to manage supply chain disruptions. But the effects of economic sanctions on the supply chain have been relatively neglected in the literature. The lack of investigations in this field is the main motivation for the author to study the interaction between economic sanctions and other types of supply chain risks.

This thesis has focused on Iranian supply chains as the case study. Iran has suffered from unprecedented economic and financial sanctions which have been imposed by several nations and international organizations. This study aims to look for comprehensions and ideas of industrial experts about the consequences of such numerous sanctions on different risks and supply chain performance measures.

1.2 Research Objectives and Questions

The purpose of this thesis is to develop the implementation of risk management among supply chains which are influenced by economic sanctions in order to gain a better understanding of the negative impacts of economic sanctions on the whole supply chain. Specifically, the main objectives of this study are:

- To investigate the vulnerability of supply chains due to sanctions.
- To identify and recognize the various supply chain risks.
- To investigate the interaction between economic sanctions and other risks in a supply chain.
- To rank/prioritize the identified risks.
- To determine the most important risks in supply chains, affected by economic sanctions.
- To propose an action plan to mitigate the significant supply chain risks.
- To investigate the effects of sanctions on various supply chain performance measures.

In order to reach these objectives the author explores the following questions:

- What is the relationship between economic sanctions and other types of supply chain risks?
- Which risks need to be prioritized by managers if their supply chain is affected by economic sanctions?
- Which mitigation strategies can be applied to manage these risks?
- Which types of industries are highly impacted by sanctions?

1.3 Research Hypotheses

Four hypotheses have been developed to test the effects of financial and economic sanctions on supply chains:

- **Hypothesis 1:** Supply chains are regarded as being more vulnerable due to sanctions.

- **Hypothesis 2:** Sanctions have different impact on various supply chain risk drivers.

- **Hypothesis 3:** Sanctions have different impact on different industries.

- **Hypothesis 4:** The occurrence probability of supply chain risks have been increased due to sanctions

1.4 Thesis Outline

With the aim of answering the research questions, the remaining of this thesis is structured as follows:

Chapter 2 includes a wide review of the previous studies and researches on the main subjects, concepts and techniques of supply chain management; supply chain risks and classifications, SCRM and economic sanctions and its potential effects on supply chains. Chapter 3 elaborates the methodology of this thesis. The processes of preparing the research questionnaire and data gathering are explained by details in this chapter. The collected data is analyzed in chapter 4. In chapter 5 discussions on findings of previous chapter are presented. The most proper responses to deal with each top ranked risk along with contributions and limitations of the study are also explained in this chapter. Finally, chapter 6 is dedicated to the main outcomes of this study along with some suggestions for future works.

Chapter 2

LITERATURE REVIEW

In the following chapter, previous researches and studies made on the subject of SCRM according to the objectives of this thesis mentioned in the last chapter, will be explained. This chapter will be divided into eight sections. In initial sections the main concepts of SCRM, including supply chain management, risks and uncertainties, supply chain risks and different classification of risks will be discussed. Later on, several frameworks for SCRM will be explained in order to have an insight on what have been done related to SCRM. Since the prime focus of this study is to develop the implementation of risk management into supply chains which are impacted by economic sanctions, the last sections of this chapter is dedicated to explaining sanctions and their impacts particularly on the Iranian economy as the case study.

2.1 Supply Chain Management (SCM)

Providing a unique definition of SCM is one of the toughest challenges for supply chain experts. However, the term "Supply Chain Management" is very popular, both among researchers and practitioners, there exists an intense disorientation toward its definition (Mentzer et al., 2001). Oliver and Webber (1982) used the term "Supply Chain Management" and discussed the discrimination between SCM and logistics for the first time. Since then, numerous definitions of SCM have been offered by different authors. Stock and Boyer (2009) identified 173 unique definitions of SCM from published sources until 2008.

Some authors define SCM from operational point of view. For example, Ellram (1991) defined SCM as a network of firms interacting with each other to bring the products to the ultimate customers alongside the flow of materials, goods and information. Some authors define SCM in terms of management philosophy and management process concentrated mainly on simplifying the outbound flows of inventory and information (Tyndall, 1998). Based on this view Walton and Miller (1995) defined SCM as a strategic iteration of trading partners.

Initial definitions of SCM mostly emphasized on the flow of materials and products from the beginning through manufacturing and distribution channels to end users. Since, the original field of SCM is logistics this point is not surprising (Bechtel and Jayaram, 1997). Over time, study of SCM has been extended over additional aspects such as SCRM, performance, efficiency, integration and information flow (Ahi and Searcy, 2013).

The absence of an inclusive and uniform definition of SCM makes several difficulties for researchers to develop supply chain theories and testing relationships between members of supply chain and also for practitioners to improve the performance and efficiency of supply chain by selecting the appropriate combination of functions and processes (Stock and Boyer, 2009). Table 1 presents some definitions of SCM which have been found in the literature analyzed.

Table 1: Definitions of SCM

Author	Definition
Jones and Riley (1987)	"Supply chain management techniques deal with the planning and control of total materials flow from suppliers through end-users." (p.94)
Ellram and Cooper (1990)	"An integrative philosophy to manage the total flow of a distribution channel from the supplier to the ultimate user." (p.1)
Larson and Rogers (1998)	"The coordination of activities, within and between vertically linked firms, for the purpose of serving end customers at a profit." (p.2)
Mentzer et al. (2001)	"The systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole." (p.22)
Eng (2005)	"Managing the inputs of goods or services for final users from procurement of raw materials through to the end of the products' useful life. The inputs of goods or services include a range of activities not only within a single department in an organization but also from different departments and outside the organization." (p.4)
Stock and Boyer (2009)	"The management of a network of relationships within a firm and between interdependent organizations and business units consisting of material suppliers, purchasing, production facilities, logistics, marketing, and related systems that facilitate the forward and reverse flow of materials, services, finances and information from the original producer to final customer with the benefits of adding value, maximizing profitability through efficiencies, and achieving customer satisfaction." (p.706)
M. Christopher (2011)	"The management of upstream and downstream relationships with suppliers and customers in order to deliver superior customer value at less cost to the supply chain as a whole." (p.3)

The definition proposed by Mentzer et al. (2001) is the most accepted one in the field of SCM (Burgess, Singh, and Koroglu, 2006; Giunipero et al., 2008). This thesis aims at performing risk management in the supply chains which are influenced by economic sanctions, thus; the more general definition of SCM allows the author to identify and assess general risks of supply chain. For this reason the author follows the definition which was proposed by M. Christopher (2011).

In the modern world, as a result of a high interactions of companies and complicated relationships between organizations supply chains have become more complex (Thun and Hoenig, 2011). A single disruption to one entity or process in the supply chain may interrupt operations of other parts of the chain. Thus, the coordination of activities within all members of supply chain is a main characteristic of SCM.

2.2 Definitions of Risk and Uncertainty

In recent decades, the term "risk" has been explored in different areas such as, finance, decision theory, marketing, management, insurance and psychology (Wagner and Bode, 2006), actuarial science, emergency planning, health care (Sodhi, Son, and Tang, 2012) and recently supply chain. Notwithstanding its long history, there is no comprehensive and encompassing definition of risk (Heckmann, Comes, and Nickel, 2015).

Three essential components are accentuated by Yates (1992) to characterize a risk: the degree of loss, the significance and likelihood of appearance. Royal society (1992) defines risk as "the probability that a particular adverse event occurs during a stated period of time, or result from a particular challenge". The definition of risk has been developed by Mitchell (1995) as "the probability of loss and significance of that loss to the organization or individual".

For assessing a risk of an event $_n$ Mitchell proposes a formula in terms of "P" as the probability of occurrence of event and "L" as the significance of its consequences.

$$\text{Risk}_n = P * L$$

Ritchie and Brindley (2007) found out that three common dimensions in most risk definitions are; probability of occurrence of a specific event, impact of the particular event and causal pathway leading to the event.

The difference between risk and uncertainty has been discussed in risk related literature. However in some cases especially in economic and finance these two terms are assumed as synonyms, technically they have different concepts. According to Waters (2007) risks take place due to uncertainty. He defines uncertainty as possible

future events that can be identified but their likelihood of occurrence is unknown. On the other hand, risks are possible future events that not only can be identified but also their likelihood of occurrence is known. Thus, the main difference between risk and uncertainty is that risk is measurable but uncertainty is not.

Zimmermann (2000) determined the main causes of uncertainty to be as follows:

- **Lack of information:** absence of knowledge is presumably the most common cause for uncertainty.

- **Abundance of information:** this sort of uncertainty is because of the restricted capacity of humans for understanding and processing huge amount of data at the same time.

- **Conflicting evidence:** accessing to wrong or irrelevant information is the main reason for this type of uncertainty.

- **Ambiguity:** a circumstance in which certain words have completely different meanings in different situations.

- **Measurement:** measurements due to several parameters (equipment, environments, procedures and etc.) affecting the measurement system are always associated with uncertainty.

- **Belief:** all accessible knowledge and information to the observer are subjective as a sort of belief in a certain circumstance.

2.3 Supply Chain Risk Definition

Supply chain is defined as "a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer." (Mentzer et al., 2001, p.4);

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thus, the scope of risks in the field of SCM is so wide that it must cover beyond the boundaries of a single organization (Jüttner, 2005).

Different authors have defined supply chain risk. Zsidisin (2003) defines supply chain risk as "the probability of an incident associated with inbound supply from individual supplier failures or the supply market occurring, in which its outcomes result in the inability of the purchasing firm to meet customer demand or cause threats to customer life and safety" (p.222). Zsidisin stated that supply chain risk includes three dimensions; outcome uncertainty, outcome expectations, and outcome potential.

Review of literature discloses a persistent tension regarding the conceivable results of risk (Mitchell, 1995). Although in dictionaries and insurance firms, risk is mostly defined as the possibility of harm, peril or loss, the outcomes of risk are not always negative but could also be positive (Wagner and Bode, 2006). Several authors in the field of SCM only consider the downside potential of risk. Such as Harland, Brenchley, and Walker (2003) who define risk as "a change of danger, damage, loss, injury or any other undesired consequences" (p.52).

Wagner and Bode (2006) state that according to supply chain business reality, it is better to concentrate only on the "downside" potential of risk. Based on this view they define risk as "the negative deviation from the expected value of a certain performance measure, resulting in negative consequences for the focal firm" (p.200).

Conversely, some authors focus on both the downside and upside potential of risk. Manuj and Mentzer (2008) for example, define risk as "the expected outcome of an uncertain event, i.e. uncertain events lead to the existence of risks" (p.196).

2.4 Supply Chain Risk Classifications

In the SCRM literature, there are various categorizations of supply chain risk and their relevance depend on the chain which has been referred to (Vilko and Hallikas, 2012). Since risk identification is the first step of SCRM (Hallikas et al., 2004; Tummala and Schoenherr, 2011) and a risk categorization system could be helpful for successful risk identification (Shi, 2004), applying an appropriate categories which can be qualified, weighted and compared has become the most critical step in SCRM (Blackhurst, Scheibe, and Johnson, 2008).

Jüttner, Peck, and Christopher (2003) categorize supply chain risks into three groups: environmental or external risks as any uncertainties derived from interactions of the supply chain and environment, internal or organizational risks, which are occurred inside the firm and network-related risks, which derive from relationships between the members of the supply chain. Manuj and Mentzer (2008) present a risk classification system with more risk categories including supply, demand, security, macro, policy, competitive and resource risks; however, their risk classification still does not cover all aspects of supply chain. For instance, the relationship risk is not included (Rangel, de Oliveira, and Leite, 2014).

O. Tang and Nurmaya Musa (2011), having conducted an extensive literature survey and citation/ co-citation analysis on SCRM, believe that in order to identify and classify the complex risk issues, it is better to divide the supply chain system into sub-systems in terms of financial, information and material flows. They also found out that risks related to information flow have gotten the least amount of attention.

The absence of consensus and the diversity of views and perceptions about risk classifications are the main reasons for conducting an extensive literature survey on 16 risk classifications by Rangel et al. (2014). Figure 1 represents the variety of risk classifications in the previous SCRM research. Rangel et al. (2014) concluded that some of the possible gaps are: different numbers of risk types with broad definitions in each classification, indistinguishable terminologies with different definitions and categorizations of risk type according to variable sources.

SVENSSON (2002)
- Time/Interruption
- Relacional

HARLAND ET AL.(2003)
- Strategic
- Operations
- Sypply
- Customer
- Asset Impairment
- Competitive
- Reputation
- Financial
- Fiscal
- Regulatory
- Legal

JÜTTNER ET AL. (2003)
- Environmental

NETWORK RELATED
- Lack of ownership
- Chaos
- Inertia
- Organizational

CAVINATO (2004)
- Physical
- Financial
- Informational
- Relational
- Innovational

CHOPRA AND SODHI (2004)
- Disruption
- Delays
- Systems
- Forecast
- Intellectual property
- Procurement
- Receivables
- Inventory
- Capacity

CHRISTOPHER AND PECK (2004)
EXTERNAL TO THE NETWORK
- Environmental

INTERNAL TO THE SC
- Demand
- Supply

INTERNAL TO THE FIRM
- Control
- Process

HALLIKAS ET AL. (2004)
- Demand
- Costumer
- Financial
- Weakness in resources, development and flexibility

SHI (2004)
CORE BUSINESS
- Value chain
- Operational
- Event

NON-CORE BUSINESS
- Credit
- Market
- Tax

C. S. TANG (2006)
- Operational
- Disruption

T. WU ET AL. (2006)
EXTERNAL
- External Controllable
- External Partially Controllable
- External Uncontrollable

INTERNAL
- Internal Controllable
- Internal Partially Controllable
- Internal Uncontrollable

WANG AND YANG (2007)
EXTERNAL
- Political
- Economy
- Culture
- Technical
- Natural
- Demand

INTERNAL
- Logistics
- Capital
- Information

MANUJ AND MENTZER (2008)
- Currency
- Transit time
- Forecast
- Quality
- Safety
- Business Disruption
- Survival
- Inventory and tools ownership
- Culture
- Oil price increase

MICCUCI (2008)
- Interruption
- Supply
- Strategic
- Inertia
- Demand
- Capacity
- Relational
- Financial
- Infrastructure support
- Regulatory or Legal
- Customer

C. TANG AND TOMLIN (2008)
- Supply
- Process
- Demand
- Intellectual property
- Behavioral
- Political/Social

RAO AND GOLDSBY (2009)
- Environmental factor
- Organizational factors
- Industry factor
- Problems-specific factors
- Decision maker factors

Q. WU (2010)
- Uncertainty of external environmental
- Uncertainty between node enterprises
- Uncertainty in node enterprises
- Uncertainty of Market demand

Legend:
- External to the Supply chain
- Internal to the Supply chain
- Internal to the Organization
- Non-classified

Figure 1: The variety of risk classifications (source: (Rangel et al. (2014))

2.5 Supply Chain Risk Management (SCRM)

The existence of SCRM goes back to the times, when managers noted that the performance and efficiency of their supply chains were under the threat of risks and they needed to manage them by SCRM (Lavastre, Gunasekaran, and Spalanzani, 2014). Reducing vulnerability to risks is the key concept behind the risk management.

Relatively, SCRM tries to apperceive and elude the adverse consequences of any risky events in the supply chain (Rangel et al., 2014).

Same as previous sections, a review of literature discloses a wide range of SCRM definitions. Jüttner et al. (2003) define SCRM as "the identification and management of risks for the supply chain, through a co-ordinated approach amongst supply chain members, to reduce supply chain vulnerability as a whole" (p.201). Therefore, the goal of SCRM is to avoid or contain supply chain vulnerability by identifying risks and taking proper actions. C. S. Tang (2006a) defines SCRM as "the management of supply chain risks through coordination or collaboration among the supply chain partners so as to ensure profitability and continuity'' (p.453). According to Handfield and McCormack (2007) SCRM is "the integration and management of organizations within a supply chain to minimize risk and reduce the likelihood of disruptions through cooperative organizational relationships, effective business processes, and high levels of information sharing."(p.436).

According to the definitions above, it is obvious that SCRM is based on coordination and collaboration of supply chain entities to predict risks for the sake of designing and implementing the proper strategies that would be fit for overcoming the negative effects of such risky events (Elzarka, 2013). Managing and analyzing risks must be done not only on a focal firm, but all possible domino effects among all members and relationships have to be considered. Thus, setting bilateral targets and plans through the whole supply chain is essential. But constructing such a cooperative structure is difficult because supply chain entities do not have possess the same way of thinking are rely on each other (Ellinger et al., 2015).

Over the last decade, trends toward globalization, outsourcing, increasing product/service complexity, e-business, higher customer requirements, increasing volatility of markers, lean supply chain and natural disasters make supply chains more vulnerable to different risk types (Harland et al., 2003; Pfohl, Köhler, and Thomas, 2010; Ponomarov and Holcomb, 2009; C. S. Tang, 2006a; Thun and Hoenig, 2011). Despite the importance of SCRM, only a minority of firms have applied appropriate methods of risk management (Thun and Hoenig, 2011). Deloitte study- having conducted a survey of 600 supply chains- show that 45% of companies felt that their SCRM programs were merely to some extend effective or not effective at all (Deloitte, 2013).

Some studies examine other aspects of SCRM. For example, Ellinger et al. (2015) investigated the roles of learning orientation as a factor which positively impacts SCRM. They suggest that, to implement an effective SCRM strategies, firms must develop learning cultures within the whole supply chain.

2.6 Supply Chain Risk Management Framework

Hendricks and Singhal (2005) noted that efficiency, reliability and responsiveness are the most important supply chain profitability drivers. Supply chains must have the capability of reacting and recoiling rapidly to supply chain risks in order to keep their profitability; therefore, having a profound perception of supply chain risks and applying an appropriate risk management process have become the most challenging duties of supply chain managers (Aqlan and Lam, 2015). To deal with this challenge, supply chain decision makers, on the one hand, must identify different risks in the supply chain, assess their negative consequences and design contingency plans before the occurrence of such risky events, and on the other hand, take extreme measure to

mitigate risks after the happening of risk events (O. Tang, Matsukawa, and Nakashima, 2012).

However as discussed in the previous sections, there is no comprehensive and definitive definition of SCRM, there exists a concurrence on the key elements of SCRM. These main components in the majority of definitions are; risk identification, risk analysis, risk management and risk monitoring and evaluation (T. Wu and Blackhurst, 2009).

According to Jüttner et al. (2003) the process of SCRM involves four main elements (figure 2).
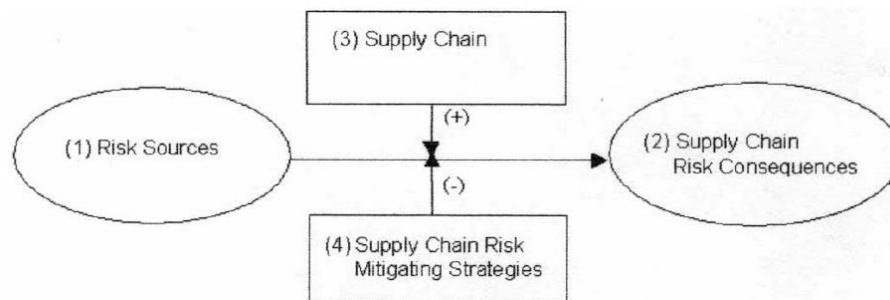
Figure 2: The basic constructs of SCRM (source: (Jüttner et al., 2003))

These four basic constructs of SCRM are as following:

- *Assessing risk sources:* an appropriate risk categorization system simplifies the process of identifying potential risk events.

- *Recognizing the supply chain risk concepts by specifying risk effects:* this step includes the determination of the negative effects of all supply chain risks based on their significances. Adverse risk effects may include financial

consequences, performance loss, reputation damage, customer dissatisfaction or injuries.

- *Identifying the risk drivers in the supply chain strategies*: the level of risk in the modern supply chains has been increased over the last decade due to market globalization, the trend towards outsourcing, shorter product lifecycle and concentrating on efficacy rather than effectiveness.

- *Applying mitigation strategies:* four main strategies can be adopted by companies to mitigate risks; (1) *avoidance,* it means the firm by dropping certain products, suppliers or markets tries to eliminate risk sources, (2) *control,* it means a company tries to control risks by decreasing the probability of occurrence of a specific risk or decreasing its negative consequences, or both, (3) *co-operation,* this method focuses on the joint agreement between supply chain members to gain a better understanding of certain risky events to provide joint business plans, (4) *flexibility,* this strategy is based on increasing the flexibility of supply chain to increase its responsiveness.

The proposed method for SCRM by Harland et al. (2003) (figure 3) is more comprehensive and has six steps. It begins with mapping the supply network where a diagrammatical representation of the supply network is created. The second step is identification of risks and their locations. Then risk assessment is done in the third step. The assessment information is used to manage risks in the fourth step. Finally, in the last two steps appropriate strategies to mitigate risky events are selected and implemented.
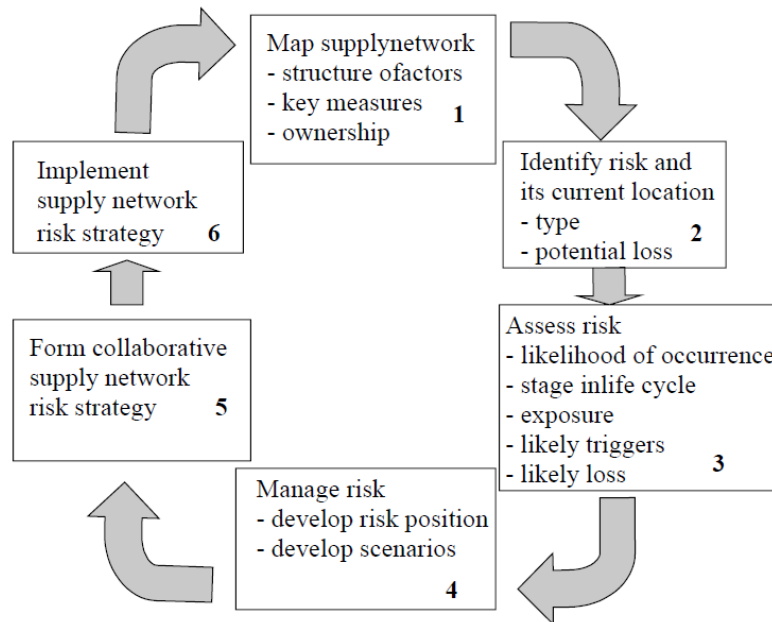
Figure 3: The basic constructs of SCRM (source :(Harland et al., 2003))

Since applying this method calls for participating and collaborating the key members of supply network, it is more difficult to use it in a real practice. In addition, the lack of validated definition of risk is the missing component of this model (Zsidisin, 2003). Teresa Wu et al. (2006) concentrate on the inbound supply risks and introduce an integrated framework to cope with such risks. The framework is classified into three categories:

- *Risk classification:* according to a literature survey and interviews, risks are classified into six different groups: internal controllable risks (e.g. quality issues, cost, on time delivery, production flexibility, management related issues, etc.), internal partially controllable risks (e.g. accidents, internal legal problems, market strength, etc.), internal uncontrollable risks, external controllable risks (e.g. selected supplier for next tier), external partially controllable risks (e.g. demand, security, external legal problems) and external uncontrollable risks (e.g. natural disasters, economic and political stability).This risk classification system helps managers to identify risks and

understand where risks are situated in order to implement appropriate mitigation strategies.

- *Risk identification:* 54 individual risk factors are identified and categorized into 19 supply risk groups.

- *Risk calculation:* to quantify risk factors and calculate overall, authors use AHP method.

In comparison with previous methods, authors do not mention how organization should deal with risks to mitigate them after calculating risk.

Waters (2003) suggests a framework with three core elements: (1) identifying risks, (2) analyzing risks and (3) responding to risks (figure 4).


Figure 4: The basic constructs of SCRM (source: (Waters, 2007))

1- Identification: According to many authors the initial and essential step of SCRM is the identification of risks and uncertainties (Manuj and Mentzer, 2008; Neiger et al., 2009; Tummala and Schoenherr, 2011; Waters, 2007). For this reason, comprehensive and structured tools and approaches have to be used to identify potential supply chain risks (Tummala and Schoenherr, 2011). Otherwise, critical risks can be missed or managers can be faced with a multitude of risks which are difficult to manage (Waters, 2007). Since in practice identifying all possible risks is not possible, the output of this step is a list of the most important supply chain risks.

A wide range of formal techniques are available to identify supply chain risks: root cause analysis (RCA), fishbone chart, check lists, supply chain mapping, brainstorming, fault tree analysis (FTA), failure mode and effects analysis (FMEA) and published documents (Bradley, 2014; Tummala and Schoenherr, 2011; Waters, 2007).

Since one of the aims of this study is to identify the systematic and significant supply chain risks, the author at first applies the risk classification system which was proposed by O. Tang and Nurmaya Musa (2011). As mentioned in section 2.4 they classified risks in terms of material, financial and information flows which are integral parts of all supply chains irrespective of their size and scope. After that to enrich the list of risks and consider all major supply chain risks a literature survey is done. The process of risk identification will be discussed in the next chapter.

2- Analyzing risk: after identifying the significant risk factors and preparing a list of risks, managers should assess the possible impacts of risks by considering their characteristics. Analyzing risks helps supply chain decision makers to prioritize risks

with the highest effect. According to Waters (2007), two main approaches can be adopted to analyzing risk: qualitative and quantitative approaches. The qualitative methods only concentrate on describing the nature and other features of risks. By applying these methods managers are able to gain a deep understanding about supply chain risks and their consequences; however, prioritizing risks due to the lack of numerical measures is more difficult. While, the quantitative approaches deal with numerical measures. The occurrence probability of each risky event and its consequences are the two main elements of quantitative approaches.

Finding the occurrence probability of an event is the first challenge for using quantitative approaches. If the proper historical data about specific event are available, estimating the probability of occurrence can be accurately done by employing probabilistic models. But under real circumstances sufficient previous data of all risky events specifically rare ones are not available. Bradley (2010) estimates that to accurately estimate an event with 10^{-5} probability of occurrence in any one year we need to collect data for 876000 years.

According to Waters (2007) three approaches can be adopted to find probabilities of events:

- The most dependable method is calculating a priori probability by using knowledge of a circumstance.
- Estimating the occurrence probability of an event by using historical data. The basis assumption here is that the future is like the past.
- Estimating the likelihood of an event by asking people's ideas and judgments. However in comparison with two first methods this method has the lowest

accuracy, it is the only method where objective information is not available (Tummala and Schoenherr, 2011).

Due to the fact that supply chain risks are so complex and fuzzy, likelihoods can be expressed in ranges instead of exact values. Table 2 shows a sample likelihood categories. It is should be noted that, these ranges can be changed to suit a given circumstances and supply chain environment (Tummala and Schoenherr, 2011).

Table 2: Classification for likelihoods (source: (Tummala & Schoenherr, 2011))

Risk probability categories	Qualitative description The identified risk factor could occur on an average of …	Probability Index
Often	… once per week	4
Infrequent	… once per month	3
Rare	… once per year	2
Extremely rare	… once per decade	1

The next step of assessing is to allocate a value on the consequences of a risky event. Different consequences have been identified through the literature review. Some consequences such as sale losses, cost increase and financial losses (Jüttner et al., 2003) have monetary values. But others same as social losses or reputation damage (Harland et al., 2003) cannot be evaluated in financial terms. One option to overcome this difficulty same is to apply ranges of values rather than looking for actual values (same as probabilities) specially in the case that the objective data are not available or it is so difficult to estimate the actual values. Table 3 presents a sample consequence severity categorization system.

Table 3: Classification for consequence severities (source: (Tummala & Schoenherr, 2011))

Consequence severity level	Qualitative description	Risk Consequence Index
Catastrophic	Plant shut down for more than a month due to lack of components with zero safety stock levels	4
Critical	Slow down of process or plant shut down for one week due to lack of components with zero safety stock levels	3
Marginal	Decreased service levels with depleting safety stocks	2
Negligible	Service levels not impacted due to sufficient safety stock levels	1

After estimating the likelihood and severity of each risk, managers can assess the significance of risks –usually by multiplying these two factors– to prepare an organized list of prioritized risks.

Risk map, probability-impact matrix, failure mode and effects analysis (FMEA) are some of the most common tools and formal procedures that can be applied to analyze the identified supply chain risks.

Risk map: it is one of the common and useful tools to illustrate the categories of risks. It is a graph that presents risks as points, where the vertical axis indicating the occurrence probability and the horizontal axis indicating the impacts. Figure 5 shows the structure of risk map.
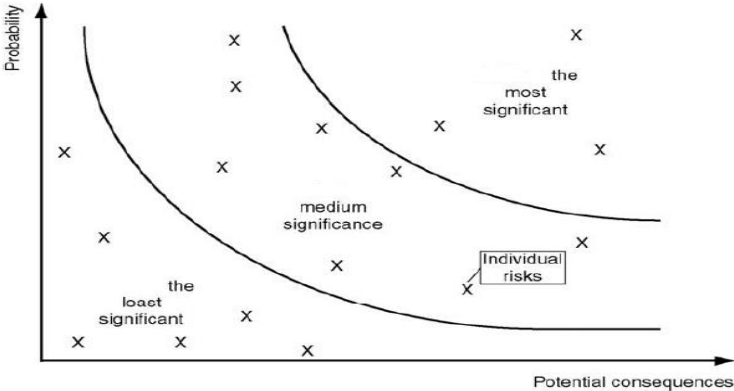

Figure 5: Sample of risk map graph (source :(Waters, 2007))

From the figure 5, it is obvious that the further a point which represents a risk is located from the origin, the more significant the said risk. It is needed to mention that risk map is used whenever the actual values of probabilities and consequences are available.

Probability-impact matrix: it is similar to the risk map. The difference is that rather than the actual values of probabilities and impacts, categories are used. The output is a table where risks are entered in the appropriate cells. Table 4 presents a sample of 5*5 matrix ranging from very low, low, medium to high and very high.

Table 4: Sample of probability-impact matrix (source :(Waters, 2007))

		Potential consequences					
		Negligible	Minor	Moderate	Serious	Critical	Cata-strophic
Probability	Very high	B	B	A	A	A	A
	High	B	B	B	B	A	A
	Medium	C	B	B	B	A	A
	Low	C	C	B	B	A	A
	Very low	C	C	C	B	B	A

Failure mode and effects analysis (FMEA): FMEA was developed in the late 1940s to study issues that may emerge from breakdowns of military systems. Since then FMEA is commonly used to identify and assess risk of failures before they occur (Geum, Cho, and Park, 2011; Puente et al., 2002). From the SCRM point of view, at first all activities in the supply chain must be identified and listed, then potential failures related to each activity are identified to prepare a list of risks. In the next step, the probability of occurrence (P), severity of consequence (S) and possibility of detection for each potential failure are determined in terms of a subjective score from 1 to 10. Finally, risk priority number (RPN) is used to quantify the significance of each failure.

$$RPN = P * S * D$$

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3- Responding to risks: After assessing and analyzing risks, managers have an ordered list of prioritized risks. Now in the last step of SCRM process, appropriate strategies and actions are selected and implemented to deal with uncertainties identified in the previous stages (Ceryno et al., 2014). According to Thun and Hoenig (2011), two main instruments can be applied to respond to a risk incident: preventive instruments and reactive instruments. Preventive instruments try to reduce the occurrence probability of risks. Concentrating on products with low demand fluctuations to avoid the risk of wrong forecasting or selecting certified suppliers to decrease risks of quality issues or delayed delivery are examples of this approach. On the other hand, reactive instruments same as multiple sourcing or building up safety stock, try to absorb the negative impacts of risks.

Waters (2007) identifies a range of possible responses: accepting or ignoring the risk, decreasing the likelihood of the risk, decreasing the negative consequences, transferring the risk, designing contingency plans, adapting to it or changing the environment.

M. M. S. Sodhi and C. S. Tang (2012) suggest three basic approaches to tackle risks:

- *Accepting:* the company accepts risks and does not do anything.
- *Avoiding:* it involves attempts to avoid the occurrence of risky events. It is the best approach to deal with security-related risks.
- *Mitigating:* it involves attempts to reduce the impact or probability of loss.

After selecting the appropriate responses based on the circumstances and specifically the magnitude of impacts, managers should translate these general responses into certain strategies and actions. Table 5 presents some of the main strategies according

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to the response classification system which was proposed by M. M. S. Sodhi and C. S. Tang (2012).

Table 5: Sample of risk mitigation strategies

Responses	Risk mitigation strategies	References
Acceptance	Using insurance	Schmitt and Singh (2012)
	Risk sharing	Jüttner et al. (2003)
Avoidance	Supplier selection systems	Sawik (2011)
	Concentrating on specific products/services	Thun, Drüke, and Hoenig (2011)
	Hesitating to enter new markets	(Miller (1992); Sofyalıoğlu and Kartal (2012))
	Design fail-safe processes	M. M. S. Sodhi and C. S. Tang (2012)
Mitigation	Dual or multiple sourcing	Thun et al. (2011)
	Adjusting the design of supply chain	Qi, Shen, and Snyder (2010)
	Flexible supply contracts	C. Tang and Tomlin (2008)
	Increasing collaboration	Li (2012)
	Flexible transportation	Sokolov, Auld, and Hope (2012)
	Adding capacity	Y.-J. Chen, Deng, and Huang (2014)
	Increasing agility	Costinot, Vogel, and Wang (2013)

2.7 Economic Sanctions

Nowadays, sanctions are becoming a common diplomatic tool in international polices as visible and less expensive substitute for armed conflict to change the human rights, trade or foreign policy of another country (Choonara, 2013). Over the last few decades, sanctions have been imposed on several nations because of extremist policies such as developing nuclear programs (e.g. Iran), using violence to keep power (e.g. Syria), human rights issues (e.g. Burma), arm conflict (e.g. Iraq), terrorism (e.g. Libya) and attempting a coup against a democratic government (e.g. Cuba) (Karimi and Haghpanah, 2015; Naghavi and Pignataro, 2015). The rationales of imposing sanctions

have comprised a wide range, from encouraging democracy, stopping violation of human rights, enforcing peace treaty to settling civil wars and preventing the spread of weapons of mass destruction. Sanctions vary by nations and situations and involve measures such as import sanctions, export sanctions, travelling sanctions, arm embargoes, financial sanctions, diplomatic sanctions, developing aid and technology sanctions (Eriksson, 2013).

The United Nations (UN), the European Union (EU) and individual states are authorized to institute sanctions. The United States has always been a leader of adopting sanctions as a diplomatic instrument. Since 1945 using economic and military pressure have become an integral part of the American foreign policy. Figure 6 illustrates that only %33 of the registered sanctions were imposed without the direct involvement of USA (Eyler, 2007).
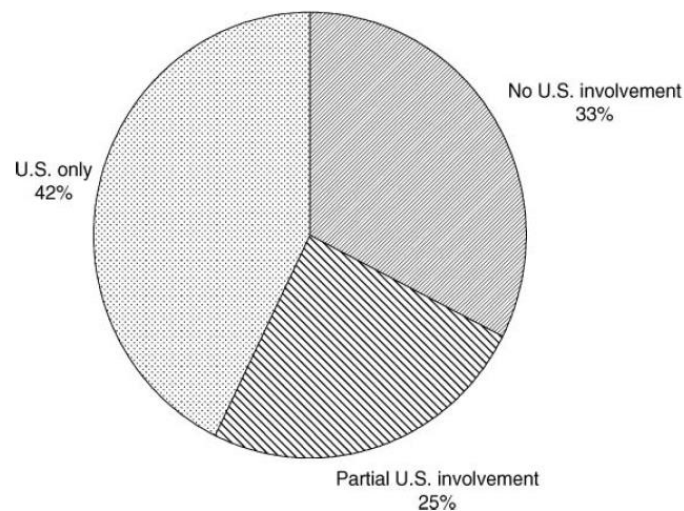

Figure 6: America's role in sanctions (1998-2005) (source: (Eyler, 2007))

The effectiveness and necessity of sanctions have become a controversial subject for not only senders (countries that imposed sanctions) but also targets (sanctioned

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nations). Since a majority of target countries have not conducted or published any scientific studies on the impact of sanctions in their territory, determining the extent of such impacts is difficult (Lektzian and Patterson, 2015; Office, 2008).

The review of literature reveals that most researches and studies in the field of economic sanctions are concentrated on two main topics:

- The effectiveness of sanctions to achieve specific diplomatic goals.
- The social and humanitarian consequences of economic sanctions.

According to de Jonge Oudraat (2000), economic sanctions have devastating effects on the target nation's economy. But in many cases, they have not been able to reach their diplomatic goals. He has also noted that sanctions can be more effective if they are used as a comprehensive mandatory policy specially when accompanied by the threat of using military power. Allen (2005) believes that the effectiveness of sanctions is related to the type of the political regime present in the target nation. The lack of democracy in target country increases the duration of sanctions and reduces their effects. Nooruddin (2002) found out that the chance for a particular sanction to be successful is affected by several factors including, the target's governmental system, the relationship between the target and the USA, and the role of the US in such sanctions. However many policymakers believe that the multilateral sanctions are more effective than unilateral sanctions, based on an empirical test which was conducted by Miers and Morgan (2002) multilateral sanctions in comparison with unilateral ones are less effective.

Several reports and studies by the UN and academia show that the consequences of sanctions are not only limited to specific activities or entities of the target's

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government, rather it is the general public that suffers the most (Karimi and Haghpanah, 2015; Peksen, 2011). In the case of Iran, for instance, notwithstanding the fact that medicine trades are exempted from sanctions, due to money transferring difficulties, sanctions have had detrimental impacts on drug supply and have caused shortages in vital medicines (Mohammadi, 2013). Drury and Peksen (2012) investigate on the impacts of sanctions on women's rights. Their findings show that respect to women's rights will be reduced as a result of economic sanctions.

Since the main purpose of this thesis is to implement risk management among supply chains which are influenced by economic sanctions and located in Iran, the history of sanctions against Iran and their impacts will be discussed.

Since the time when the World became aware of Iranian nuclear programs in 2002, Iran has suffered from numerous economic and financial sanctions which have been imposed by several countries and international organizations against her such as the UN, the EU, the United States, Japan, Australia Canada, etc. Developing nuclear and missile programs are main reasons behind such unprecedented sanctions on Iran (Moret, 2014). Table 6 presents the time series of sanctions against Iran.

Table 6: History of sanctions against Iran

Year	Sender	Imposed Sanction
1979	USA	$ 12 bn in Iranian assets held in the USA Were confiscated (Taylor, 2009).
1987	USA	Importing and exporting any goods or services from/to Iran became forbidden (Taylor, 2009).
1995	USA	Foreign companies were prohibited from investing more than $20 million a year on Iranian energy sector (Taylor, 2009).
2004	USA	A rule was passed to stop scientific collaborations between U.S scientists and Iranian counterparts (Taylor, 2009).
2005	USA	The assets of individuals and entities related to Iran's nuclear programs were blocked (Taylor, 2009).
2006	UN/Resolution 1696	Iran was banned from transferring the materials that could be used for Iran's nuclear and missile activities (UN Security Council, Resolution 1696, 2006).
2006	UN/Resolution 1737	Iran was banned from transferring any nuclear-related technologies and materials. The assets of main firms and individuals connected with Iran's nuclear programs were blocked (UN Security Council, Resolution 1737, 2006).
2007	UN/Resolution 1747	Iran was prohibited from all arms trades. All countries and financial institutions were banned from giving any financial assistance or loans to Iran. (UN Security Council, Resolution 1747, 2007).
2007	USA	Three Iranian banks were forbidden from using the U.S banks for transferring money (Taylor, 2009).
2008	UN/Resolution 1803	All countries were asked to exercise vigilance in exported credits, guarantees and insurance in their trade with Iran. All states were asked to inspect cargos which are transferred by Iran Air and Iran Shipping Lines as long as that cargo is suspected containing prohibited items. Iran was banned from importing all dual-use materials and equipment. (UN Security Council, Resolution 1803, 2008)
2010	UN/Resolution 1929	Iran was banned from constructing new nuclear facilities. Iran was forbidden from all commercial activities related to nuclear programs (e.g. uranium mining). All states are forbidden to deliver bunkering services to Iranian vessels. Iran Shipping Lines was added to the backlist. All countries were prohibited to let Iranian banks open new branches and establish new joint ventures. (UN Security Council, Resolution 1929, 2010)
2012	EU	Iranian Central Bank's assets were blocked. Iranian banks were disconnected from the SWIFT. Strict restrictions were imposed on transactions between Iranian banks and the EU. Prohibitions were Imposed on purchasing, importing and transporting gas from Iran. Investing on Iranian oil and gas industries were banned. Exporting key equipment and technologies in the field of oil and gas industries were stopped. Producing new oil tankers for Iran was stopped. Selling, supplying and transferring raw or semi-finished metals and graphite to Iran were prohibited. (Council Regulation (EU) , No. 267/2012, 2010)

Figure 7 illustrates the role of countries and institutes on foreign sanctions against Iran.
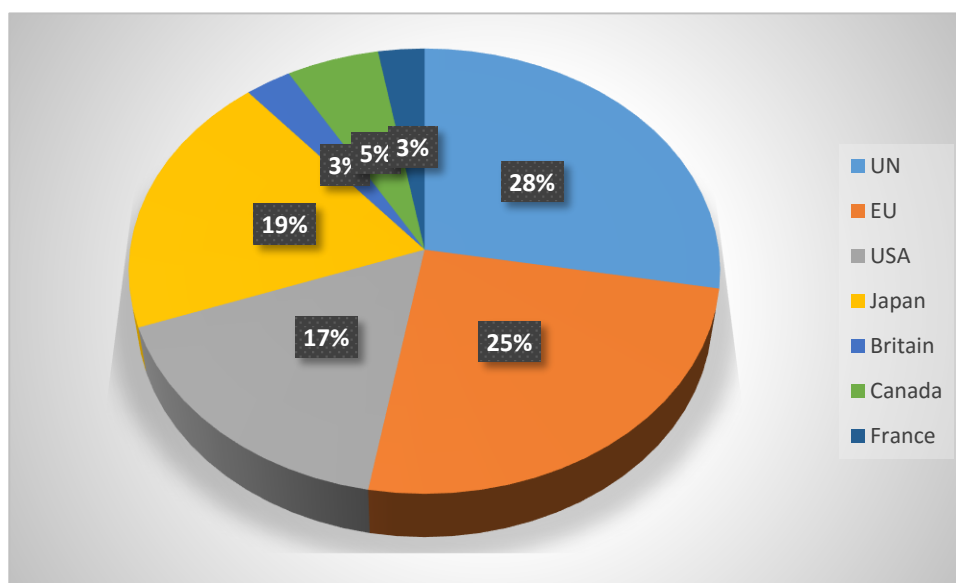

Figure 7: The role of countries on sanctions against Iran

Due to the lack of net assessment from Iranian officials (these assessment may exist but are classified), it is very difficult to determine the effectiveness of sanctions on Iran. The following effects are identified based on Western countries' point of view.

A wide range of sanctions against Iran are related to Iranian petroleum sector aiming at reducing crude oil exports. These sanctions caused the amount of crude oil exports to fall from 2.2 million barrels per day (mbd) in 2011 to 1.1 mbd in 2013(BBC, 2015a). Iranian economic structure heavily relies on oil and gas revenues. According to Farzanegan and Markwardt (2009) %90 of export incomes and %60 of government revenues are relied on oil exports; therefore, this dramatic reduction in oil sales decreased Iran's revenues from $ 118.9 billion in 2011 to $ 64.8 billion in 2013(BBC, 2015b). It caused Iran to experience about %5 reduction in its gross domestic product (GDP) in 2013 (Katzman, 2015). The situation became worse when Iran (due to

financial sanctions) was not able to access the money earned through oil exports. It is estimated that about $ 80 billion of Iran's hard currency is held in foreign banks (Katzman, 2015). Shortage of foreign currencies in the domestic market caused the value of Iranian (Rial) to decline about %56 between 2012 until 2014 (Katzman, 2015). Iran's currency devaluation led to a high inflation rate during 2011-2013. According to the Iranian Central Bank, inflation rate in 2013 was %45. Some economists believe that in addition to sanctions, some policies of the last president had more effect on such a huge inflation (Katzman, 2015).

Given the history of sanctions and resolutions issued against Iran, three scenarios can be considered for the future: the reduction of sanctions (optimistic scenario), maintaining the current situation (middle scenario) and intensification of sanctions (pessimistic scenario) (Hoda Davarzani and Zargerdi, 2011). According to the last round of long term negotiations between the "P+1" countries (Britain, Russia, France, United States, China and Germany) and Iran over Iranian nuclear programs on April 2, 2015 both sides reached an agreement on a potential comprehensive solution. This agreement raised the hope for the sanctions to be lifted, so at the time of writing this thesis the optimistic scenario is more probable.

2.8 Economic Sanctions and Supply Chains

Over the past few decades, due to globalization of industries and supply chains, the relationships between countries have had a crucial role in the success of supply chains. Sanctions are directly related to the relations between countries and the occurrence of them has a very huge potential to damage supply chains. The first thing which crosses the mind about sanctions is prohibition on imports and exports; although, it is just the first and immediate impacts. After a while, financial issues will be appeared which

lead to restrictions on banking transactions and money transferring. In this situation, firms are not able to participate in international financial activities. Moreover, in the long term sanctions reduce foreign investments and collaborations with international organizations. Since sanctions are limited to certain countries such as Iran, Iraq, North Korea and Cuba, their effects on the target's economy and in particular supply chain has received a little attention in the literature. The limited investigations conducted in this area have mostly been concentrating on the effectiveness of sanctions on changing the target nation's policies and other political issues (Zegordi and Davarzani, 2012).

Sanctions are rare but whenever they are imposed they can severely interrupt or delay financial, material and information flows. The occurrence probability of sanction is not fixed and does not follow any distribution function. In the normal situation, the probability is extremely low but due to some political issues and instabilities it may increase rapidly. As a consequence, firms in the normal circumstances do not have a tendency to invest on mitigation strategies to cope with this type of disruption. But during the period when the probability of sanction being imposed increases, taking extreme actions on conceivable choices are reasonable (H. Davarzani et al., 2011). The effectiveness of sanctions on supply chains just like other disruptions depends on several factors:

- The firm's degree of preparedness (Thun and Hoenig, 2011).
- The supply chain's development and sourcing policy (H. Davarzani et al., 2011).
- The level of collaboration with foreign suppliers (Allon and Mieghem, 2010).

Zegordi and Davarzani (2012) use a mathematical model based on Petri net to illustrate the interrelationship and effects of supply chain's disruptions on each other. The

proposed model can be effectively applied to determine the side effects of sanctions on other types of disruptions.

Chapter 3

METHODOLOGY

This chapter seeks to describe how the study has been carried out. This chapter includes three sections. The first section discusses the chosen research method. After that the data collection method and the structure of the questionnaire are illustrated at the second section. The last section of this chapter is dedicated to the reliability analysis of this study.

3.1 Research Method

According to the main research objective, which is implementing risk management among supply chains which are influenced by economic sanctions, multiple methods have been chosen for collecting and analyzing data. Figure 8 illustrates the research methodology of this study.
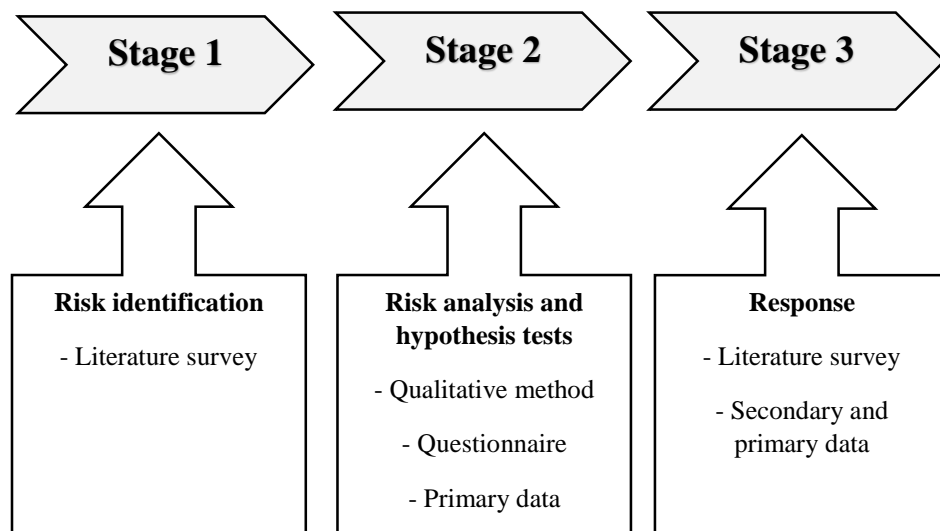

Figure 8: Research methodology (source: own contribution)

The study takes its starting point from the identification of supply chain risks. In order to identify the most important supply chain risks a detailed literature survey about SCM, supply chain risks, risk classifications and SCRM was conducted through several reliable sources like scientific journal articles, books and the Internet. The gathered data of this stage formed the foundation of SCRM and helped the author to prepare a comprehensive list of common supply chain risks. Saving time and accessing higher-quality data were two the main reasons of using secondary data (collecting data from existing sources) at the first stage.

The second stage focuses on calculating and analyzing of all risks which were identified at the first stage. It seems that the qualitative research method is the most suitable approach for this stage. Because the author used the ideas and comprehensions of industrial experts on assessing supply chain risks in order to gain a better understanding of the impacts of economic sanctions. This study concentrates on the Iranian supply chains as a case study. The main reason of selecting such a case study is that Iranian firms and industries have been suffered from tremendous economic and financial sanctions. As a result, analyzing supply chains under this circumstance can provide extremely rich and reliable information related to the research objectives.

Due to some limitations such as distance, number of samples and time restriction, the questionnaire survey method was selected to the collect primary data. The questionnaire (structure of questionaries' is shown in appendix A) was developed based on the literature survey which was conducted at the previous stage.

At the third stage, after assessing and analyzing risks, appropriate responses and actions were selected to deal with the risks with high priority.

3.2 Questionnaire Structure and Data Collection

As mentioned before risk identification is the initial and essential step of SCRM. In order to identify the most important and common supply chain risks the author applied the risk classification system which was proposed by O. Tang and Nurmaya Musa (2011) (see section 2.4 for more information). They categorized supply chain risks in terms of material, information and financial flows (figure 9).

Applying this classification system seems to be more appropriate for the objectives of this study because all supply chains regardless of their size and scope have been always involved with such flows. After that to enrich the list of all common risks which may occur in any supply chain a literature review was done to find reliable data. Literature has been reviewed through scientific data bases including Science Direct, Emerald Insight, Taylor and Francis, Scopus and Google-Books by using keywords supply chain risk, SCRM, economic sanction and supply chain. The results of literature survey and identified risks will be presented in the following sections.
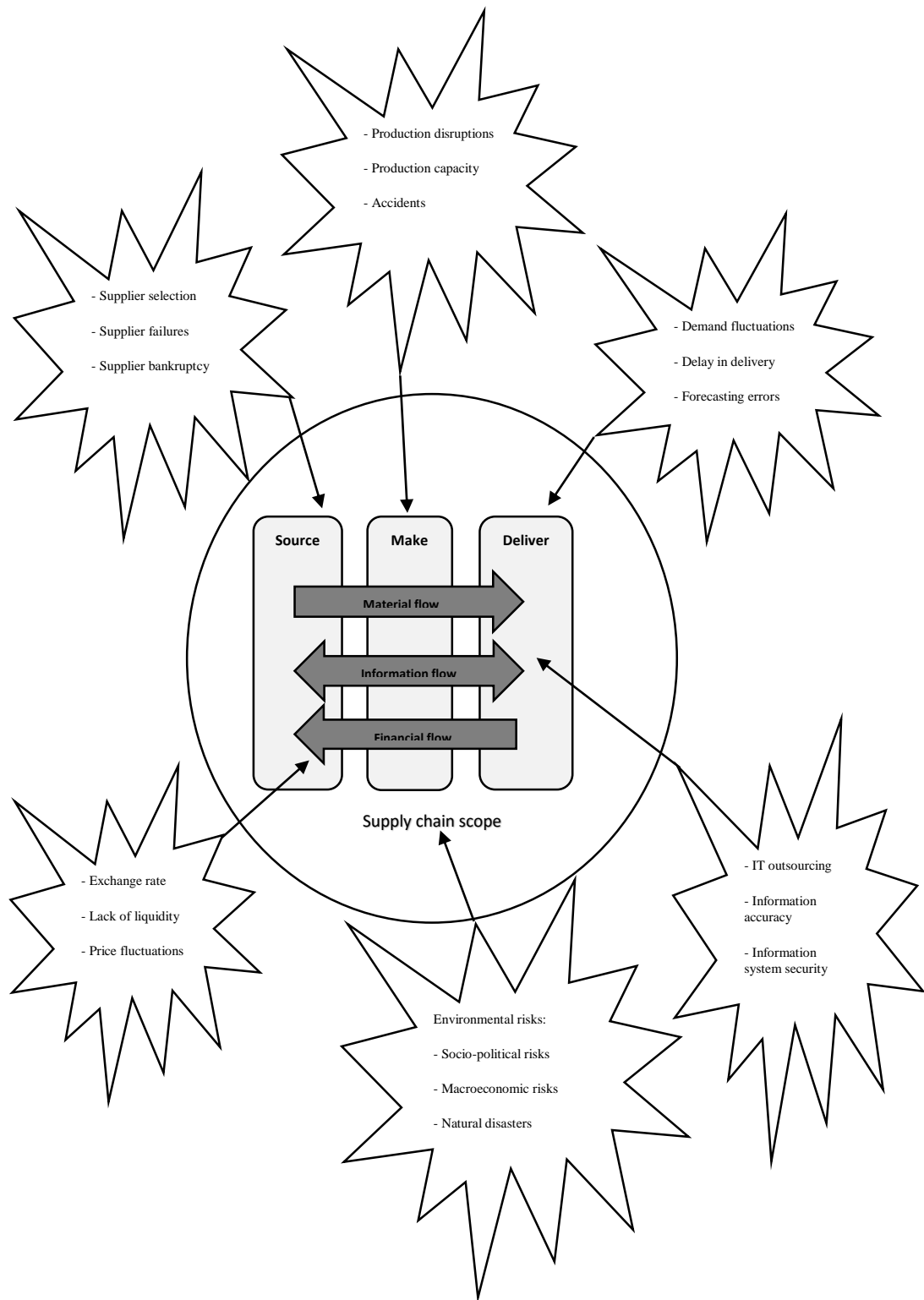
Figure 9: Key drivers of supply chain risks (adopted from :(Musa, 2012))

3.2.1 Financial Flow Risks

Manufacturers dedicate impressive time and resources to deal with their physical supply chain, however regularly it's their financial supply chain which requires the most consideration. As expenses keep on raising, managing cash flow and capital is as critical as managing relationships between supply chain entities.

The financial or cash flow according to Blanchard (2013) can be defined as "the transactions that occur between trading partners that facilitate the purchase and payment for goods and services such as sending purchase orders and invoices and making payment". Relatively financial flow related risks could cause lack of ability to settle payment and inappropriate investment (Yeboah et al., 2014).

A supply chain's cash flow can be affected by three factors:
1- Cash collectable from customer's payment for delivered goods or services.
2- Cash invested on goods which are kept in inventory.
3- Cash may be made accessible to a firm providing that it decides to postpone payments to suppliers for goods and services (Kroes and Manikas, 2014).

The first common financial risk especially in multinational firms is the exchange rate. Based on a survey conducted by the Economist Intelligence Unit (2009) across 500 companies in Europe, North America and Asia-Pacific, 59% of survey respondents believed that their company's supply chain have been negatively affected by fluctuations of exchange rate. Table 7 presents other common financial risks which are founded through the literate survey.

Table 7: Financial flow related risks

Risk factor	References
Exchange rate	(Meulbroek (2002); Tummala and Schoenherr (2011))
Price and cost fluctuations	Cucchiella and Gastaldi (2006)
Shortage of cash (lack of liquidity)	Waters (2007)
Financial strength of supply chain partners	O. Tang and Nurmaya Musa (2011)
Inability of collecting all receivables	Rangel et al. (2014)
Low profitability	Waters (2007)

3.2.2 Information Flow Risks

There is a constant flow of information among the supply chain entities which plays a prominent role in a supply chain's performance. Any disruption or security breach in this flow would cause devastating consequences on the whole network.

The information risk can be defined as "the possibility of loss caused by inaccurate, deficient or unlawful access to data" and information risk management as "the process of managing information risks in a supply chain in order to increase efficiency, benefit and stability". Some common information security risks are: hackers, viruses, worms, spyware, internal employee frauds and outsourcing Information System/Information Technology (IS/IT) (Faisal, Banwet, and Shankar, 2007).

Outsourcing information system is one of the approaches that some companies choose to concentrate more on their core business. Decreasing cost, improving service quality and access to advanced technologies are some of the advantages of this approach. However, it also increases the risks of opportunism of vendors, losing ability of improving valuable competences (Barthélemy, 2003), information security (Khalfan, 2004), loss of business competence, service debasement (Bahli and Rivard, 2005), hidden costs, lack of organization learning and loss of innovative capacity. Table 8

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presents the most common information risks which are founded through the literate survey.

Table 8: Information flow related risks

Risk factor	References
Information security risk (hackers, worms, spyware and etc.)	(Blackhurst et al. (2008); Punniyamoorthy et al. (2013))
IT/IS outsourcing risks	Faisal et al. (2007)
Intellectual property theft risk	Faisal et al. (2007)
Information accuracy	Olson and Wu (2010)
Inadequate IT system	Aloini et al. (2012)
Disclosure of information	Ratnasingam (2006)
Information infrastructure breakdown	Rangel et al. (2014)

3.2.3 Material Flow Risks

The material or physical flow risks involve all risks which are related to the actual movements or flows within and between different elements of a supply chain. All risks which are connected with production processes, storage and inventories, suppliers, transportations and distributions are considered as material risks (Cavinato, 2004). According to O. Tang and Nurmaya Musa (2011) material flow risks can be classified into source, make and delivery risks.

3.2.3.1 Source Related Risks

The fundamental risk here is the disruptions which have been brought about by failures of suppliers to on-time-delivery, quality issues, supplier's financial problems, commitment failures and communication failures (Schlegel and Trent, 2014). Since nowadays more manufacturers tend to outsource their noncore business activities in order to reduce manufacturing costs, increase responsiveness and maintain the competitiveness, the significance of source related risks has increased. This strategy on the other hand, poses serious risks to the supply chain entities such as: exchange

rate, quality issues, production disruption, supplier failure and etc. (Liu and Nagurney, 2011). Table 9 presents the most common source risks which are founded through the literate survey.

Table 9: Source related risks

Risk factor	References
Supplier fulfillment errors(delivery delays and delivery mistakes)	Micheli, Cagno, and Zorzini (2008); Ceryno et al. (2014)
Inflexibility of supply source	(Ceryno et al. (2014); Punniyamoorthy et al. (2013))
Quality issues	(Ceryno et al. (2014); Punniyamoorthy et al. (2013))
Procured from a single source	Tummala and Schoenherr (2011)
Supplier selection	O. Tang and Nurmaya Musa (2011)
Supplier insolvency	Waters (2007)
Supplier bankruptcy	Ceryno et al. (2014)
Supplier breach contract agreement	Pujawan and Geraldin (2009)
Lack of control over supplier	Rangel et al. (2014)
Financial strength of suppliers	Micheli et al. (2008)
Inability to quickly implement product and technological changes	Micheli et al. (2008)
Difficulties in satisfying the demand	Micheli et al. (2008)

3.2.3.2 Operational Related Risks

Make or operational risks in supply chain generally depend on design, manufacturing and distribution (M. S. Sodhi and C. S. Tang, 2012).These risks would be connected to issues of production systems, procedures, process and labor (Rangel et al., 2014).

However, supply chains which have invested a lot in total quality management, lean manufacturing and 6-sigma to develop quality and capabilities, their operational activities are still vulnerable to problems that may cause variability in effective capacity and quality (C. Tang and Tomlin, 2008). The important risks in this category are presented in table 10.

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Table 10: Make related risks

Risk factor	References
Inadequate production capability	Punniyamoorthy et al. (2013)
Inflexibility in capacity	Tummala and Schoenherr (2011)
Disruption in production	O. Tang and Nurmaya Musa (2011)
Weakness in the planning and control of production and inventory	Rangel et al. (2014)
Machine breakdown	Sudeep and Srikanta (2014)
Service, maintenance and spares	Waters (2007)
Critical equipment and tools	Waters (2007)
Technological backwardness	Sudeep and Srikanta (2014)
Lack of skilled worker	Vilko and Hallikas (2012)
Labor strikes	Vilko and Hallikas (2012)
Carelessness and lack of motivation among the workforce	Vilko and Hallikas (2012)
Health and safety issues	Waters (2007)
Accidents (fire…)	Waters (2007)
Customer health and product safety	Ceryno et al. (2014)
Product and process design risks	O. Tang and Nurmaya Musa (2011)
Shortage of material	Pujawan and Geraldin (2009)
Interrupted gas/electricity supply	Pujawan and Geraldin (2009)
R&D uncertainty(uncertain results from R&D activities)	Ceryno et al. (2014)
Product design changes	Cagliano et al. (2012)
Technological changes	Cagliano et al. (2012)
Poor quality	Sudeep and Srikanta (2014)
Hesitation in sharing of design and other documents with supplier	Punniyamoorthy et al. (2013)
higher product cost	Tummala and Schoenherr (2011)

3.2.3.3 Delivery Related Risks

Delivery risks are derived from disruptions coming up from downstream supply chain operations (Jüttner, 2005). Disruptions arise from a mismatch between a firm's estimation and actual demand as well as from inadequate supply chain coordination. The findings of Economist Intelligence Unit (2009) survey show that 62% of supply chains decision makers consider the inability to forecast future demand as the most

important risk. The negative consequences of these disruptions are costly shortages, obsolescence, inefficient capacity utilization and bullwhip effect (Wagner and Bode, 2006). Table 11 presents the most common delivery risks.

Table 11: Delivery risks

Risk factor	References
Forecast error in demand	Punniyamoorthy et al. (2013)
Unanticipated or very volatile changes in demand	Punniyamoorthy et al. (2013)
Demand fluctuates seasonally	Wagner and Bode (2006)
Delay in delivery to customers	Punniyamoorthy et al. (2013)
Changes in customers tastes	Ceryno et al. (2014)
Customer insolvency	Pfohl, Gallus, and Kohler (2010)
Balance of unmet demand and excess inventory	O. Tang and Nurmaya Musa (2011)
Cost of holding inventories	Tummala and Schoenherr (2011)
Rate of product obsolescence	Tummala and Schoenherr (2011)
Bullwhip effect	Ceryno et al. (2014)
Reputation risk or confidence loss in product or brand	Rangel et al. (2014)
Lack of transportation capacity	Pfohl, Gallus, et al. (2010)
Logistic outsourcing risks	Drewry (2009)
Higher cost of transportation	Tummala and Schoenherr (2011)
Port issues (lack of adequate capacity, port strikes, …)	Tummala and Schoenherr (2011)
Border crossing and customs regulations	Blackhurst et al. (2008)
Theft and cargo loss or damage	Drewry (2009)

3.2.4 Environmental Risks

Environmental risks are derived from socio-politics, macroeconomics and natural disasters. These risks may have impacts on the focal firm, the whole chain and even the marketplace (Martin christopher and Peck, 2002). Furthermore, such external risks can scarcely be affected and conducted directly or indirectly inside the supply chain

(Thun and Hoenig, 2011). Table 12 presents the most common environmental risks which are founded through the literate survey.

Table 12: Environmental risks

Risk factor	References
Fiscal and monetary reforms	Ceryno et al. (2014)
Trade restrictions	Ceryno et al. (2014)
Strict safety regulations	Rangel et al. (2014)
Strict environmental policies	Waters (2007)
Economic sanctions	Ceryno et al. (2014)
Political stability	Ceryno et al. (2014)
Democratic changes in government	Ceryno et al. (2014)
War/Revolution	Waters (2007)
Terrorist attack or Sabotage	Waters (2007)
Social unrest	Blackhurst et al. (2008)
Changing social concerns	Ceryno et al. (2014)
Energy price volatility	Meulbroek (2002)
Inflation	Meulbroek (2002)
Interest rate	Ceryno et al. (2014)
Tax and tariff changes	Rangel et al. (2014)
Material prices fluctuations	Rangel et al. (2014)
Climate change	Vilko and Hallikas (2012)
Natural disasters (earthquakes, floods, droughts, …)	Vilko and Hallikas (2012)

3.2.5 Data Collection

The aim of this survey is the empirical investigation of the effects of economic sanctions on the SCRM in order to give an insight on this issue from the Iranian supply chain expert's point of view. For this research, 64 companies conducted in Iran from different industries have been chosen and the questionnaire have been sent via email. In order to gather accurate and reliable data all selected companies are familiar with

the concept of SCM and related risks and issues in this field. The participants belonged to different positions but all had a comprehensive knowledge of their firm's operations.

The questionnaire used three five-point Likert scales to estimate probability, consequence and economic sanctions of each identified risk. This helps the participants to determine the consent to a specific statement.

Tables 13, 14 and 15 illustrate the classification for probability, consequence and economic sanctions.

Table 13: Illustrative probability scale

Descriptor	Description	Frequency	score
Certain	Event is expected to happen	Has occurred more than 4 times a year	5
Likely	Event is likely to occur	Has occurred 3 or 4 times a year	4
Possible	Event may occur at sometime	Has occurred 1 or 2 times a year	3
Unlikely	Event is unlikely to occur	Has occurred once in 1 or 2 years	2
Rare	Event is highly unlikely	Has occurred once in more than 3 years	1

Table 14: Illustrative impact scale

Descriptor	Description			score
	People	property	Financial	
Catastrophic	Multiple deaths(employees, customers, vendors)	Destruction or loss of > 50% of total assets	Financial loss of > 50% of annual profit	5
Major	Single death or multiple major injuries	Major damage to property or loss of < 50% of total assets	Financial loss of < 50% of annual profit	4
Moderate	Major injury requiring hospitalization	Damage or loss of <20% of total assets	Financial loss of < 20% of annual profit	3
Minor	Injury requiring medical treatment	Loss of <10% of total assets	Financial loss of < 10% of annual profit	2
Insignificant	Minor injury requiring first aid treatment	Minor damage to property	Negligible lost profit	1

Table 15: Illustrative economic sanctions scale

Descriptor	Description	score
Integral	Economic sanctions are the only source of the risk	5
Very strong	There is a very strong connection between the risk and economic sanctions	4
Strong	There is a strong connection between the risk and economic sanctions	3
Limited	There is a restricted connection between the risk and economic sanctions	2
Irrelevant	There is no connection between the risk and economic sanction	1

After specifying ranges of probability, consequence and economic sanctions by participants, the risk score was calculated by multiplying the three mentioned measures.

3.3 Reliability Analysis

According to Saunders, Lewis, and Thornhill (2009) reliability analysis must be done to measure the extent to which the data collection methods or analysis techniques will

yield the same findings. For this study, the Cronbach's Alpha which is one of the most accepted test of reliability was used. This coefficient is utilized to determine the effectiveness of a questionnaire to measure success factors and to specify to which extent items of a questionnaire are related; furthermore, this coefficient can help a researcher to recognize and exclude problematical items in order to increase reliability.

The reliability coefficient of the questionnaire in this study was calculated by SPSS statistics 22.

According to Nunnally (1978), minimal Cronbach' Alpha value of 0.7 is regarded as acceptable. The value of Cronbach's Alpha in this study was 0.97 which illustrated that all items of the questionnaire had high internal consistency; therefore, the questionnaire was reliable.

Chapter 4

FINDINGS AND ANALYSIS

In this chapter, the findings and analysis obtained from the collected data will be presented. As mentioned in the previous chapter, the questionnaire survey was used to explore the opinions of Iranian industrial experts on assessing supply chain risks. The questionnaire seems to be an appropriate method for the purpose of this thesis because it is more practical, it is not expensive, a plenty of information can be gathered from a large group of participants and the findings can be simply quantified.

The chapter goes on to illustrate the results from questionnaire through each participant's point of view. Furthermore, the required statistical analysis have been done for the raw data.

4.1 Profile of Questionnaire Respondents

To reach the purpose of this research, 64 companies located in Iran were selected. The chosen companies belong to different industrial sectors from automotive to medical, food, electronic and others. Having enough knowledge about supply chain and risk management and implementation of supply chain or logistics management were the main criteria to select the case companies. In order to collect reliable and accurate data, it is important that all participants have not only an extensive understanding about the concept of SCM and risk management but also a comprehensive information about their company's operations. For this reason, the participants were asked to identify

individuals who would be appropriate to response the questionnaire. A total of 64 questionnaires were sent via email to experts.

Among the 64 selected companies, 34 participated in the study. Among the respondents, 16 participants filled out the questionnaire by email and 18 of them were participated in face-to-face interview. The total response rate in the study was 53%. Table 16 presents the response rate of the study for different industry type.

Table 16: Response rate

Industry type	Number of distributed	Number of responded	Response rate %
Automotive	14	7	50
Medical	9	4	44
Electronic	11	7	64
Manufacturing	10	6	60
Food	8	4	50
Construction	7	3	43
Others	5	3	60
Total	64	34	53

The participants had a wide range of duties and varied in terms of job title. In terms of working experience, the average respondent's working experience was 14 years. Figure 9 and 10 describe the research sample by job position and working experience.
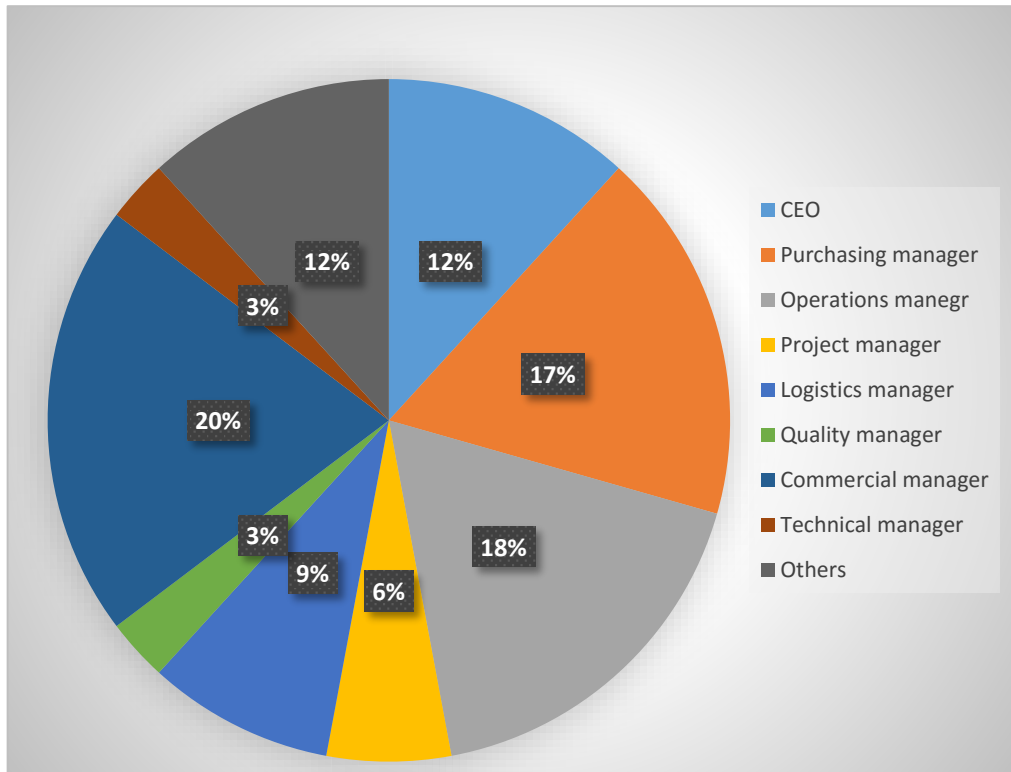
Figure 10: The respondent's job title
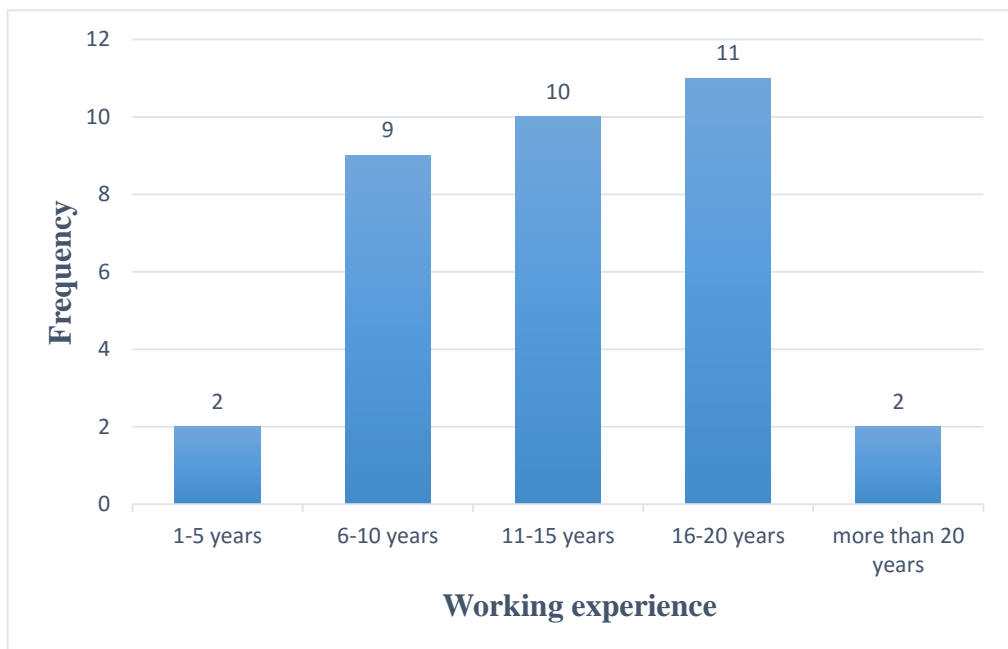
Figure 11: The respondent's working experience

The high level of working experience and their position show that their opinions are trustworthy and representative. Table 17 presents an overview of respondent attributes.

Table 17: Respondent attributes

		Frequency	Percentage (%)
Industry type	Automotive	7	20.59
	Medical	4	11.76
	Electronic	7	20.59
	Manufacturing	6	17.65
	Food	4	11.76
	Construction	3	8.82
	Others	3	8.82
	Total	34	100.00
Job title	CEO	4	11.76
	Purchasing manager	6	17.65
	Operations manger	6	17.65
	Project manager	2	5.88
	Logistics manager	3	8.82
	Quality manager	1	2.94
	Commercial manager	7	20.59
	Technical manager	1	2.94
	Others	4	11.76
	Total	34	100.00
Working experience	1-5 years	2	5.88
	6-10 years	9	26.47
	11-15 years	10	29.41
	16-20 years	11	32.35
	more than 20 years	2	5.88

4.2 Risk Analysis

Risks were assessed by experts in terms of their probability, impact and economic sanctions (the process of calculating is presented in section 3.2.5) in order to prioritize them. Appendix B shows the descriptive statistics of all identified risks. In this appendix mean, standard deviation and rank of each individual risk in terms of probability, impact, economic sanctions and risk score are calculated. The results of appendix B were prioritized based on the risk score in table 18. In addition, 2 charts were used to gain a better understanding of risks with high priority (see appendix C and figure 12)

Table 18 (cont.): Risk prioritize

Risk factors	Mean of risks	Percentage %
Exchange rate	49.15	3.21%
Material prices fluctuations	48.24	3.15%
Supplier bankruptcy	46.41	3.03%
Inability to not collecting all receivables	46.03	3.00%
Procured from a single source	42.56	2.78%
Inflation	40.15	2.62%
Energy price volatility	37.09	2.42%
Shortage of cash(lack of liquidity)	35.50	2.32%
Technological backwardness	35.12	2.29%
Quality issues	34.91	2.28%
Trade restrictions	33.38	2.18%
Price and cost fluctuations	32.91	2.15%
Customer insolvency	32.76	2.14%
Interest rate	32.76	2.14%
Currency devaluations	32.65	2.13%
Shortage of material	31.76	2.07%
Oil price	31.00	2.02%
Low profitability	29.47	1.92%
Poor quality	25.88	1.69%
Tax and tariff changes	25.65	1.67%
higher product cost	24.41	1.59%
Political instability	22.47	1.47%
Disruption in production	21.41	1.40%
Delay in delivery to customers	20.62	1.35%
Supplier fulfillment errors(delivery delays and delivery mistakes)	19.79	1.29%
Financial strength of supply chain partners	19.26	1.26%
Critical equipment and tools	19.21	1.25%
Higher cost of transportation	18.85	1.23%
Machine breakdown	18.06	1.18%

Table 18 (cont.): Risk prioritize

Risk factors	Mean of risks	Percentage %
Supplier insolvency	17.50	1.14%
Fiscal and monetary reforms	17.35	1.13%
Inflexibility of supply source	16.50	1.08%
Loss of key suppliers	16.41	1.07%
Technological changes	16.18	1.06%
Border crossing and customs regulations	16.00	1.04%
Inadequate production capability	15.97	1.04%
Information infrastructure breakdown	15.68	1.02%
Difficulties in satisfying the demand	15.59	1.02%
Lack of transportation capacity	15.12	0.99%
War/Revolution	14.94	0.98%
Inability to quickly implement product and technological changes	14.91	0.97%
Supplier selection	14.50	0.95%
Supplier breach contract agreement	14.38	0.94%
Service, maintenance and spares	14.38	0.94%
Social unrest	14.32	0.94%
Inadequate IT system	14.15	0.92%
Port issues (lack of adequate capacity, port strikes, …)	14.12	0.92%
Financial strength of suppliers	13.53	0.88%
Logistic outsourcing risks	13.53	0.88%
R&D uncertainty(uncertain results from R&D activities)	13.47	0.88%
Democratic changes in government	13.47	0.88%
Weakness in the planning and control of production and inventory	12.94	0.84%
Forecast error in demand	12.47	0.81%
Inflexibility in capacity	12.29	0.80%
Unanticipated or very volatile changes in demand	12.12	0.79%
Changes in customers tastes	12.03	0.79%
Changing social concerns	11.97	0.78%
Cost of holding inventories	11.91	0.78%

Table 18 (cont.): Risk prioritize

Risk factors	Mean of risks	Percentage %
Terrorist attack or Sabotage	11.56	0.75%
Demand fluctuates seasonally	11.35	0.74%
Interrupted gas/electricity supply	11.24	0.73%
Reputation risk or confidence loss in product or brand	11.09	0.72%
Information accuracy	10.56	0.69%
Lack of control over supplier	10.47	0.68%
Carelessness and lack of motivation among the workforce	9.68	0.63%
Customer health and product safety	9.59	0.63%
Hesitation in sharing of design and other documents with supplier	9.44	0.62%
Bullwhip effect	9.35	0.61%
Product and process design risks	9.15	0.60%
Lack of skilled workers	8.38	0.55%
Strict environmental policies	8.06	0.53%
Information security risk (hackers, worms, spyware and etc.)	7.79	0.51%
Health and safety issues	7.71	0.50%
Labor strikes	7.21	0.47%
Rate of product obsolescence	7.06	0.46%
Disclosure of information	7.03	0.46%
Intellectual property theft risk	6.74	0.44%
Strict safety regulations	6.62	0.43%
Accidents (fire…)	6.12	0.40%
Theft and cargo loss or damage	6.06	0.40%
IT/IS out sourcing risks	5.91	0.39%
Climate change	4.29	0.28%
Natural disasters (earthquakes, floods, droughts, …)	4.15	0.27%
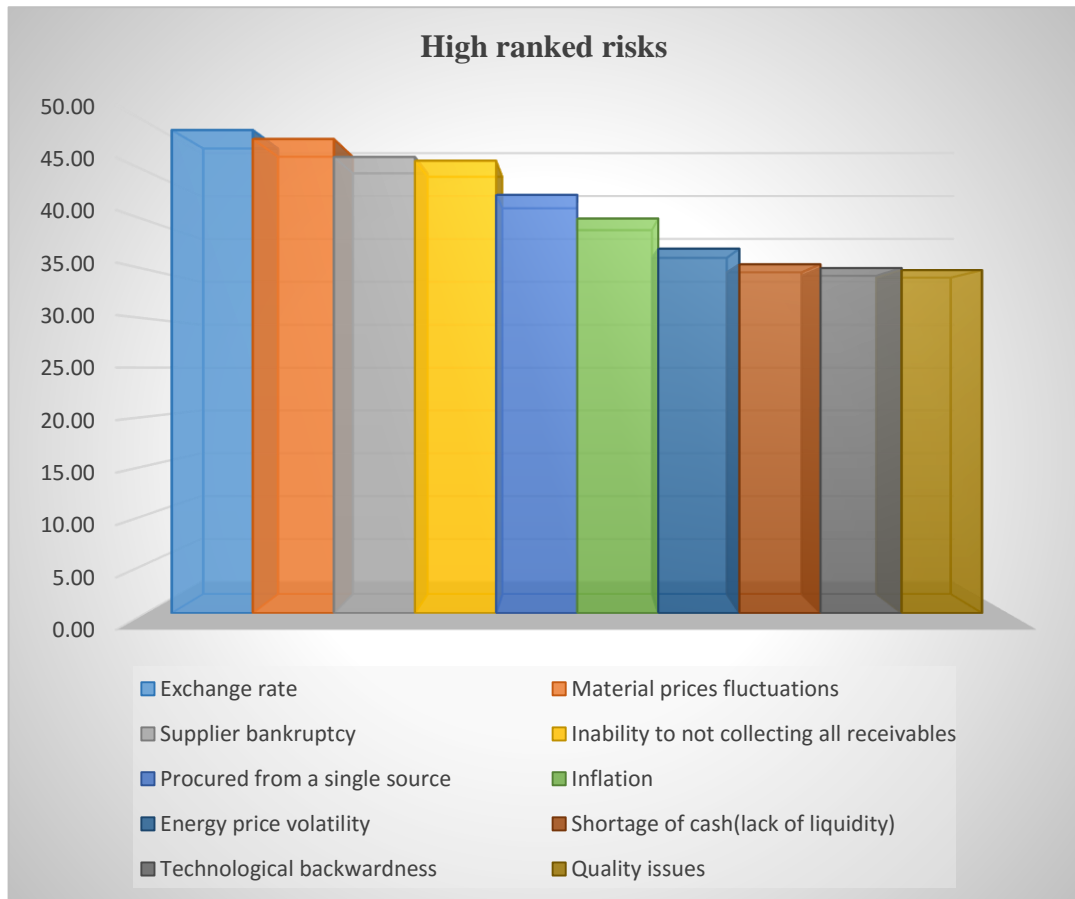
Figure 12: High ranked risks

According to table 18 and figure 12, the risk of currency fluctuation was the top concern of supply chain executives. In case of Iran, global financial sanctions are considered to be the main reason of experiencing such a huge fluctuations in foreign currencies.

The second-highest concern among supply chain decision makers in Iran was raw material price fluctuations. Raw material cost is considered as one of the main elements in the cost of product especially in the process industries where 50 to 60 % of overall costs of manufacturers derive from raw materials (Leybovich, 2012). In this situation, in order to increase the earning margins, improve security of supply and

enhance supply chain operations companies have been implementing an appropriate raw material management.

Supplier bankruptcy, inability to collect all receivables and procuring from a single source were the other important risks among companies in Iran. In the next chapter more discussions will be presented related to these high ranked risks.

4.4 Effects of Economic Sanctions

After assessing supply chain risks, the participants were asked for their estimation concerning the vulnerability of their supply chain with regards to economic sanctions. The mean value of all participants was 3.53 on the five-point Likert scale (1 is no effect, 2 is low, 3 is moderate, 4 is high and 5 is very high negative effect). The results obtained from respondents are presented in table 19.

Table 19: Vulnerability of supply chain

Score	Frequency	Percentage %
1	0	0
2	2	5.9
3	13	38.2
4	18	52.9
5	1	2.9
Total	34	100

According to table 19, 55.8% of respondents regarded their supply chain as being highly vulnerable due to the sanctions (point 4 or 5). Only 5.9% of them estimated that economic sanctions had little or no negative effects on their supply chain (point 1 or 2 on the Likert scale).

The individual Likert items was used to gather data for this part. So, utilizing the Wilcoxon Signed Rank Test seems more appropriate to the first hypothesis (H1: Supply chains are regarded as being more vulnerable due to sanction). This test determines whether the median of answers differs significantly from a specific value or not.

Mathematically speaking the null and alternative hypotheses are defined as:

H_0 = the median is equal to 3

H_1 = the median is greater than 3

Table 20: Wilcoxon test for the first hypothesis

	N	N for test	Wilcoxon Statistic	p	Estimated median
C1	34	21	210.0	0.001	3.500

The results of the Wilcoxon test in table 20 show that the null hypothesis is rejected (P-value = 0.001) and it can be stated that the median is greater than 3. In the other words, the majority of participants believed that their supply chain was more vulnerable as a results of sanctions. Thus, the first hypothesis of this study (H1: Supply chains are regarded as being more vulnerable due to sanction) cannot be rejected.

In addition, to understand which of the supply chain performance measures are mostly affected by the sanctions, the participants were asked to give their estimations with regards to each of the performance measure. The results obtained from participants' responses are shown in figure 13.
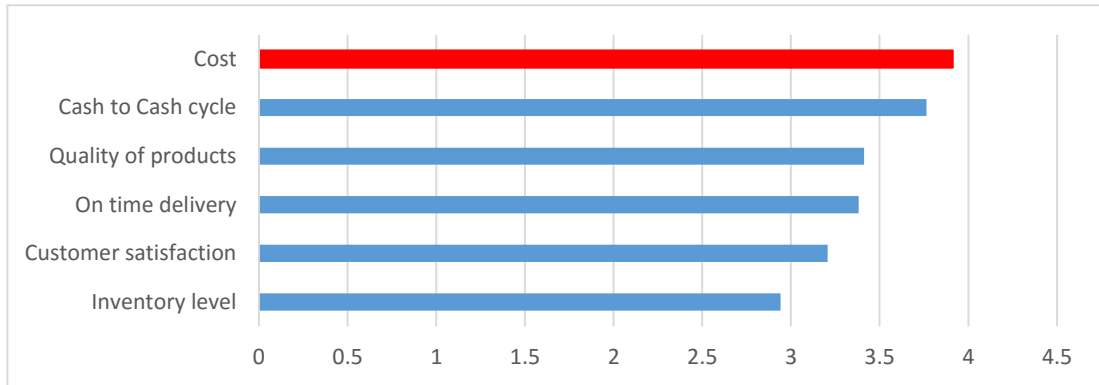
Figure 13: Supply chain performance measures

According to figure 13, the average value of all participants related to the cost was 3.9 on the five point Likert scale, so cost increases in the supply chains must be considered as the most critical performance measure which is highly impacted due to the sanctions.

In the next step, the effects of sanctions on different supply chain risk drivers were investigated to see whether all risk drivers were equally affected by sanctions or not?

As shown in figure 14, 98.6% of participants believed that economic sanctions have no or limited impacts on natural disasters risks. On the other hand, 65.6%, 64.6% and 54.7% of participants believed that sanctions have strong effects on financial, macroeconomic and Scio-political risk drivers, respectively.
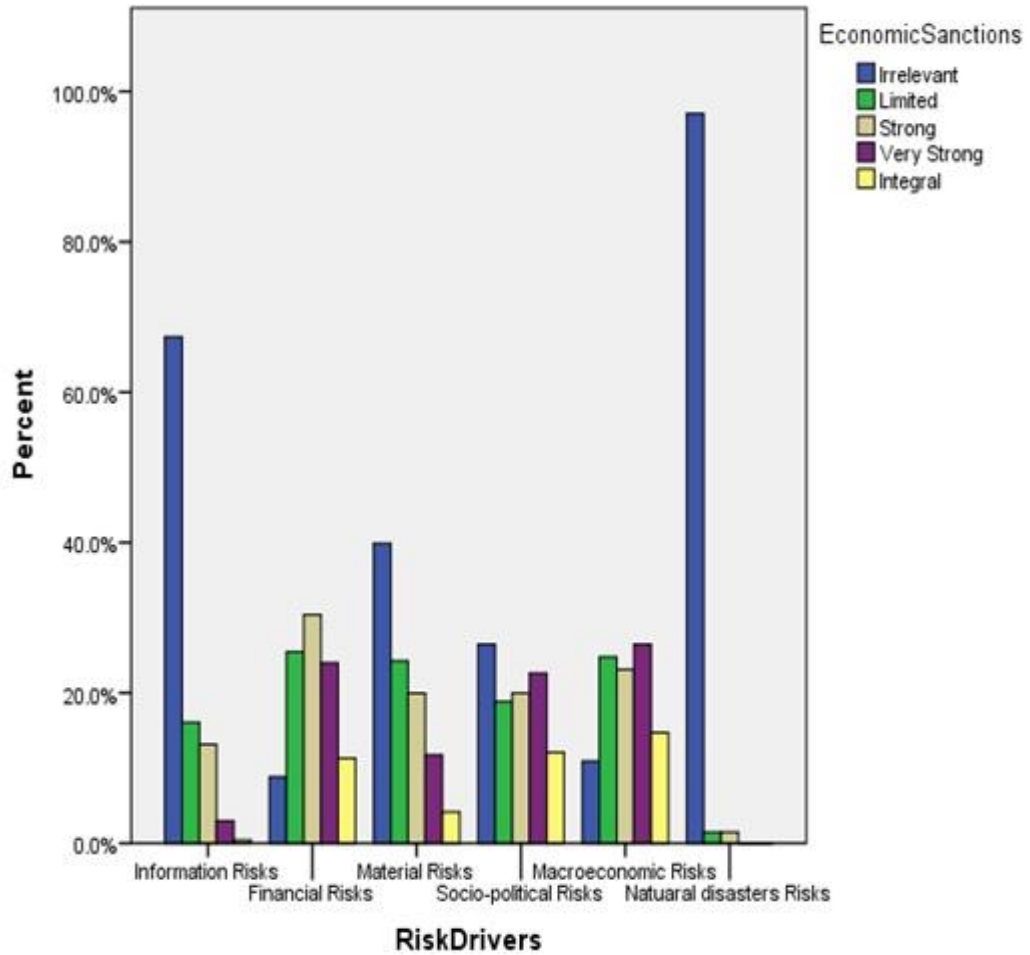
Figure 14: Impact of sanctions on risk drivers

One way ANOVA was applied to test the second hypothesis (H2: Sanctions have different impacts on various supply chain risk drivers). Since for testing this hypothesis several Likert questions which have the same Likert scale are summed, parametric statistical tests such as analysis of variance based on the Central Limit Theorem can be applied.

To do this, the means and standard deviations of all identified risk drivers were calculated as shown in table 21.

Table 21: Descriptive statistics related to risk drivers

Risk drivers	Mean of sanctions	Standard deviation of sanctions
Information flow risks	1.53	0.32
Financial flow risks	3.03	0.43
Material flow risks	2.16	0.57
Scio-political risks	2.75	0.75
Macroeconomic risks	3.09	0.31
Environmental risks	1.04	0.06

This test assumes that samples are randomly selected from a normal population, samples are independent and that their standard deviations are equal. For testing the equality of variance the Levene's test was applied. According to which, the null hypothesis was that the variance are equal against the alternative hypothesis that they are not equal for the means of sanctions affect (dependent variable) on different risk drivers (fixed factors).

Mathematically speaking:

H_0: $\sigma1^2 = \sigma2^2 = \sigma3^2 = \sigma4^2 = \sigma5^2 = \sigma6^2$

H_1: above not true for at least one σi^2

It is needed to mention that α (the level of significance) was assumed 0.05 for rejecting the null hypothesis.

According to table 22, since the p-value was 0.139 (p-value> 0.05), the null hypothesis cannot be rejected. It means that at the 5% level of confidence variance did not show any statistical difference.

Table 22: Results of the Levene's test related to risk drivers

F	df1	df2	Sig (p-value)
1.724	5	77	.139

While the equality of variance assumption was satisfied, the one way ANOVA was done by the SPSS and the results are shown in table 23.

Table 23: Results of ANOVA related to risk drivers

Source	Sum of Squares	df	Mean Square	F_0	Sig.
Corrected Model	17.968a	5	3.594	11.758	.000
Intercept	172.777	1	172.777	565.321	.000
Risk Drivers	17.968	5	3.594	11.758	.000
Error	23.533	77	.306		
Total	477.724	83			
Corrected Total	41.502	82			

Since critical F-value for this test ($F_{0.05, 5, 77}$) is 2.33 and it is much less than F_0 (11.758), it can be stated that economic sanctions have different effects on the risk drivers. In other words, the second hypothesis (H2: Sanctions have different impacts on various supply chain risk drivers) cannot be rejected. Furthermore, to identify which supply chain risk drivers are more affected by sanctions the Tukey multiple comparisons method was applied.

From the table 24, it can be stated that financial risks, macroeconomic risks and Scio-political risks are significantly different (p-value <0.05) from other risk drivers and are mostly impacted by sanctions.

Table 24: Multiple comparisons

(I) Risk drivers	(J) Risk drivers	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Information Risks	Financial risks	-1.5048*	.30757	.000	-2.4037	-.6058
	Material risks	-.6310	.22283	.063	-1.2823	.0202
	Scio-political risks	-1.2214*	.27244	.000	-2.0177	-.4252
	Macroeconomic risks	-1.5643*	.29550	.000	-2.4280	-.7006
	Natural disasters	.4836	.44325	.884	-.8119	1.7791
Financial risks	Information Risks	1.5048*	.30757	.000	.6058	2.4037
	Material risks	.8737*	.23860	.006	.1764	1.5711
	Scio-political risks	.2833	.28548	.919	-.5511	1.1177
	Macroeconomic risks	-.0595	.30757	1.000	-.9585	.8394
	Natural disasters	1.9883*	.45139	.000	.6691	3.3076
Material risks	Information Risks	.6310	.22283	.063	-.0202	1.2823
	Financial risks	-.8737*	.23860	.006	-1.5711	-.1764
	Scio-political risks	-.5904*	.19119	.032	-1.1492	-.0316
	Macroeconomic risks	-.9332*	.22283	.001	-1.5845	-.2820
	Natural disasters	1.1146	.39850	.069	-.0501	2.2793
Scio-political risks	Information Risks	1.2214*	.27244	.000	.4252	2.0177
	Financial risks	-.2833	.28548	.919	-1.1177	.5511
	Material risks	.5904*	.19119	.032	.0316	1.1492
	Macroeconomic risks	-.3429	.27244	.806	-1.1391	.4534
	Natural disasters	1.7050*	.42822	.002	.4534	2.9566
Macroeconomic risks	Information Risks	1.5643*	.29550	.000	.7006	2.4280
	Financial risks	.0595	.30757	1.000	-.8394	.9585
	Material risks	.9332*	.22283	.001	.2820	1.5845
	Scio-political risks	.3429	.27244	.806	-.4534	1.1391
	Natural disasters	2.0479*	.44325	.000	.7524	3.3434
Natural disasters	Information Risks	-.4836	.44325	.884	-1.7791	.8119
	Financial risks	-1.9883*	.45139	.000	-3.3076	-.6691
	Material risks	-1.1146	.39850	.069	-2.2793	.0501
	Scio-political risks	-1.7050*	.42822	.002	-2.9566	-.4534
	Macroeconomic risks	-2.0479*	.44325	.000	-3.3434	-.7524

Figure 15 clearly points to the fact that sanctions have a moderate impact on the material and information risks in comparison with the first mentioned supply chain risk drivers. And, as expected, no association was identified between sanctions and natural disasters.
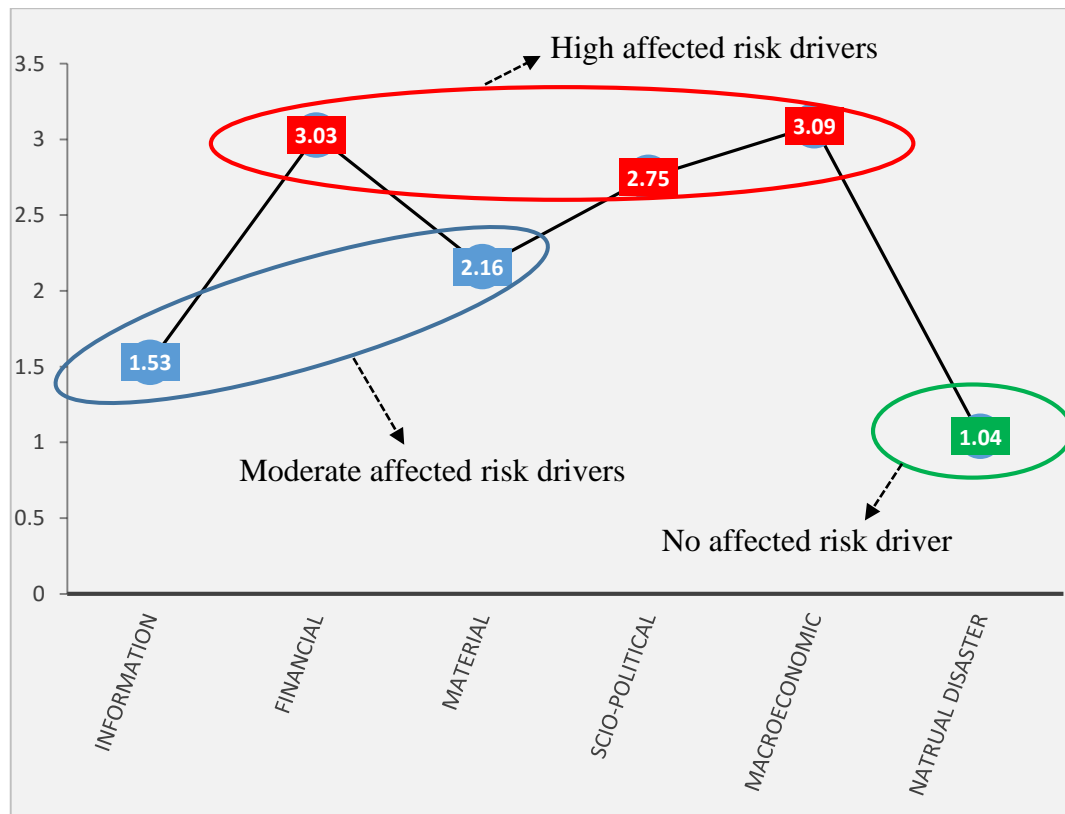

Figure 15: Effect of sanctions on supply chain risk drivers

The one way ANOVA was used again to investigate how sanctions might affect different industries. As mentioned before, the questionnaire was distributed among various companies. Means and standard deviations of sanction score regarded to each type of industry were calculated as shown in table 25.

Table 25: Descriptive statistics related to industry type

Industry type	Mean of sanctions	Standard deviation of sanctions
Automotive	2.40	0.59
Medical	1.88	0.34
Electronic	2.62	0.54
Manufacturing	2.34	0.66
Food	2.06	0.51
Construction	1.78	0.32
Others	2.59	0.41

Same as the previous statistical analysis, at first the Levene's test was performed to check the equality of variance among all samples (Table 26).

Table 26: Results of the Levene's test related to industry type

F	df1	df2	Sig (p-value)
.707	6	27	.647

Since based on table 26 the assumption of variance equality was satisfied (p-value is greater than 0.05), one way ANOVA was applied. Results of ANOVA is presented in table 27.

Table 27: Results of ANOVA related to risk drivers

Source	Sum of Squares	Df	Mean Square	F_0	Sig.
Corrected Model	2.819	6	.470	1.638	.175
Intercept	152.103	1	152.103	530.363	.000
Industry types	2.819	6	.470	1.638	.175
Error	7.743	27	.287		
Total	190.222	34			
Corrected Total	10.563	33			

Table 27 shows that all industries regardless of their type, size and scope are negatively affected by the sanctions. And, there is no significant difference between different industry types in this field ($F_0= 1.638 <$ critical F-value= 2.459). Thus, the third hypothesis (H3: Sanctions have different impact on different industries) is rejected.

Furthermore, the participants were asked to give their estimation about the effect of sanctions on the occurrence probability of other disruptions in their supply chain. The results obtained from respondents are presented in table 28.

Table 28: Effect of sanctions on the occurrence probability of other risk factors

Score	Frequency	Percentage %
1	0	0
2	2	5.9
3	14	41.2
4	17	50.0
5	1	2.9
Total	34	100.0

The mean value of all participants was 3.5 on the five-point Likert scale (1 means sanctions have no effect, 2 means sanctions have a low effect, 3 means sanctions have a moderate effect, 4 means sanctions have a high effect and 5 means sanctions have a very high effect on increasing the occurrence probability of supply chain risks). Almost 94.1% of the firms believed that the occurrence probability of supply chain risks has been increased due to sanctions (point 3 or 4 or 5 on the Likert scale) and only 5.9% of the managers stated that there is little or no relation between sanctions and the occurrence probability of supply chain risks (point 1 or 2 on the Likert scale).

Same as the first hypothesis the individual Likert items was used to gather data for this past. Therefore, the Wilcoxon test was applied to see whether the median of answers differs significantly from specific value or not.

Mathematically speaking the null and alternative hypotheses are defined as:

H_0 = the median is equal to 3

H_1 = the median is greater than 3

Table 29: Wilcoxon test for the fourth hypothesis

	N	N for test	Wilcoxon Statistic	p	Estimated median
C2	34	20	190.0	0.001	3.500

According to table 29 the null hypothesis is rejected (P-value = 0.001) and it can be stated that the median is greater than 3. In other words, the most of participants believed that the occurrence probabilities of supply chain risks have been increased due to the sanctions. So, the last hypothesis (H4: the occurrence probability of supply chain risks has been increased due to sanctions) cannot be rejected.

Chapter 5

DISCUSSION OF RESULTS

The following chapter aims to discuss the results extracted from the survey carried out on Iranian companies in order to illustrate the impacts of sanctions on supply chains. Iran has been suffering from tremendous global economic and financial sanctions, therefore; selecting the Iranian companies as the case study provides reliable data for the thesis's questions.

This chapter includes four sections. In the first two sections, discussions will be made on the results of the questionnaire to identify the high ranked risks and propose effective responses to each high risk factor in the supply chains which are affected by sanctions. The implications of findings will be presented in the third section and last section will be devoted to the explanation of the main limitations of this study.

5.1 Discussion on Risk Analysis

Based on the statistical analysis results presented in previous chapter, the top five ranked risks are as follows:

- Exchange rate

- Material prices fluctuations

- Supplier bankruptcy

- Inability to collect all receivables

- Procured from a single source

5.1.1 Exchange Rate

The results of this study show that the unfavorable exchange rate movements have been considered as the most important risk factor among Iranian companies. It is believed that sanctions have the main role in experiencing this huge exchange rate fluctuations in Iran's market. Due to the mentioned sanctions (see table 6) Iran's access to the global financial market and its oil revenue has been dramatically limited. As shown in figure 16, in 2010 with the start of the new economic and financial sanctions, the value of Iran's currency (Rial) has decreased unexpectedly. Because the center bank of Iran – the organization which makes foreign currencies available to importers and fixes the exchange rates – could not supply enough foreign currency to the market. So, the foreign currency was sold on the free market at a higher price.
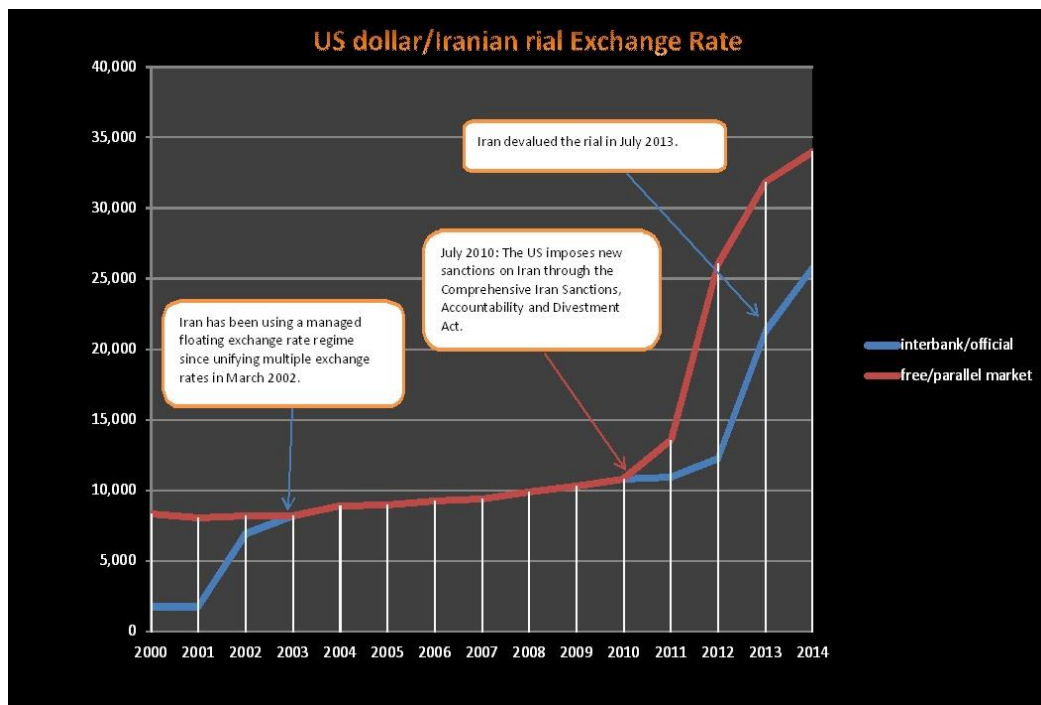

Figure 16: Iranian Rial's Exchange rate against the U.S. Dollar (source: (The center bank of Iran, 2015))

From the SCM point of view, increasing the value of foreign currencies makes it difficult for producers to schedule their production and forecast the cost and selling prices of products. Under these circumstances, the lower profitability and performance of labor force employed in manufacturing units have turned into the serious concerns for producers. Continued fluctuations in the exchange rate causes instability in activities of all supply chain entities. The main consequences of exchange rate fluctuations on the supply chains are as follows:

- Increase in the total production cost and reduction in supply chain's competitiveness due to inability of forecasting the exchange rate and higher prices of imported items.

- Lack of working capital. When foreign currencies are considered as assets, all economic actors seek to hold their wealth in foreign currencies instead of investing it on business.

- Disruption in the purchasing system and economic transactions. In the case of currency fluctuations in the market, all transactions are conducted using cash payment. Under these circumstances, manufacturers are also required to purchase raw material by cash (Tashkini, 2014).

It is worthwhile to mention that in several previous researches and studies the risk of exchange rate has been considered as a major disrupting force (Kim and Park, 2014; Kouvelis, 1999; Liu and Nagurney, 2011). For instance, according to the Economist Intelligence Unit (2009), which surveyed 500 international company executives, 59% of the companies surveyed viewed exchange rate uncertainty as the second key risk factor next to inability to forecast future demands.

Although the majority of Iranian companies are not international and their relationships and products are mostly restricted to the domestic market, their high dependency on imported parts causes the exchange rate fluctuations become the main threat for them just like the global and multinational firms.

Considering all the aforementioned facts, managing the foreign exchange rate and applying effective risk responses have become one of the most important responsibilities of the supply chain decision makers.

Since exchange rate is considered as an external risk, which is out of the company's control and the firm has no power to decrease its occurrence probability, reactive instruments should be applied to reduce the magnitude of the undesired outcomes of this risk. Financial hedges and operational hedges are two popular approaches that can be used to lessen the impact from currency rate changes.

Forward contracts, future contracts and foreign currency optional contracts are the more standard financial instruments for hedging risk from exchange rate uncertainty (Kouvelis et al., 2012). But, in the case of Iran, due to the financial sanctions the majority of companies have no access to the International financial markets. Thus, they are not able to take advantages of the contracted foreign currencies. For this reason, operational techniques such as risk shifting and risk sharing need to be adopted by firms to deal with foreign currency movements.

5.1.2 Material Prices Fluctuations

Over the last few years, the rise in the price of raw materials required for industrial producers (such as metals, petrochemical products, etc.) have put severe financial pressure on many Iranian companies.

In comparison with the results of the previous studies in this field (Lavastre et al., 2014; Thun and Hoenig, 2011), the severity of material price fluctuations among Iranian companies is much higher. In countries with a stable microeconomic environment, the martial price movements are basically driven by supply and demand relationship. But, in case of Iran, economic sanctions and their negative side effects including the sharp rise of inflation and the sharp devaluation of Rial and also adopting some controversial economic policies are considered as the main reasons behind this fact.

In this situation, applying the effective raw material management is not recognized as a competitive advantage, but a vital tool to keep the firm in business. Risk transferring and mitigation techniques are two popular approaches to deal with raw material price volatility:

- **Risk transferring:** Contracting techniques like fixed or long term contracts can be applied to restrict the power of suppliers to put on extra costs. Increasing the number of suppliers for essential raw materials can also be used as a leverage to control an individual supplier when prices rise.
  The mentioned risk can also be transferred to customers by adding terms and conditions in contracts with customers for adjusting product prices during the contract period whenever raw material prices spike.
- **Mitigation techniques:** improving flexibility in production operations and product developments is the main strategy. This strategy gives firms the shifting ability to low-cost materials when prices rise or transfer their production to a different location which has a cost advantage. Building up

inventory of raw materials when prices are low can also be used by firms (Shulman, Corr, and Ibanez, 2010)

5.1.3 Supplier Bankruptcy

Results of this study reveal that the bankruptcy of supplier is one of the important potential risks among the Iranian supply chains. With the extreme interdependences and interrelations among supply chain entities, bankruptcy of one supply chain's member can put other entities into a huge financial crisis.

According to Gestel et al. (2006), the company's own poor management, autocratic leadership, problems in working efficiency and some economic factors including, slower demand due to recession, lack of liquidity and the pressures of cost are factors that lead to bankruptcy (Shah, 2009). In addition to all aforementioned factors, bankruptcy is usually a result of the occurrence of another primary disruption and if this disruption is managed properly future problems including insolvency or bankruptcy can be controlled (Hoda Davarzani and Zargerdi, 2011).

The results of this study show that bankruptcy of suppliers in Iran's market is highly influenced by the occurrence of sanctions.

In this environment, firms must take extreme measures to avoid the negative effects of supplier's insolvency or bankruptcy. According to Dun and Bradstreet (2009) three main steps must be taken by companies:

- Automatical gathering and management of information of all internal and external suppliers.

- Financial and operational status of all suppliers must be monitored constantly and proactively.

- Quickly develop and execute emergency plans and projects once a risk has been recognized.

5.1.4 Inability to Collect All Receivables

The findings of this study indicate that receivables risk, inability to collect all receivables, must be considered as an important financial flow risk that has a great potential to affect the results of operations and cash flows of any firm.

Lack of liquidity due to inability to collect receivables has led many Iranian companies, especially those who sell their products or services to government agencies to suffer from severe financial difficulties. An example would be Iran's automotive industry. The two main and largest Iranian automakers (Iran Khodro and Saipa) that belong to the government and sell their products in the market without serious competitors. Over the last few years, automakers as a result of the reduction in car production and growth of exchange rate have been hit by drastic liquidity problems and consequently are not able to pay their debts to suppliers. According to the Iranian secretary of the Association of Automobile Manufacturers, automakers owe the amount of 45 trillion Rials ($ 1.5 billion) to their suppliers (Nemat Bakh, 2015).

The receivables risk is more intense for companies who export their products or services. Because limitations resulting from the sanctions including, lack of access to the international banks for transferring money has caused their money in foreign banks to be blocked. As a result, the cash to cash cycle as an important supply chain financial measure, which is referred to as "the average days required to turn a dollar invested in raw material into a dollar collated from a customer" (Gordon, 1995 , p.43), has been given a large value among Iranian companies.

Based on the results of this study, almost 67.6% of participants believe that increasing the amount of the cash to cash cycle is a consequence of sanctions.

Chopra and Sodhi (2012) propose two approaches to deal with receivables risk. Separating clients for creditworthiness is an extremely cautious and capable approach to diminish receivables risk. Another way is to spread the risk crosswise over more clients. It means that a firm with a huge number of customers experiences a much lower receivables risk in comparison with a company that sell to only a few large customers.

5.1.5 Procured From a Single Source

Another impact of the sanctions on Iran's supply chains has been the reduction in the number of potential suppliers of some raw materials, equipment and specific parts for large companies. The discontinuation of cooperation with some of the big and leading international companies which are the only firms that are capable of producing some of the important strategic goods, equipment and technologies has caused serious problems. Most of aforementioned goods and services have high prices and financing of these purchases is almost not possible for companies by any method except using LC method. In the absence of suppliers from the previous suppliers, the companies should look for new sources, which will be a time consuming process and can cause additional costs, and in some cases, the lower quality of the replaced raw materials and technologies would lead to customers' dissatisfaction.

One example of this problem can be seen in the relations between Iran Khodro Company, of Iran and Peugeot Company of France. In 2013, Peugeot left Iran because of international sanctions and buying of 8% of its share by GM Company, while the Iranian party had spent millions of dollars on building the necessary infrastructure to

produce Peugeot products. In the same year, Iran Khodro deposited 250 million euros into the Peugeot account through Tejarat Bank. Although the purchase money for Peugeot parts had been paid to the company account, the Peugeot Company refused to deliver the parts to Iran Khodro. Dozens of containers of parts for Peugeot, which had been bought by Iran, remained in a Belgian port for a long time. Finally, through one year of effort by the Iranian party and Tejarat Bank, the 250 million €s were returned to Tejarat bank account, and none of the parts purchased from Peugeot were delivered to Iran. This made Iran Khodro face a lot of problems to find another supplier. For, the specific technical knowledge of producing some of automotive electronic components such as ECU belong to the US and some European countries which were not possible to work with them after the imposition of sanctions.

The following measures can be used to reduce the negative impacts of this risk (Hoda Davarzani & Zargerdi, 2011):

- Using the alternative foreign purchases (in the case of domestic single-sources)

- Revising the terms of purchase agreements with suppliers

- Investment in second sources

- Purchasing the technology license for the production of critical and sensitive components

- Modifying the process of selecting suppliers

- Enhancing the competitiveness of suppliers through the creation of a training commitment in the process of classification

- Providing the context for export to create economies of scale for new supply

- Increasing the percentage of pre-payment and contributing to fund for encouraging new investors

5.2 Sanctions and Supply Chain Performance Measures

The study results indicated that economic sanctions have many negative impacts on the performance indicators of supply chains. Due to the creation of isolation, sanctions lead to a crisis in achieving economic production methods and a more efficient allocation of resources. They make production uneconomical and more expensive and prevent the efficient allocation of resources from the economy of the country under sanctions due to refusing to exchanges.

According to the study results, the sanctions have caused an increment in the production costs become the main concern of the Iranian manufacturers. Increased costs of trading and transactions due to denial of the LCs of Iranian banks, the rising cost of insurance and freight costs are among possible reasons for increased cost of products of firms in Iran.

In addition to the increased Cash to Cash Cycle discussed in the previous section, reduced quality of products is among the risks with a strong association with sanctions according to the study participants. Prohibition of cooperation with American and European companies that are the main manufacturers of some of the raw materials and special equipment has forced the Iranian manufacturers to import similar products with lower quality and often higher prices than other countries. For example, when the Peugeot Company seized relations with Iran, Iran Khodro was forced to use the products of second-tier Chinese suppliers to supply 40% of the Peugeot 206 automobile parts previously imported from France. This led to a sharp drop in the volume production in the short-term due to the lack of parts and long-term reduction in the quality of vehicles and customers' dissatisfaction.

5.3 Limitations of Study

This research has some limitations that readers should take into consideration:

- Because of the differences existing between firms and industries it is almost impractical to list all possible risks. However, the author tried to identify the most significant risks through an extensive literature survey, the prepared list of risks may not cover all supply chain risks of each individual firm.

- Due to lack of time and resources, the sample size of this study was restricted to 34 participants which belonged to different industries in a single country. As a consequence, generalizability of findings might seem to be limited.

- The sensitivity of the information especially about the actual impacts of sanctions on Iran's economy and lack of official and empirical studies in this field from the Iranian point of view, cause many problems for the author to discuss and compare the findings with the existing studies and researches.

5.4 Contributions to Industries

The results of this study prepare a worthy and useful information for practitioners. First, the findings from this study provide a comprehensive and intensive list of supply chain risks that can be used by different industries to start the SCRM process. Second, this study enhances the awareness of the practitioners about the risks that must be taken into consideration when economic and financial sanctions have been imposed against their supply chain. Finally, this study has disclosed that among all supply chain risk drivers, sanctions had the most adverse effects on financial and macroeconomic risks. So, supply chain managers should pay more attention to such risks.

Chapter 6

CONCLUSION

Risks are present in every part of business, and the capability of managing risks is a critical perspective which separates prosperous business pioneers from the others. Each stage of any supply chain can be a source of risk. From developing a new product to product realization and from releasing to after-sales services, supply chains are susceptible to risks. Managing such risks has become much more complicated and arduous whenever the source of risks are external and beyond the direct control of the firm's executives. Natural disasters, political instability, wars, energy price volatility, inflation, currency devaluations and raw material price fluctuations are only a few external risks that have a huge potential to disrupt supply chain of many companies for an extended period.

Due to the globalization of industries and supply chains, instability in the political and economic relationships between countries should be considered an external source of risks. When the political relations between two countries start to deteriorate and become more tense and hostile, governments adopt various actions to impose their policies. In this situation, one possible measure which has been progressively adopted as a substitute to armed conflict is imposing economic and financial sanctions against an opponent.

There have been several studies and researches about the effectiveness of sanctions and its social and humanitarian consequences. But in the field of SCM and specifically SCRM the need for more studies are strongly felt.

This study was focused on the Iranian firms- which are highly impacted by several strict and multilateral economic and financial sanctions- to implement SCRM by considering sanction's factor, investigate on the effects of sanctions on different supply chain risk drivers, identify top ranked risks and propose risk management strategies to reduce the current risk exposure and avoid future risk exposures.

6.1 General Summary and Conclusion

The results of this study can be summarized as:

First, the empirical analysis discloses that Iranian supply chains are mostly viewed as being vulnerable to sanctions. Limitations caused by sanctions such as; difficulties in importing and exporting, restrictions on transportation of purchased/ sold items, reducing number of suppliers, lack of access to international financial markets and banks are the factors that increase supply chain vulnerability.

Second, top five ranked supply chain risk in the presence of sanctions are:

- Exchange rate

- Material prices fluctuations

- Supplier bankruptcy

- Inability to collect all receivables

- Procured from a single source

The results reveal that sanctions have the greatest negative impact on the financial and macroeconomic risk drivers compared to other supply chain risk drivers.

Third, the study reveals that the occurrence probability of supply chain risks are increased due to sanctions. In addition to direct consequences of sanctions on supply chains such as increasing the cost of material supply and logistics, diminishing the access to specific materials, equipment and technologies under sanctions circumstances, the occurrence probability of other disruptions like exchange rate, commodity prices volatility, lack of liquidity and bankruptcy are sharply increased.

Fourth, the results show that supply chain performance measures have been also adversely affected by sanctions. Among all investigated performance criteria, supply chain cost and cash to cash cycle should receive more attention.

Finally, according to countries imposing sanctions against Iran, only certain industries such as the nuclear industry and oil and gas sectors have been the targets of sanctions. But the analysis shows that all investigated industries are vulnerable to direct and indirect consequences of sanctions. The multilateral relations and communications between different industries and sectors of a country might be a reason for this fact.

6.2 Suggested Areas of Future Research

This study has highlighted a number of areas meriting future studies:

- The occurrence and consequences of sanctions are generally beyond the control of supply chain executives. In this situation, the role of government's economic and political policies becomes more prominent in the effectiveness of sanctions. So in the future studies the role of government measures to reduce

or increase the effects of sanctions, particularly on the supply chains can be investigated.

- Sanctions usually are imposed for an interim period of time. After the lifting of sanctions, firms should return to their normal business in the shortest time. Assessing and proposing the best strategies and action plans to help supply chains in this step can be studied in the future researches.

- The results of this study showed that sanctions have negative impacts on the supply chain performance measures. More empirical studies are needed to determine the exact impact of sanctions on different performance measures.

REFERENCES

Ahi, P., & Searcy, C. (2013). A comparative literature analysis of definitions for green and sustainable supply chain management. *Journal of Cleaner Production, 52*(0), 329-341. doi: http://dx.doi.org/10.1016/j.jclepro.2013.02.018

Allen, S. H. (2005). The determinants of economic sanctions success and failure. *International Interactions, 31*(2), 117-138. doi: 10.1080/03050620590950097

Allon, G., & Mieghem, J. A. V. (2010). Global dual sourcing: tailored base-surge allocation to near- and offshore production. *Management Science, 56*(1), 110-124. doi: doi:10.1287/mnsc.1090.1099

Aloini, D., Dulmin, R., Mininno, V., & Ponticelli, S. (2012). Supply chain management: a review of implementation risks in the construction industry. *Business Process Management Journal, 18*(5), 735-761. doi: doi:10.1108/14637151211270135

Aqlan, F., & Lam, S. S. (2015). A fuzzy-based integrated framework for supply chain risk assessment. *International Journal of Production Economics, 161*(0), 54-63. doi: http://dx.doi.org/10.1016/j.ijpe.2014.11.013

Attri, R., Grover, S., & Dev, N. (2013). A graph theoretic approach to evaluate the intensity of barriers in the implementation of total productive maintenance (TPM). *International Journal of Production Research, 52*(10), 3032-3051. doi: 10.1080/00207543.2013.860250

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Bahli, B., & Rivard, S. (2005). Validating measures of information technology outsourcing risk factors. *Omega,* 33(2), 175-187. doi: http://dx.doi.org/10.1016/j.omega.2004.04.003

Barthélemy, J. (2003). The hard and soft sides of IT outsourcing management. *European Management Journal,* 21(5), 539-548. doi: http://dx.doi.org/10.1016/S0263-2373(03)00103-8

BBC. (2015a). Iran nuclear crisis: what are the sanctions? (2015, April 3). Retrieved from http://www.bbc.com/news/world-middle-east-15983302

BBC. (2015b). Offcial statistics about Iranian oil production and export was released after two and a half year. (2015, March 3). Retrieved from http://www.bbc.com/persian/business/2015/01/150117_centralbank_iran_economy

Bechtel, C., & Jayaram, J. (1997). Supply chain management: a strategic perspective. *The international journal of logistics management,* 8(1), 15-34.

Blackhurst, J. V., Scheibe, K. P., & Johnson, D. J. (2008). Supplier risk assessment and monitoring for the automotive industry. *International Journal of Physical Distribution & Logistics Management,* 38(2), 143-165. doi: doi:10.1108/09600030810861215

Blanchard, D. (2013). Managing the financial supply chain. (2015, March 8). Retrieved from http://www.industryweek.com/supply-chain/managing-financial-supply-chain

Bode, C., & Wagner, S. M. (2015). Structural drivers of upstream supply chain complexity and the frequency of supply chain disruptions. *Journal of Operations Management*(0). doi: http://dx.doi.org/10.1016/j.jom.2014.12.004

Bradley, J. R. (2010). *The complexity of assessing supply chain risk*. Santa Barbara, CA: Praeger.

Bradley, J. R. (2014). An improved method for managing catastrophic supply chain disruptions. *Business Horizons,* 57(4), 483-495. doi: http://dx.doi.org/10.1016/j.bushor.2014.03.003

Burgess, K., Singh, P. J., & Koroglu, R. (2006). Supply chain management: a structured literature review and implications for future research. *International Journal of Operations & Production Management,* 26(7), 703-729. doi: doi:10.1108/01443570610672202

Cagliano, A. C., De Marco, A., Grimaldi, S., & Rafele, C. (2012). An integrated approach to supply chain risk analysis. *Journal of Risk Research,* 15(7), 817-840. doi: 10.1080/13669877.2012.666757

Cavinato, J. L. (2004). Supply chain logistics risks. *International Journal of Physical Distribution & Logistics Management,* 34(5), 383-387. doi: doi:10.1108/09600030410545427

Ceryno, P. S., Scavarda, L. F., & Klingebiel, K. (2014). Supply chain risk: empirical research in the automotive industry. *Journal of Risk Research*, 1-20. doi: 10.1080/13669877.2014.913662

Chen, K., & Xiao, T. (2009). Demand disruption and coordination of the supply chain with a dominant retailer. *European Journal of Operational Research,* 197(1), 225-234. doi: http://dx.doi.org/10.1016/j.ejor.2008.06.006

Chen, Y.-J., Deng, M., & Huang, K.-W. (2014). Hierarchical screening for capacity allocation in supply chains: the role of distributors. *Production and Operations Management,* 23(3), 405-419. doi: 10.1111/poms.12063

Choonara, I. (2013). Economic sanctions and child health. *Medicine, Conflict and Survival,* 29(2), 93-98. doi: 10.1080/13623699.2012.739048

Chopra, S., & Sodhi, M. (2012). Managing risk to avoid supply-chain breakdown. *MIT Sloan Management Review (Fall 2004)*.

Christopher, M. (2011). *Logistics and Supply Chain Management* (4 ed.): Financial Times Prentice Hall.

Christopher, M., & Peck, H. (2002). Building the resilient supply chain. *The International Journal of Logistics Management,* 15(2), 14.

Costinot, A., Vogel, J., & Wang, S. (2013). An elementary theory of global supply chains. *The Review of Economic Studies,* 80(1), 109-144. doi: 10.1093/restud/rds023

Craighead, C. W., Blackhurst, J., Rungtusanatham, M. J., & Handfield, R. B. (2007). The severity of supply chain disruptions: design characteristics and mitigation capabilities. *Decision Sciences,* 38(1), 131-156. doi: 10.1111/j.1540-5915.2007.00151.x

Cucchiella, F., & Gastaldi, M. (2006). Risk management in supply chain: a real option approach. *Journal of Manufacturing Technology Management,* 17(6), 700-720. doi: doi:10.1108/17410380610678756

Danese, P., Romano, P., & Formentini, M. (2013). The impact of supply chain integration on responsiveness: The moderating effect of using an international supplier network. *Transportation Research Part E: Logistics and Transportation Review,* 49(1), 125-140. doi: http://dx.doi.org/10.1016/j.tre.2012.08.002

Davarzani, H., & Zargerdi, S. (2011). *Sanctions and disruption in supply chain: analysis and coping strategies*. Tehran: Industrial Management Institute.

Davarzani, H., Zegordi, S. H., & Norrman, A. (2011). Contingent management of supply chain disruption: Effects of dual or triple sourcing. *Scientia Iranica, 18*(6), 1517-1528. doi: http://dx.doi.org/10.1016/j.scient.2011.02.001

De Jonge Oudraat, C. (2000). Making economic sanctions work. *Survival, 42*(3), 105-128. doi: 10.1093/survival/42.3.105

Deloitte. (2013). The ripple effect: how manufacturing and retail Executives view the growing challenge of supply chain risk: Deloitte Development LLC.

Drewry. (2009). Risk management in international transport and logistics. (2015, May 3). Retrieved from http://www.drewry.co.uk/publications/view_publication.php?id=343#

Drury, A. C., & Peksen, D. (2012). Women and economic statecraft: the negative impact international economic sanctions visit on women. *European Journal of International Relations*. doi: 10.1177/1354066112448200

Dun and Bradstreet. (2009). Three steps to decisive action. (2015, May 7). Retrieved from http:// www.dnbsweden.se

Economist Intelligence Unit. (2009). Managing supply chain risk for reward. (2015 March 4). Retrieved from http://www.acegroup.com/se-en/assets/ace-supply-chain-web

Ellinger, A. E., Chen, H., Tian, Y., & Armstrong, C. (2015). Learning orientation, integration, and supply chain risk management in Chinese manufacturing firms. *International Journal of Logistics Research and Applications*. doi: 10.1080/13675567.2015.1005008

Ellram, L. M. (1991). Supply-chain management: the industrial organisation perspective. *International Journal of Physical Distribution & Logistics Management, 21*(1), 13-22. doi: doi:10.1108/09600039110137082

Ellram, L. M., & Cooper, M. C. (1990). Supply chain management, partnership, and the shipper - third party relationship. *The International Journal of Logistics Management, 1*(2), 1-10. doi: doi:10.1108/95740939080001276

Elzarka, S. M. (2013). Supply chain risk management: the lessons learned from the Egyptian revolution 2011. *International Journal of Logistics Research and Applications, 16*(6), 482-492. doi: 10.1080/13675567.2013.846307

Eng, T.-Y. (2005). The influence of a firm's cross-functional orientation on supply chain performance. *Journal of Supply Chain Management, 41*(4), 4-16. doi: 10.1111/j.1745-493X.2005.04104002.x

Eriksson, M. (2013). *Targeting peace: understanding UN and EU targeted sanctions*: Ashgate Publishing Limited.

Eyler, R. (2007). *Economic sanctions: international policy and political economy at work*: Palgrave Macmillan.

Faisal, M. N., Banwet, D. K., & Shankar, R. (2007). Information risks management in supply chains: an assessment and mitigation framework. *Journal of Enterprise Information Management,* 20(6), 677-699. doi: doi:10.1108/17410390710830727

Farzanegan, M. R., & Markwardt, G. (2009). The effects of oil price shocks on the Iranian economy. *Energy Economics,* 31(1), 134-151. doi: http://dx.doi.org/10.1016/j.eneco.2008.09.003

Gestel, T. V., Baesens, B., Suykens, J. A. K., Van den Poel, D., Baestaens, D.-E., & Willekens, M. (2006). Bayesian kernel based classification for financial distress detection. *European Journal of Operational Research,* 172(3), 979-1003. doi: http://dx.doi.org/10.1016/j.ejor.2004.11.009

Geum, Y., Cho, Y., & Park, Y. (2011). A systematic approach for diagnosing service failure: Service-specific FMEA and grey relational analysis approach. *Mathematical and Computer Modelling,* 54(11–12), 3126-3142. doi: http://dx.doi.org/10.1016/j.mcm.2011.07.042

Giunipero, L. C., Hooker, R. E., Joseph-Matthews, S., Yoon, T. E., & Brudvig, S. (2008). A decade of SCM literature: past, present and future implications. *Journal of Supply Chain Management,* 44(4), 66-86. doi: 10.1111/j.1745-493X.2008.00073.x

Golini, R., & Kalchschmidt, M. (2011). Moderating the impact of global sourcing on inventories through supply chain management. *International Journal of*

Production   Economics,   133(1),   86-94.   doi:
http://dx.doi.org/10.1016/j.ijpe.2010.06.011

Gordon, S. (1995). Supply chain performance benchmarking study reveals keys to
supply chain excellencenull. *Logistics Information Management,* 8(2), 38-44.
doi: 10.1108/09576059510085000

Hallikas, J., Karvonen, I., Pulkkinen, U., Virolainen, V.-M., & Tuominen, M. (2004).
Risk management processes in supplier networks. *International Journal of
Production   Economics,*   90(1),   47-58.   doi:
http://dx.doi.org/10.1016/j.ijpe.2004.02.007

Handfield, R. B., & McCormack, K. P. (2007). *Supply chain risk management.* Boca
Raton: Auerbach Publications.

Harland, C., Brenchley, R., & Walker, H. (2003). Risk in supply networks. *Journal of
Purchasing   and   Supply   Management,*   9(2),   51-62.   doi:
http://dx.doi.org/10.1016/S1478-4092(03)00004-9

He, B., Huang, H., & Yuan, K. (2015). The comparison of two procurement strategies
in the presence of supply disruption. *Computers & Industrial Engineering,*
85(0), 296-305. doi: http://dx.doi.org/10.1016/j.cie.2015.03.019

Heckmann, I., Comes, T., & Nickel, S. (2015). A critical review on supply chain risk
– Definition, measure and modeling. *Omega,* 52(0), 119-132. doi:
http://dx.doi.org/10.1016/j.omega.2014.10.004

Hendricks, K. B., & Singhal, V. R. (2005). Association between supply chain glitches and operating performance. *Management Science,* 51(5), 695-711. doi: doi:10.1287/mnsc.1040.0353

Jones, T. C., & Riley, D. W. (1987). Using inventory for competitive advantage through supply chain management. *International Journal of Physical Distribution & Materials Management,* 17(2), 94-104. doi: doi:10.1108/eb014655

Jüttner, U. (2005). Supply chain risk management. *The International Journal of Logistics Management,* 16(1), 120-141. doi: doi:10.1108/09574090510617385

Jüttner, U., Peck, H., & Christopher, M. (2003). Supply chain risk management: outlining an agenda for future research. *International Journal of Logistics Research and Applications,* 6(4), 197-210. doi: 10.1080/13675560310001627016

Karimi, M., & Haghpanah, S. (2015). The effects of economic sanctions on disease specific clinical outcomes of patients with thalassemia and hemophilia in Iran. *Health Policy,* 119(2), 239-243. doi: http://dx.doi.org/10.1016/j.healthpol.2014.12.011

Ketkar, S. P., Shankar, R., & Banwet, D. K. (2014). Telecom KYC and mobile banking regulation: An exploratory study. *Journal of Banking Regulation,* 15, 117-128.

Khalfan, A. M. (2004). Information security considerations in IS/IT outsourcing projects: a descriptive case study of two sectors. *International Journal of Information Management,* 24(1), 29-42. doi: http://dx.doi.org/10.1016/j.ijinfomgt.2003.12.001

Kim, K.-K., & Park, K. S. (2014). Transferring and sharing exchange-rate risk in a risk-averse supply chain of a multinational firm. *European Journal of Operational Research,* 237(2), 634-648. doi: http://dx.doi.org/10.1016/j.ejor.2014.01.067

Kleindorfer, P. R., & Saad, G. H. (2005). Managing disruption risks in supply chains. *Production and Operations Management,* 14(1), 53-68. doi: 10.1111/j.1937-5956.2005.tb00009.x

Kouvelis, P. (1999). Global sourcing strategies under exchange rate uncertainty. In S. Tayur, R. Ganeshan & M. Magazine (Eds.), *Quantitative Models for Supply Chain Management* (Vol. 17, pp. 625-667): Springer US.

Kouvelis, P., Dong, L., Boyabatli, O., & Li, R. (2012). *Integrated risk management in global supply chains*. Hoboken, N.J: Wiley.

Kroes, J. R., & Manikas, A. S. (2014). Cash flow management and manufacturing firm financial performance: A longitudinal perspective. *International Journal of Production Economics,* 148(0), 37-50. doi: http://dx.doi.org/10.1016/j.ijpe.2013.11.008

Larson, P. D., & Rogers, D. S. (1998). Supply chain management: definition, growth and approaches. *Journal of Marketing Theory and Practice,* 6(4), 1-5. doi: 10.2307/40469931

Lavastre, O., Gunasekaran, A., & Spalanzani, A. (2014). Effect of firm characteristics, supplier relationships and techniques used on supply chain risk management (SCRM): an empirical investigation on French industrial firms. *International Journal of Production Research,* 52(11), 3381-3403. doi: 10.1080/00207543.2013.878057

Lektzian, D., & Patterson, D. (2015). Political cleavages and economic sanctions: the economic and political winners and losers of sanctions. *International Studies Quarterly,* 59(1), 46-58. doi: 10.1111/isqu.12198

Leybovich, I. (2012). How to cope with unpredictable raw materials costs. (2015, August 12). Retrieved from http://news.thomasnet.com/imt/2012/06/05/how-to-cope-with-unpredictable-raw-materials-costs

Li, L. (2012). Effects of enterprise technology on supply chain collaboration: analysis of China-linked supply chain. *Enterprise Information Systems,* 6(1), 55-77. doi: 10.1080/17517575.2011.639904

Liu, Z., & Nagurney, A. (2011). Supply chain outsourcing under exchange rate risk and competition. *Omega,* 39(5), 539-549. doi: http://dx.doi.org/10.1016/j.omega.2010.11.003

Lockamy, A., & McCormack, K. (2009). Analysing risks in supply networks to facilitate outsourcing decisions. *International Journal of Production Research,* 48(2), 593-611. doi: 10.1080/00207540903175152

Lummus, R. R., Krumwiede, D. W., & Vokurka, R. J. (2001). The relationship of logistics to supply chain management: developing a common industry definition. *Industrial Management & Data Systems,* 101(8), 426-432. doi: doi:10.1108/02635570110406730

Manuj, I., & Mentzer, J. T. (2008). Global supply chain management *Journal of Business Logistics,* 29(1), 133-155. doi: 10.1002/j.2158-1592.2008.tb00072.x

Mentzer, J. T., DeWitt, W., Keebler, J. S., Min, S., Nix, N. W., Smith, C. D., & Zacharia, Z. G. (2001). Defining supply chain management *Journal of Business Logistics,* 22(2), 1-25. doi: 10.1002/j.2158-1592.2001.tb00001.x

Meulbroek, L. K. (2002). A senior manager's guide to integrated risk management. *Journal of Applied Corporate Finance,* 14(4), 56-70. doi: 10.1111/j.1745-6622.2002.tb00449.x

Micheli, G. J. L., Cagno, E., & Zorzini, M. (2008). Supply risk management vs supplier selection to manage the supply risk in the EPC supply chain. *Management Research News,* 31(11), 846-866. doi: doi:10.1108/01409170810913042

Miers, A., & Morgan, T. (2002). Multilateral sanctions and foreign policy success: can too many cooks spoil the broth? *International Interactions,* 28(2), 117-136. doi: 10.1080/03050620212099

Miller, K. D. (1992). A framework for integrated risk management in international business. *Journal of International Business Studies,* 23(2), 311-331. doi: 10.2307/154903

Mitchell, V.-W. (1995). Organizational risk perception and reduction: a literature review. *British Journal of Management,* 6(2), 115-133. doi: 10.1111/j.1467-8551.1995.tb00089.x

Mohammadi, D. (2013). US-led economic sanctions strangle Iran's drug supply. *The Lancet,* 381(9863), 279. doi: 10.1016/S0140-6736(13)60116-6

Moret, E. S. (2014). Humanitarian impacts of economic sanctions on Iran and Syria. *European Security,* 24(1), 120-140. doi: 10.1080/09662839.2014.893427

Naghavi, A., & Pignataro, G. (2015). Theocracy and resilience against economic sanctions. *Journal of Economic Behavior & Organization,* 111(0), 1-12. doi: http://dx.doi.org/10.1016/j.jebo.2014.12.018

Neiger, D., Rotaru, K., & Churilov, L. (2009). Supply chain risk identification with value-focused process engineering. *Journal of Operations Management,* 27(2), 154-168. doi: http://dx.doi.org/10.1016/j.jom.2007.11.003

Nemat Bakh, A. (2015). 4 housand and 500 billion dept automakers to parts makers. (2015, October 3). Retrieved from http://vista.ir/news/21681364

Nooruddin, I. (2002). Modeling selection bias in studies of sanctions efficacy. *International Interactions,* 28(1), 59-75. doi: 10.1080/03050620210394

Norrman, A., & Jansson, U. (2004). Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident. *International Journal of Physical Distribution & Logistics Management,* 34(5), 434-456. doi: doi:10.1108/09600030410545463

Nunnally, J. C. (1978). *Psychometric theory*: McGraw-Hill.

Office, U. S. G. A. (2008). *Iran sanctions: impact good or bad?* : Nova Science Publishers.

Olson, D. L., & Wu, D. D. (2010). A review of enterprise risk management in supply chain. *Kybernetes*, 39(5), 694-706. doi: doi:10.1108/03684921011043198

Peksen, D. (2011). Economic sanctions and human ecurity: the public health effect of economic sanctions. *Foreign Policy Analysis,* 7(3), 237-251. doi: 10.1111/j.1743-8594.2011.00136.x

Pfohl, H.-C., Gallus, P., & Kohler, H. (2010). Supply chain logistics risk in Germany. (2015, May 7). Retrieved from http://www.husdal.com/2010/10/20/supply-chain-logistic-risk-in-germany/

Pfohl, H.-C., Köhler, H., & Thomas, D. (2010). State of the art in supply chain risk management research: empirical and conceptual findings and a roadmap for the implementation in practice. *Logistics Research,* 2(1), 33-44. doi: 10.1007/s12159-010-0023-8

Ponomarov, S. Y., & Holcomb, M. C. (2009). Understanding the concept of supply chain resilience. *The International Journal of Logistics Management,* 20(1), 124-143. doi: doi:10.1108/09574090910954873

Puente, J., Pino, R., Priore, P., & Fuente, D. d. l. (2002). A decision support system for applying failure mode and effects analysis. *International Journal of Quality & Reliability Management,* 19(2), 137-150. doi: doi:10.1108/02656710210413480

Pujawan, I. N., & Geraldin, L. H. (2009). House of risk: a model for proactive supply chain risk management. *Business Process Management Journal,* 15(6), 953-967. doi: doi:10.1108/14637150911003801

Punniyamoorthy, M., Thamaraiselvan, N., & Manikandan, L. (2013). Assessment of supply chain risk: scale development and validation. *Benchmarking: An International Journal,* 20(1), 79-105. doi: doi:10.1108/14635771311299506

Qi, L., Shen, Z.-J. M., & Snyder, L. V. (2010). The effect of supply disruptions on supply chain design decisions. *Transportation Science,* 44(2), 274-289. doi: doi:10.1287/trsc.1100.0320

Rangel, D. A., de Oliveira, T. K., & Leite, M. S. A. (2014). Supply chain risk classification: discussion and proposal. *International Journal of Production Research*, 1-20. doi: 10.1080/00207543.2014.910620

Ratnasingam, P. (2006). Perceived risks in supply chain management e-collaboration. *Journal of Internet Commerce,* 5(4), 105-124. doi: 10.1300/J179v05n04_07

Ritchie, B., & Brindley, C. (2007). Supply chain risk management and performance. *International Journal of Operations & Production Management,* 27(3), 303-322. doi: doi:10.1108/01443570710725563

Saunders, M., Lewis, P., & Thornhill, A. (2009). *Research methods for business students* (5 ed.). Harlow: Financial Times Prentice Hall.

Sawik, T. (2011). Supplier selection in make-to-order environment with risks. *Mathematical and Computer Modelling,* 53(9–10), 1670-1679. doi: http://dx.doi.org/10.1016/j.mcm.2010.12.039

Sawik, T. (2013). Selection of resilient supply portfolio under disruption risks. *Omega,* 41(2), 259-269. doi: http://dx.doi.org/10.1016/j.omega.2012.05.003

Schlegel, G. L., & Trent, R. J. (2014). *Supply chain risk management: an emerging discipline*. Hoboken: Taylor & Francis.

Schmitt, A. J., & Singh, M. (2012). A quantitative analysis of disruption risk in a multi-echelon supply chain. *International Journal of Production Economics,* 139(1), 22-32. doi: http://dx.doi.org/10.1016/j.ijpe.2012.01.004

Shah, M. (2009). Supplier bankruptcy – a real risk during recession. (2015 October 5). Retrieved from http://www.infosysblogs.com/supply-chain/2009/03/supplier_bankruptcy_a_real_ris.html

Sheffi, Y. (2007). *The resilient enterprise: overcoming vulnerability for competitive advantage*. Cambridge, MA: MIT Press.

Shi, D. (2004). A review of enterprise supply chain risk management. *Journal of Systems Science and Systems Engineering,* 13(2), 219-244. doi: 10.1007/s11518-006-0162-2

Shulman, J., Corr, A., & Ibanez, P. (2010). The volatility of raw materials markets. (2015, October 10). Retrieved from http://www.rmmagazine.com/2010/06/01/the-volatility-of-raw-materials-markets/

Sodhi, M. M. S., & Tang, C. S. (2012). *Managing supply chain risk*: Springer New York.

Sodhi, M. S., Son, B.-G., & Tang, C. S. (2012). Researchers' perspectives on supply chain risk management. *Production and Operations Management,* 21(1), 1-13. doi: 10.1111/j.1937-5956.2011.01251.x

Sodhi, M. S., & Tang, C. S. (2012). *Managing supply chain risk*. New York: Springer.

Sofyalıoğlu, Ç., & Kartal, B. (2012). The selection of global supply chain risk management strategies by using fuzzy analytical hierarchy process – a case from Turkey. *Procedia - Social and Behavioral Sciences,* 58(0), 1448-1457. doi: http://dx.doi.org/10.1016/j.sbspro.2012.09.1131

Sokolov, V., Auld, J., & Hope, M. (2012). A flexible framework for developing integrated models of transportation systems using an agent-based approach. *Procedia Computer Science,* 10(0), 854-859. doi: http://dx.doi.org/10.1016/j.procs.2012.06.111

Stecke, K. E., & Kumar, S. (2009). Sources of supply chain disruptions, factors that breed vulnerability, and mitigating strategies. *Journal of Marketing Channels,* 16(3), 193-226. doi: 10.1080/10466690902932551

Stock, J. R., & Boyer, S. L. (2009). Developing a consensus definition of supply chain management: a qualitative study. *International Journal of Physical Distribution & Logistics Management,* 39(8), 690-711. doi: doi:10.1108/09600030910996323

Sudeep, K. P., & Srikanta, R. (2014). Analyzing the supply chain risk issues for an Indian manufacturing company. *Journal of Advances in Management Research,* 11(2), 144-162. doi: doi:10.1108/JAMR-11-2012-0047

Tang, C., & Tomlin, B. (2008). The power of flexibility for mitigating supply chain risks. *International Journal of Production Economics,* 116(1), 12-27. doi: http://dx.doi.org/10.1016/j.ijpe.2008.07.008

Tang, C. S. (2006a). Perspectives in supply chain risk management. *International Journal of Production Economics,* 103(2), 451-488. doi: http://dx.doi.org/10.1016/j.ijpe.2005.12.006

Tang, C. S. (2006b). Robust strategies for mitigating supply chain disruptions. *International Journal of Logistics Research and Applications,* 9(1), 33-45. doi: 10.1080/13675560500405584

Tang, O., Matsukawa, H., & Nakashima, K. (2012). Supply chain risk management. *International Journal of Production Economics,* 139(1), 1-2. doi: http://dx.doi.org/10.1016/j.ijpe.2012.06.015

Tang, O., & Nurmaya Musa, S. (2011). Identifying risk issues and research advancements in supply chain risk management. *International Journal of Production Economics,* 133(1), 25-34. doi: http://dx.doi.org/10.1016/j.ijpe.2010.06.013

Tashkini, A. (2014). The effect of exchange rate and uncertainty on production. (2015, August 13). Retrieved from http://www.itsr.ir/Newsletter/article/126/

Taylor, B. (2009). Chapter three: sanctioning Iran. *The Adelphi Papers,* 49(411), 59-100. doi: 10.1080/19445571.2009.488091

Thun, J.-H., Drüke, M., & Hoenig, D. (2011). Managing uncertainty – an empirical analysis of supply chain risk management in small and medium-sized enterprises. *International Journal of Production Research, 49*(18), 5511-5525. doi: 10.1080/00207543.2011.563901

Thun, J.-H., & Hoenig, D. (2011). An empirical analysis of supply chain risk management in the German automotive industry. *International Journal of Production Economics, 131*(1), 242-249. doi: http://dx.doi.org/10.1016/j.ijpe.2009.10.010

Tummala, R., & Schoenherr, T. (2011). Assessing and managing risks using the supply chain risk management process (SCRMP). *Supply Chain Management: An International Journal, 16*(6), 474-483. doi: doi:10.1108/13598541111171165

Tyndall. (1998). *Supercharging supply chains: new ways to increase value through global*. New York: John Wiley & Sons Australia, Limited.

Vilko, J. P. P., & Hallikas, J. M. (2012). Risk assessment in multimodal supply chains. *International Journal of Production Economics, 140*(2), 586-595. doi: http://dx.doi.org/10.1016/j.ijpe.2011.09.010

Wagner, S. M., & Bode, C. (2006). An empirical investigation into supply chain vulnerability. *Journal of Purchasing and Supply Management, 12*(6), 301-312. doi: http://dx.doi.org/10.1016/j.pursup.2007.01.004

Walton, L. W., & Miller, L. G. (1995). Moving toward LIS theory development: a framework of technology adoption within channels. *Journal of Business Logistics,* 16(2), 117.

Waters, D. (2007). *Supply chain risk management: vulnerability and resilience in logistics*. London: Kogan Page.

Wilson, M. C. (2007). The impact of transportation disruptions on supply chain performance. *Transportation Research Part E: Logistics and Transportation Review,* 43(4), 295-320. doi: http://dx.doi.org/10.1016/j.tre.2005.09.008

Wu, T., Blackhurst, J., & Chidambaram, V. (2006). A model for inbound supply risk analysis. *Computers in Industry,* 57(4), 350-365. doi: http://dx.doi.org/10.1016/j.compind.2005.11.001

Wu, T., & Blackhurst, J. V. (2009). *Managing supply chain risk and vulnerability: tools and methods for supply chain decision makers*: Springer London.

Yates, F. (1992). *Risk-taking behavior*. New York: Wiley.

Yeboah, N. E., Feng, Y., Daniel, O.-S., & Joseph, N. B. (2014). Agricultural supply chain risk identification- a case finding from Ghana. *Journal of Management and Strategy,* 5(2), 31-48.

Zegordi, S. H., & Davarzani, H. (2012). Developing a supply chain disruption analysis model: Application of colored Petri-nets. *Expert Systems with Applications, 39*(2), 2102-2111. doi: http://dx.doi.org/10.1016/j.eswa.2011.07.137

Zimmermann, H. J. (2000). An application-oriented view of modeling uncertainty. *European Journal of Operational Research, 122*(2), 190-198. doi: http://dx.doi.org/10.1016/S0377-2217(99)00228-3

Zsidisin, G. A. (2003). A grounded definition of supply risk. *Journal of Purchasing and Supply Management, 9*(5–6), 217-224. doi: http://dx.doi.org/10.1016/j.pursup.2003.07.002

APPENDICES

Appendix A: Sample of Questionnaire

This questionnaire aims to look for comprehensions and ideas of industrial experts on assessing risks in the supply chains which are influenced by economic sanctions in order to gain a better understanding of the negative impacts of economic sanctions on the whole supply chain.

Full confidentiality is guaranteed and information about your company and employees will not be disclosed.

Section 1 – Basic personal information

Company name: Respondent name (Optional):   Position:

Work experience: Field of industry: Number of employee:

Section 2 – Method of filling out

Table 1. Illustrative probability scale

Descriptor	Frequency	score
Certain	Has occurred more than 4 times a year	**5**
Likely	Has occurred 3 or 4 times a year	**4**
Possible	Has occurred 1 or 2 times a year	**3**
Unlikely	Has occurred once in 1 or 2 years	**2**
Rare	Has occurred once in more than 3 years	**1**

Table 2. Illustrative impact scale

Descriptor	Description			score
	People	**property**	**Financial**	
Catastrophic	Multiple deaths(employees, customers, vendors)	Destruction or loss of $> 50\%$ of total assets	Financial loss of $> 50\%$ of annual profit	**5**
Major	Single death or multiple major injuries	Major damage to property or loss of $< 50\%$ of total assets	Financial loss of $< 50\%$ of annual profit	**4**
Moderate	Major injury requiring hospitalization	Damage or loss of $<20\%$ of total assets	Financial loss of $< 20\%$ of annual profit	**3**
Minor	Injury requiring medical treatment	Loss of $<10\%$ of total assets	Financial loss of $< 10\%$ of annual profit	**2**
Insignificant	Minor injury requiring first aid treatment	Minor damage to property	Negligible lost profit	**1**

Table 3. Illustrative Economic sanctions scale

Descriptor	Description	score
Integral	Economic sanctions are the only source of the risk	5
Very strong	There is a very strong connection between the risk and economic sanctions	4
Strong	There is a strong connection between the risk and economic sanctions	3
Limited	There is a restricted connection between the risk and economic sanctions	2
Irrelevant	There is no connection between the risk and economic sanction	1

Section 3 – Risk assessing

What is your estimations about the following risks in terms of probability of occurrence, negative consequences and the impact of economic sanctions?

Risk drivers	Risk factor	Probability					Consequence					Economic sanction				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Information flow risks	Information security risks (hackers, worms, spyware and etc.)															
	IT/IS out sourcing risks															
	Intellectual property theft risk															
	Information accuracy															
	Inadequate IT system															
	Disclosure of information															
	Information infrastructure breakdown															
Financial flow risks	Exchange rate															
	Price and cost fluctuations															
	Shortage of cash(lack of liquidity)															
	Financial strength of supply chain partners															
	Inability to not collecting all receivables															
	Low profitability															
Material flow risks (Source related risks)	Supplier fulfillment errors(delivery delays and delivery mistakes)															
	Inflexibility of supply source															
	Quality issues															

Risk drivers	Risk factor	Probability					Consequence					Economic sanction				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Material flow risks (Source related risks)	Procured from a single source															
	Supplier selection															
	Supplier insolvency															
	Supplier bankruptcy															
	Supplier breach contract agreement															
	Lack of control over supplier															
	Financial strength of suppliers															
	Inability to quickly implement product and technological changes															
	Difficulties in satisfying the demand															
	Loss of key suppliers															
Material flow risks (Make related risks)	Inadequate production capability															
	Inflexibility in capacity															
	Disruption in production															
	Weakness in the planning and control of production and inventory															
	Machine breakdown															
	Service, maintenance and spares															
	Critical equipment and tools															
	Technological backwardness															
	Lack of skilled workers															
	Labor strikes															
	Carelessness and lack of motivation among the workforce															
	Health and safety issues															
	Accidents (fire…)															
	Customer health and product safety															
	Product and process design risks															
	Shortage of material															
	Interrupted gas/electricity supply															
	R&D uncertainty(uncertain results from R&D activities)															
	Technological changes															
	Poor quality															
	Hesitation in sharing of design and other documents with suppliers															
	higher product cost															

Risk drivers	Risk factor	Probability					Consequence					Economic sanction				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Material flow risks (Delivery related risks)	Forecast error in demand															
	Unanticipated or very volatile changes in demand															
	Demand fluctuates seasonally															
	Delay in delivery to customers															
	Changes in customers tastes															
	Customer insolvency															
	Cost of holding inventories															
	Rate of product obsolescence															
	Bullwhip effect															
	Reputation risk or confidence loss in product or brand															
	Lack of transportation capacity															
	Logistic outsourcing risks															
	Higher cost of transportation															
	Port issues (lack of adequate capacity, port strikes, …)															
	Border crossing and customs regulations															
	Theft and cargo loss or damage															
Socio-political risks	Fiscal and monetary reforms															
	Trade restrictions															
	Strict safety regulations															
	Strict environmental policies															
	Economic sanctions															
	Political instability															
	Democratic changes in government															
	War/Revolution															
	Terrorist attack or Sabotage															
	Social unrest															
	Changing social concerns															
Macroeconomic risks	Energy price volatility															
	Inflation															
	Interest rate															
	Currency devaluations															
	Tax and tariff changes															
	Material prices fluctuations															
	Oil price															

Risk drivers	Risk factor	Probability					Consequence					Economic sanction				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Natural disasters	Climate change															
	Natural disasters (earthquakes, floods, droughts, …)															

Section 4 – Effects of economic sanctions

- In general, to which extend do you consider your supply chain is susceptible to economic sanctions?

□ no effect   □ low   □ moderate   □ high   □ very high

- To what extend can the economic sanctions increase the occurrence probability of supply chains risks?

□ no effect   □ low   □ moderate   □ high   □ very high

- To what extend the negative effects of supply chain risks might be increased due to the economic sanctions?

□ no effect   □ low   □ moderate   □ high   □ very high

- To which extend do the following supply chain performance measures of your company are negatively   affected in relation to economic sanctions?

On time delivery	□ no effect	□ low	□ moderate	□ high	□ very high
Customer satisfaction	□ no effect	□ low	□ moderate	□ high	□ very high
Inventory level	□ no effect	□ low	□ moderate	□ high	□ very high
Quality of products	□ no effect	□ low	□ moderate	□ high	□ very high
Cost	□ no effect	□ low	□ moderate	□ high	□ very high
Cash to cash cycle	□ no effect	□ low	□ moderate	□ high	□ very high

Appendix B: Statistical results of risk assessment

Risks drivers	Risk factors	Code	Probability			Impact			Economic sanctions			Risk score		
			Mean	S.D	Rank	Mean	S.D	Rank	Mean	S.D	Rank	Mean	S.D	Rank
Information flow risks	Information security risk (hackers, worms, spyware and etc.)	I1	2.09	1.19	52	2.12	0.91	75	1.44	0.75	74	7.79	8.90	72
	IT/IS out sourcing risks	I2	1.70	0.85	72	2.24	0.87	66	1.45	0.67	73	5.91	5.35	81
	Intellectual property theft risk	I3	1.44	0.82	78	3.00	1.28	22	1.26	0.67	79	6.74	12.44	77
	Information accuracy	I4	2.50	1.08	29	3.00	1.02	23	1.29	0.63	77	10.56	13.23	63
	Inadequate IT system	I5	2.35	1.10	40	2.59	1.05	42	2.06	1.13	48	14.15	13.86	46
	Disclosure of information	I6	1.88	1.01	60	2.68	1.20	38	1.29	0.63	78	7.03	5.98	76
	Information infrastructure breakdown	I7	2.97	1.21	18	2.39	0.86	53	1.91	1.10	54	15.68	14.95	37
Financial flow risks	Exchange rate	F1	3.79	1.04	1	3.15	1.10	15	3.76	0.89	1	49.15	33.99	1
	Price and cost fluctuations	F2	3.15	1.26	10	2.91	1.14	25	2.85	1.21	20	32.91	28.26	12
	Shortage of cash(lack of liquidity)	F3	3.09	1.19	12	3.59	1.02	4	3.03	0.94	16	35.50	28.66	8
	Financial strength of supply chain partners	F4	2.35	1.23	41	2.32	1.07	59	2.50	1.29	33	19.26	22.88	26
	Inability to not collecting all receivables	F5	3.53	1.13	2	3.71	1.00	3	3.24	1.02	11	46.03	29.11	4
	Low profitability	F6	2.59	1.21	27	3.15	1.13	16	2.82	1.11	22	29.47	31.49	18
Material flow risks (Source related risks)	Supplier fulfillment errors(delivery delays and delivery mistakes)	MS1	3.00	1.02	17	2.50	1.08	46	2.21	1.15	40	19.79	19.14	25
	Inflexibility of supply source	MS2	2.50	0.90	30	2.26	0.96	63	2.18	1.14	43	16.50	20.57	32

Risks drivers	Risk factors	Code	Probability			Impact			Economic sanctions			Risk score		
			Mean	S.D	Rank	Mean	S.D	Rank	Mean	S.D	Rank	Mean	S.D	Rank
Material flow risks (Source related risks)	Procured from a single source	MS4	3.21	1.15	8	3.29	1.06	10	3.50	1.11	4	42.56	28.04	5
	Supplier selection	MS5	2.09	1.03	53	2.29	1.14	62	2.26	1.05	39	14.50	15.43	42
	Supplier insolvency	MS6	2.21	1.07	46	2.71	1.06	37	2.59	1.21	31	17.50	15.23	30
	Supplier bankruptcy	MS7	2.59	1.23	28	3.79	1.20	1	3.68	1.27	2	46.41	38.35	3
	Supplier breach contract agreement	MS8	2.32	1.01	43	2.59	1.10	43	2.06	0.78	49	14.38	12.22	43
	Lack of control over supplier	MS9	2.15	0.96	49	2.15	0.96	73	1.88	0.95	55	10.47	11.00	64
	Financial strength of suppliers	MS10	2.21	1.09	47	2.35	0.98	57	2.29	1.06	37	13.53	12.61	48
	Inability to quickly implement product and technological changes	MS11	2.09	0.97	54	2.47	1.08	48	2.29	1.24	38	14.91	17.61	41
	Difficulties in satisfying the demand	MS12	2.47	0.96	34	2.68	1.07	39	2.06	0.92	50	15.59	15.19	38
	Loss of key suppliers	MS13	1.82	0.85	66	3.12	1.17	18	2.61	0.93	30	16.41	15.74	33
Material flow risks (Make related risks)	Inadequate production capability	MM1	2.41	1.23	38	2.85	0.96	29	2.12	1.07	45	15.97	14.22	36
	Inflexibility in capacity	MM2	2.15	1.16	50	2.59	0.82	44	2.06	1.15	51	12.29	10.36	54
	Disruption in production	MM3	3.06	1.32	13	3.15	0.93	17	2.35	0.77	36	21.41	11.56	23
	Weakness in the planning and control of production and inventory	MM4	2.65	1.32	24	2.85	0.78	30	1.82	1.09	58	12.94	11.04	52
	Machine breakdown	MM5	3.06	1.56	14	2.35	1.10	58	2.06	1.13	52	18.06	18.46	29
	Service, maintenance and spares	MM6	2.50	1.46	31	2.18	1.19	70	2.12	1.04	46	14.38	17.23	44

Risks drivers	Risk factors	Code	Probability			Impact			Economic sanctions			Risk score		
			Mean	S.D	Rank	Mean	S.D	Rank	Mean	S.D	Rank	Mean	S.D	Rank
Material flow risks (Make related risks)	Critical equipment and tools	MM7	2.03	1.19	56	2.88	1.20	28	2.76	1.30	24	19.21	18.99	27
	Technological backwardness	MM8	2.74	1.24	22	3.26	1.05	12	3.35	1.28	7	35.12	26.16	9
	Lack of skilled workers	MM9	1.74	0.86	71	3.09	1.00	19	1.53	0.79	69	8.38	7.30	70
	Labor strikes	MM10	1.35	0.60	81	3.29	1.40	11	1.44	0.86	75	7.21	8.37	74
	Carelessness and lack of motivation among the workforce	MM11	2.65	1.25	25	2.76	1.10	35	1.35	0.60	76	9.68	7.65	65
	Health and safety issues	MM12	1.52	0.76	75	2.91	1.42	27	1.58	0.94	67	7.71	9.44	73
	Accidents (fire…)	MM13	1.18	0.46	82	3.47	1.26	7	1.26	0.57	80	6.12	6.93	79
	Customer health and product safety	MM14	1.50	0.71	76	3.18	1.40	14	1.79	0.91	59	9.59	9.95	66
	Product and process design risks	MM15	1.76	1.07	68	2.32	1.27	60	1.79	1.04	60	9.15	11.84	69
	Shortage of material	MM16	3.06	1.23	15	2.94	1.23	24	3.24	1.10	12	31.76	24.52	16
	Interrupted gas/electricity supply	MM17	2.85	1.26	20	2.18	1.19	71	1.68	0.98	64	11.24	12.41	61
	R&D uncertainty(uncertain results from R&D activities)	MM18	1.97	1.09	59	2.06	1.13	77	2.09	1.36	47	13.47	21.80	50
	Technological changes	MM19	2.00	0.92	57	2.65	1.12	40	2.21	1.37	41	16.18	21.64	34
	Poor quality	MM20	2.47	1.26	35	3.44	0.93	8	2.74	1.05	25	25.88	22.17	19
	Hesitation in sharing of design and other documents with supplier	MM21	2.18	1.31	48	1.71	1.00	83	1.59	0.99	66	9.44	14.88	67
	higher product cost	MM22	2.74	1.16	23	3.03	1.31	21	2.53	1.16	32	24.41	21.32	21

Risks drivers	Risk factors	Code	Probability			Impact			Economic sanctions			Risk score		
			Mean	S.D	Rank	Mean	S.D	Rank	Mean	S.D	Rank	Mean	S.D	Rank
Material flow risks (Delivery related risks)	Forecast error in demand	MD1	2.64	1.29	26	2.79	0.89	34	1.55	0.83	68	12.47	12.26	53
	Unanticipated or very volatile changes in demand	MD2	2.41	0.74	39	2.44	0.86	49	1.85	1.02	56	12.12	10.53	55
	Demand fluctuates seasonally	MD3	2.50	1.16	32	2.38	0.92	54	1.79	0.95	61	11.35	10.77	60
	Delay in delivery to customers	MD4	2.94	1.23	19	2.91	0.90	26	2.18	1.03	44	20.62	16.70	24
	Changes in customers tastes	MD5	2.35	1.32	42	2.50	1.29	47	1.53	0.99	70	12.03	14.81	56
	Customer insolvency	MD6	3.35	1.07	4	3.26	0.96	13	2.79	1.15	23	32.76	22.69	13
	Cost of holding inventories	MD7	2.24	1.13	45	2.18	1.09	72	1.79	1.04	62	11.91	13.87	58
	Rate of product obsolescence	MD8	2.06	1.28	55	2.41	1.35	51	1.24	0.55	81	7.06	7.43	75
	Bullwhip effect	MD9	1.85	0.87	64	2.18	1.10	69	1.85	1.03	57	9.35	10.44	68
	Reputation risk or confidence loss in product or brand	MD10	1.62	0.70	73	3.50	1.31	6	1.76	1.07	63	11.09	10.80	62
	Lack of transportation capacity	MD11	2.44	1.21	37	2.15	0.99	74	2.21	1.20	42	15.12	17.78	39
	Logistic outsourcing risks	MD12	2.26	0.99	44	2.32	1.15	61	1.94	1.28	53	13.53	16.70	49
	Higher cost of transportation	MD13	2.85	1.18	21	2.26	0.96	64	2.47	1.13	34	18.85	16.75	28
	Port issues (lack of adequate capacity, port strikes, …)	MD14	1.85	1.05	61	1.94	0.92	79	2.88	1.30	19	14.12	14.72	47
	Border crossing and customs regulations	MD15	1.85	0.96	62	2.21	1.15	67	2.74	1.38	26	16.00	19.98	35
	Theft and cargo loss or damage	MD16	1.47	0.79	77	1.94	1.07	80	1.62	1.02	65	6.06	8.22	80
	Fiscal and monetary reforms	SP1	2.12	0.98	51	2.38	1.18	55	2.71	1.22	27	17.35	17.54	31
	Trade restrictions	SP2	2.50	1.21	33	2.79	1.27	32	3.62	1.21	3	33.38	31.45	11

Risks drivers	Risk factors	Code	Probability			Impact			Economic sanctions			Risk score		
			Mean	S.D	Rank	Mean	S.D	Rank	Mean	S.D	Rank	Mean	S.D	Rank
Socio-political risks	Strict safety regulations	SP3	1.79	0.88	67	1.82	1.06	82	1.47	0.66	72	6.62	8.84	78
	Strict environmental policies	SP4	1.85	0.99	63	1.85	0.99	81	1.50	0.90	71	8.06	16.27	71
	Political instability	SP5	2.00	1.26	58	2.41	1.16	52	3.38	1.21	6	22.47	25.59	22
	Democratic changes in government	SP6	1.76	1.02	69	2.21	1.01	68	2.85	1.21	21	13.47	14.03	51
	War/Revolution	SP7	1.38	0.92	80	3.06	1.43	20	3.41	1.31	5	14.94	16.85	40
	Terrorist attack or Sabotage	SP8	1.44	0.99	79	2.26	1.38	65	3.21	1.30	14	11.56	11.97	59
	Social unrest	SP9	1.76	1.16	70	2.12	1.15	76	2.91	1.29	17	14.32	18.74	45
	Changing social concerns	SP10	1.82	0.97	65	1.97	0.87	78	2.44	1.44	35	11.97	16.07	57
Macroeconomic risks	Energy price volatility	M1	3.32	1.17	5	2.74	1.14	36	3.32	1.04	10	37.09	33.83	7
	Inflation	M2	3.29	1.24	6	2.79	1.15	33	3.35	1.23	8	40.15	37.78	6
	Interest rate	M3	3.15	1.18	11	2.85	1.18	31	3.09	1.16	15	32.76	31.18	14
	Currency devaluations	M4	3.06	1.28	16	2.65	1.15	41	3.24	1.16	13	32.65	27.96	15
	Tax and tariff changes	M5	2.47	1.19	36	2.59	1.35	45	2.65	1.20	28	25.65	32.96	20
	Material prices fluctuations	M6	3.53	1.11	3	3.38	1.16	9	3.35	1.25	9	48.24	35.23	2
	Oil price	M7	3.21	1.20	9	2.44	1.35	50	2.65	1.45	29	31.00	35.55	17
Natural disasters	Climate change	ND1	1.59	0.92	74	2.38	1.30	56	1.09	0.38	82	4.29	4.74	82
	Natural disasters (earthquakes, floods, droughts, …)	ND2	1.18	0.72	83	3.74	1.16	2	1.00	0.00	83	4.15	1.71	83

Appendix C: Risk prioritize