

CHAPTER-1

INTRODUCTION

Modern supply chain networks are becoming complex day by day. Due to the presence of various risks and uncertainties associated with supply chain, it is a tough assignment for supply chain managers to ensure delivery of the product of the right quality, of right quantity and at the right place within a stipulated delivery period in a cost-effective manner. Chopra and Sodhi (2004) carried out a study of the Phillips semiconductor plant, wherein a production disruption resulted in a loss of \$400 million to Ericsson. Similarly, the 9/11 terrorist attack, Tsunami, earthquake, Uttarakhand disaster, Katerina typhoon and Covid-19 pandemic had disrupted the supply chain of many organisations, and the wave of their impact could be felt in the whole world. Such disruptions have an impact not only on the organisations of that particular geographical area but also on the upstream and downstream supply partners. In the Indian context, the most recent incidents, such as the Cyclone ‘Fani’ in Odisha (2019) and Cyclone ‘Amphan’ in East India (2020), have severely affected the supply chain of these areas. Maintaining uninterrupted supply chain flow is the primary concern of the supply chain managers, but due to risks involved in the supply chain, it becomes difficult for SC managers to maintain continuous supply chain flow every time. Supply Chain Risk Management (SCRM) help firms to enable proactive management of supply chain risks and maintain the performance of the supply chain. Therefore, Supply Chain Risk Management (SCRM) has rapidly become a popular topic amongst researchers and managers of Supply Chain Management (SCM).

1.1 SUPPLY CHAIN MANAGEMENT (SCM)

The term "Supply Chain Management" came into existence in the late 1980s. Jones and Riley (1985) defined, "*Supply chain management deals with the total flow of materials from suppliers through end users.*" Many articles and books were published on this subject in the 1990s, and this subject became very popular due to its practical relevance. Supply Chain Management (SCM) can be defined as the management of handling the entire material flow from the procurement of the raw material from the supplier till the delivery of finished product to the ultimate customer. This process is not only limited to management within the organisation, but also include the upside and downside of the supply chain. In this process, the material flows in the forward direction while the information and money flows in the backward direction (Beamon, 1998). Supply chain management is the integrated process that involves the activities that ensure the efficient flow of materials, information and finance throughout the supply chain network.

1.1.1 Supply Chain Network

In a supply chain network, every linkage is the key feature of failure; if any of the link weakens, it ultimately weakens the entire supply chain. So, coordination among the partners along the supply chain is required to eliminate various types of supply chain risks. A conceptual supply chain network may consist of different echelons like suppliers, manufacturers, distributors and retailers. In this research, a four echelons supply network has been considered. The first echelon is supplier echelon that supplies the raw material to produce the final product, the second one is the manufacturing echelon which produces the product, the third and fourth are distributors and retailer's echelons to facilitate the transportation and distribution of product from manufacturing units to the ultimate customer. Figure 1.1 shows a schematic diagram of this supply chain network with different echelons. Different challenges arise along the supply chain network over its echelons while managing supply chains and its risks.

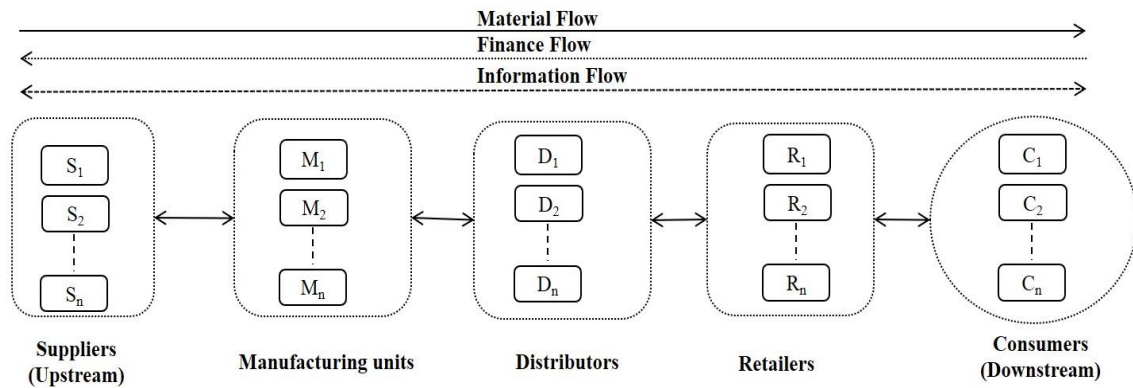


Figure 1.1 Supply chain network

1.1.2 Challenges in Supply Chain Management

To make a more efficient supply chain, SC managers deal with several challenges in their supply chain operations. The priority of SC managers is to overcome these challenges and ensure an uninterrupted supply of materials. Some of the significant supply chain challenges are related to

- i. materials management,
- ii. customer relationship management,
- iii. cost control management,
- iv. demand management,
- v. advancement of technology,
- vi. supply chain risk management,
- vii. reverse logistic management,

From the literature, it is observed that the problem of coordinating among the different echelons of supply chain is a big challenge for SC managers. This problem may lead to delay and distortion of information throughout the supply chain. As a result, it creates complexities and conflicts among supply chain members. Also, due to globalization, competition, advancement in technologies and other associated challenges, organisations are facing various supply chain risks making them more vulnerable. These supply chain

risks cannot be completely eliminated, but the impact of such risks can be mitigated by proactively identifying, understanding and analysing the risks. Therefore, supply chain risk management is one of the biggest challenge for supply chain managers.

1.2 SUPPLY CHAIN RISK MANAGEMENT (SCRM)

The concept of risk can be defined as a “*combination of probability or frequency of occurrence of a defined hazard and magnitude of the occurrence*” (BS 4778, 1991). It can also be understood as uncertainties carrying disruptions. If it occurs, it has a direct impact on the system. In relation to the supply chain, Zsidisin (2003) defined 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*”. Supply chain risks can cause huge losses and so it is required to manage these proactively.

SCRM is an integrated process, involving the identification, assessment, prioritization, mitigation and monitoring of the risks associated with the supply chain. In the literature, several definitions for supply risk and SCRM) are available. SCRM can be defined as “*the management of supply chain risks through coordination or collaboration among the supply chain partners so as to ensure profitability and continuity*” (Tang, 2006). Jüttner *et al.* (2003) defined SCRM as “*the identification and management of risks for the supply chain, through a coordinated approach amongst supply chain members, to reduce supply chain vulnerability as a whole*”. According to Harland *et al.* (2003), supply risk “*adversely affects inward flow of any type of resource to enable operations to take place*”.

Tummala and Schoenherr (2011) proposed a comprehensive and coherent approach for managing risks in supply chains. They proposed a supply chain risk management process (SCRMP) for a better understanding of the implementation of SCRM to manage supply chain risks more effectively. Their SCRMP consisted of three phases. Phase-1

consists of risk identification, risk measurement and risk assessment, Phase-2 consists of risk evaluation, risk mitigation and contingency plans while Phase-3 consists of risk control and monitoring. The proposed SCRMP helps SC managers in decision-making and strategic thinking to assess the risk progress based on the respective SC risk profiles. Ultimately, the SCRMP provides insight into how to make the most appropriate decision. This study has outlined the general structure of risk management and the same can also be adopted for risk management in the Indian MSMEs (micro, small and medium enterprises).

In the present research work, the risk management process suggested by Tummala and Schoenherr (2011) has been modified in line with the requirement of Indian MSMEs. The risk management process is taken to be consisted of two phases: (1) risk analysis and (2) risk control. These two phases are comprised of five steps, namely, (i) risk identification, (ii) risk assessment, (iii) risk prioritization, (iv) risk management planning and (v) implementation and monitoring of risk management plan. This process is depicted in Figure 1.2. These steps are explained in the following sub-sections.

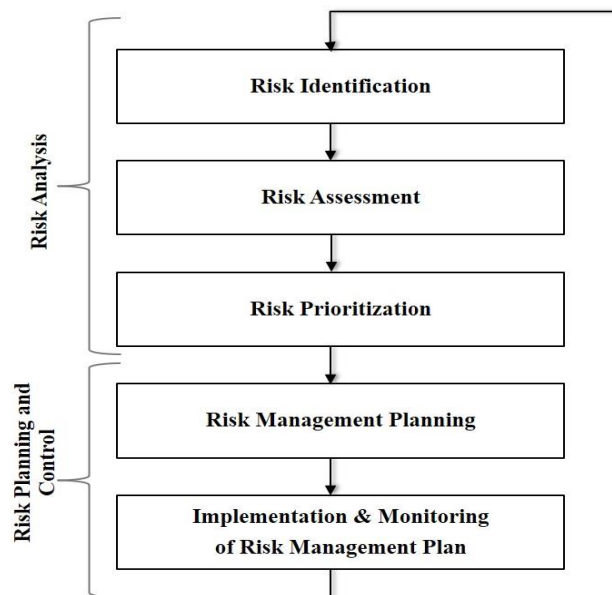


Figure 1.2 Risk management process

1.2.1 Risk Identification

Risk management process starts with risk identification. This step involves determination and comprehensive understanding of significant risks associated with the supply chain. The unpredictable nature of risks, improper evaluation of the impact and selection of wrong strategy, in turn, leads to an adverse effect on the performance of the supply chain. SC managers need to identify and understand the significant supply chain risks for better SCRM.

Supply chain risks can be classified in several ways based on their impact, occurrence or source of risks. In this study, supply chain risks have been classified into two broad categories, i.e., internal and external risks. Internal supply chain risks such as supply risk, process risk etc. are those risks that emerge from inside of the supply chain and directly affect its performance. On the other hand, external risks are referred to those risks such as environmental risks which emerge from outside of the supply chain and directly or indirectly affect its performance.

1.2.2 Risk Assessment

The second step of the risk management process is risk assessment. It is concerned with the determination of likelihood/probability of occurrence and the consequences of the identified risks. For example, the occurrence probability of an event such as Cyclone 'Fani' can be classified as 'rare' and the impact of this event can be classified as 'critical'. For quantitative assessment of risk, the associative qualitative data is converted into quantitative data by using a five-point rating scale. This scale assessed the risks on a scale of 1 to 5, where '1' represents the 'insignificant' and '5' represents 'critical' impact of an occurrence of a risk. Similarly, for probability of occurrence, '1' represents a 'rare' and '5' represents 'almost certain' probability of the risk. An assessment of risk of qualitative data requires a measure. One such conceptual measure of risk is Risk Index or Composite Risk

Index, which is product of the probability of occurrence and the impact of the risk event. (Harland *et al.*, 2003; Hallikas *et al.*, 2004; Norrman & Jansson, 2004).

$$\text{Composite risk index} = \text{impact of risk event} * \text{probability of occurrence}$$

1.2.3 Risk Prioritization

Every risk has a different effect on the performance of supply chain, which is mainly due to their levels of impact and a probability of occurrence. Some risks have significant consequences, while others have negligible consequences. Therefore, prioritization of risks is essential for supply chain managers for proactive planning of each risk. In this third step, the identified risks are prioritized on the basis of their composite risk score. The composite risk score value lies between 1 to 25. Based on the composite risk score, risks are classified into four categories: (i) minor risks (1-3), (ii) moderate risks (3-8), (iii) significant risks (8-15) and (iv) critical risks (15-25). The classification of four risk categories is shown in Table 1.1. In this research work, supply chain risks are prioritized with the help of (AHP) methodology, which is explained in Chapter 5.

Table 1.1 Classification of risk

Occurrence of risk event	Almost Certain (5)	Moderate (5)	Major (10)	Critical (15)	Critical (20)	Critical (25)
	Likely (4)	Moderate (4)	Major (8)	Major (12)	Critical (16)	Critical (20)
	Possible (3)	Moderate (3)	Moderate (6)	Major (9)	Major (12)	Critical (15)
	Unlikely (2)	Minor (2)	Moderate (4)	Moderate (6)	Major (8)	Major (10)
	Rare (1)	Minor (1)	Minor (2)	Moderate (3)	Moderate (4)	Moderate (5)
		Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Critical (5)
	Impact index of risk event					

1.2.4 Risk Management Planning

This step involves the development of a risk management plan to anticipate the effect of identified risks. Risk management plan is developed based on the composite risk score value. Chances having low composite risk score value [1-3] are known as minor risks as

their impact and probability of occurrence is very low. These risks have an insignificant effect on the supply chain performance. Therefore, these risks are of least concern for SC managers and thus do not call for resources up on it. On the other hand, the risks having high composite risk score value [15-25] are known as critical risks as these risks can result in the complete shutdown of the supply chain. Such supply chains are under an unsustainable zone. SC managers need to manage these risks in advance. The moderate and significant risks having respective risk score value as [3-8} and [8-15} have a substantial effect on the supply chain performance. These risks can interrupt the supply chain at any stage. Thus, SC managers should monitor these risks continuously. If any improvement is possible to mitigate the effect of these risks, the same should be implemented as early as possible.

The risk management planning focuses mainly on identification and evaluation of significant risks and on treatment of these risks by using appropriate risk strategies to reduce the impact/probability of the risk event. There are several techniques to manage supply chain risks, such as designing the new process to manage the identified risk, implementing mitigating risk strategies and periodically re-assessing the risks, transferring the risks to another party, avoiding the risks, etc. (Jüttner *et al.* 2003). Tarei *et al.*, (2020) designed a supply chain risk management plan for the Indian petroleum supply chain. They explored the relationship between five risk management strategies, namely, ignore, control, accept, mitigate, transfer and avoid. In the present study, the following four main generic risk management strategies have been analysed that cover all risk management strategies.

1.2.4.1 Risk avoidance strategy

Such strategies mainly focus on how to avoid/eliminate the occurrence of the risk or not to be involved in any type of activity/process that falls under the category of critical risk. These strategies mainly suggest avoiding/eliminating the process/element of the supply

chain leading to critical risks, for example, not using low quality equipment and machineries, dropping of specific products (Jüttner *et al.*, 2003), changing the production facility from high-risk zone to low-risk zone, selection of proven supplier (Novaes and Souza, 2005).

1.2.4.2 Risk mitigation strategy

Mitigation strategies are also known as risk reduction/ risk optimization strategies. In some cases, it is not possible to completely avoid the risks due to the high cost of avoidance plan or it may not be physically feasible. Sometimes high risk also attracts high profit in business. Therefore, in such cases, mitigation strategies are preferred over avoidance strategies. Risk reduction/mitigation strategy basically works on how to reduce the severity of risk or how to reduce the frequency of risk occurrence. Multiple sourcing, postponement, flexible manufacturing process (Jüttner *et al.*, (2003), increased inventory or safety stock level, better and advanced material handling equipment (Chopra and Sodhi, 2004), are a few examples of mitigating strategies.

1.2.4.3 Risk sharing strategy

Risk sharing strategy is defined as sharing of impact/consequences of risk with another party to reduce the impact of risk on the principal organisation. Risk sharing strategy is often called as the risk transfer strategy. These strategies cannot reduce the impact of the risk, but they may share the risk consequences. For example, outsourcing and contract manufacturing (Miller, 1992; Swink and Zsidisin, 2006; Lavastre *et al.*, 2012), are some popular risk sharing strategies in which a firm shares its risks with another party.

1.2.4.4 Risk retention strategy

There are the cases when it is not feasible for an organisation to adopt any of the above three strategies. If the organisation can neither avoid the risk nor mitigate the risk and also cannot share the risk with another party, then risk retention strategies are to be used. These

strategies basically accept the risks and their consequences. Company, by default, bear the risk under such kind of circumstances due to financial or operation implications. Such strategies deal with those risks which are catastrophic in nature and cannot be insured due to the high insurance charges.

1.2.5 Implementation and Monitoring of Risk Management Plan

The last step of risk management involves the implementation and continuous monitoring of risk management plan. This step provides guidelines for implementing a risk management plan and provides preventive measures to maintain supply chain performance. In case of any deviation in supply chain performance, SC managers should take corrective measures to manage these. This process does not stop here as SCRM is a continuously improving. It keeps on working in a continuous loop, and subsequently repeats the process to improve the supply chain performance.

1.3 RELEVANCE OF SCRM IN INDIAN CONTEXT

Due to globalization, competition, advancement in technologies and other factors, SC managers face various risks associated with their supply chain. These supply chain risks make a tough assignment for supply chain managers to ensure delivery of the product of the right quality, of right quantity and at the right place within a stipulated delivery period in a cost-effective manner. These supply chain risks cannot be eliminated completely. Better understanding of supply chain risks would help firms to develop suitable strategies to manage supply chain risks (Faisal, 2009). Thus, the study of Supply Chain Risk Management is essential and relevant for the supply chain managers.

Identification, understanding and proactive management of uncertainties is the main objective of SCRM (Norrman and Jansson, 2004). Carter and Rogers (2008) explored SCRM and emphasised on proactive planning for the effective management of economic, environmental, and social risks in the supply chain. SCRM also facilitates the achievement

of supply chain targets, speeding up of supply chain operations and ultimately enhancing supply chain performance. The anticipation of supply chain risks is a prime requisite to set clear, realistic and measurable objectives for the SCRM. Developing an SCRM model requires research, time and commitment, but it is a treasured process that can significantly contribute to supply chain performance. In order to put the effort effectively, an understanding of Supply Chain Risk (SCR) variables will help a lot in building a model for planning and controlling.

1.4 SUPPLY CHAIN RISK VARIABLES

SCR variables associated with the Indian MSMEs supply chain, can be identified either by primary research (methods such as expert opinions, survey, etc.) or secondary research (literature review and expert opinion, etc.). In the literature, various types of SCR variables are available, which contribute to SCRM. Cultural, operational, infrastructure, economic, forecasting and supplier risk are six main risk variables that Indian companies are facing (Roger *et al.* 2016). Tummala and Schoenherr (2011) classified internal risk into the following subcategories: Demand risks, Delay risks, Disruption risks, Inventory risks, Process risks, Capacity risks, Supply risks, System risks and Transportation risks. A better understanding of risk variables and risk attributes helps in reducing the vulnerability of the supply chains. Study of all SCR variables at the same time can make the SCRM model very complicated and, sometimes, it is also not financially feasible for MSMEs. Accordingly, in this study, only the seven significant SCR variables that potentially affect the Indian MSMEs, have been considered. These are as follows.

- (i) Environmental risk (ER)
- (ii) Information technology risk (IR)
- (iii) Supply risk (SR)
- (iv) Process risk (PR)

- (v) Transportation risk (TR)
- (vi) Delay risk (DE)
- (vii) Demand risk (DR)

1.4.1 Environmental Risk (ER)

The risks which emerge from outside to the supply chain and affect the supply chain externally are known as external risks such as environmental risk. These risks may directly or indirectly affect supply chain performance. Natural disasters, Extreme weather conditions are the main example of these type of risks. The frequency of these risks are very low but their impact is very severe. Indian manufacturing organisations expand their production facilities at a different location to expand their business expansion or cost cutting of the product. It may also lead the chances of environmental risks because some area is in the seismic zone (Bhuj, Gujarat), some area is prone to storm (Coastal Areas, etc.), some area is terrorism/Naxalite zone (Jharkhand, Chhattisgarh). These risks have a very high impact on Indian manufacturing supply chain.

1.4.2 Information Technology Risk (IR)

Information technology plays a vital role in supply chain on any organisation. Information management system includes the software as well as hardware failure. Information Technology works as a support system for supply chain and it improves the coordination among the supply chain partners. Hardware/software failure, distortion in information sharing, failure in IT systems, human errors, viruses and malicious attacks are the examples of Information technology risks. It can be managing by continuous risk assessment of information technology system.

1.4.3 Supply Risk (SR)

Indian manufacturing organisations are more vulnerable with the upstream side (supplier dependent) of their supply chain. As production process, product quality and product cost

of the product, etc., are mainly dependent on the quantity, quality, and availability of the supplied raw material, so it is most important for any organisation to focus on their upstream supply chain. Dependency on the key supplier, inflexible supplier capacity, variation in replenishment lead-times, buyer-supplier relationship, quality and cost issues, selection of the wrong supplier, etc. is the main causes for supply chain risks. These risks directly impact on the quality and cost of the final product, which may have a significant effect on the organisation profit.

1.4.4 Process Risk (PR)

Process risks are a type of internal risk, which are directly associated with the manufacturing process of the supply chain. These type of risks occurs due to rapid changes in production technologies, machine/material failure, higher production cost, Manufacturing variability, Demand and supply uncertainty, inflexible manufacturing processes, Limited capacity/bottlenecks, Costs of holding inventories, etc. Process risks also known as production risks, operational risks, etc. Good co-ordination between Production manager and SCRM manager can help to better management of these type of risks.

1.4.5 Transportation Risk (TR)

Risks which are associated with the distribution network of the supply chain are known as Distribution risks or Transportation risks. In India, road and rail network are the main transportation medium for the movement of goods within the country. Every product has a different nature, so it needs different attention to transport like some product are fragile, some are perishable in nature, etc. Hence, the selection of the right mode of transport is very important for supply managers. Transporter's strikes, limited capacity of transport, higher costs of transportation, cargo Damage/theft, warehouse Inadequacies are the main reasons for disruption in the distribution system.

1.4.6 Delay Risk (DE)

Delay risks are those risks, which results delay in the flow of material, information and finance through an organisation's supply chain. These risks may directly or indirectly affect supply chain performance. Excessive handling due to border crossings, port capacity and congestion, long custom clearance process at ports, delay in material or information flow, production failure, supplier's inability to respond quickly to a change in demand are the main example of these type of risks.

1.4.7 Demand Risk (DR)

Demand means to understand, analyze and forecast the right demand at the right time for production, followed by the supply of the right quantity of right quality product at the right time. Demand and supply both are inter-related terms and generally studied simultaneously. Demand risks relate to the disruption occurs from the downstream side (unpredictable nature of customer demand) of the supply chain. The main examples of demand risks are lack of collaborative planning, poor forecasts, bullwhip effects due to multiple echelons, short product life cycles, lack of SC visibility. If any demand risk occurs, it directly impacts on the demand-supply gap, which leads to detrimental effects on supply chain performance.

1.5 SCRM IN INDIAN MSMES PERSPECTIVE

Revolution due to emergence and implementation of information and communication technology in the industrial era, new markets and opportunities have been witnessed by the Indian MSMEs. Since then, Indian MSMEs have been growing continuously and contributing significantly to the country's economic and social development. As per the Gazette of India dated 01.06.2020, these enterprises comprise both manufacturing and service entities. MSMEs have been redefined based on investment in plant and machinery or equipment and annual turnover. Indian MSMEs are classified into three categories: micro, small and medium enterprises, with further details as shown in Table 1.2.

Table 1.2 Classification of micro, small and medium enterprises in India

Composite criteria: Investment and Annual Turnover*		
Description	Investment in Plant & Machinery or Equipment	Annual Turnover
Micro Enterprises	up to ₹ 1 Crore	up to ₹ 5 Crore
Small Enterprises	₹ 1 Crore to ₹ 10 Crore	₹ 5 Crore to ₹ 50 Crore
Medium Enterprises	₹ 10 Crore to ₹ 50 Crore	₹ 50 Crore to ₹ 250 Crore

* As per the Gazette of India dated 01st June 2020.

Indian manufacturing MSMEs face several challenges such as local and global competition, poor supply chain coordination, advancement of technology and poor demand management. Moreover, they have a complex supply chain network having multiple echelons, multiple partners and multiple locations. Due to these complexities, Indian MSMEs are facing several risks associated with their supply chain. But due to limited resources, it is not feasible to give equal attention to all types of risks. As such, it creates a strong and justifiable reason to identify the dominant SCR variables and develop a comprehensive framework of SCRM to mitigate the supply chain risks in the Indian MSMEs context.

1.6 MOTIVATION FOR THIS RESEARCH

In the Indian context, the most recent incidents, such as the Cyclone “Fani” in Odisha (2019) and Cyclone “Amphan” in East India (2020), have severely affected the supply chain of these geographical areas. Maintaining uninterrupted supply chain flow is the primary concern of the supply chain managers. But due to the risks involved in the supply chain, it is difficult for managers to maintain continuous supply. Supply Chain Risk Management (SCRM) helps SC managers to enable proactive management of supply chain risks and so maintaining the performance of the supply chain. External risks such as natural disasters (e.g., Tsunami, flood, earthquake) and man-made risks (e.g., Terrorism, volatile financial market, war, etc.) have a significant impact on the supply chain performance (Ho *et al.*, 2015).

SCRM has rapidly become a popular topic amongst researchers and supply chain managers. A literature review on SCRM indicates that several research studies have been conducted on SCRM. These research findings have been implemented in various fields, such as automotive industry (Blackhurst *et al.*, 2008), food industry (Diabat *et al.*, 2012), Indian automotive industry (Gautam *et al.*, 2018), pharmaceutical companies of Bangladesh (Moktadir *et al.*, 2018). Most of the research studies are conducted on large companies or MNCs, and SCRM models/frameworks are developed based on their requirements. Such models/frameworks for Indian MSMEs are rare. Indian MSMEs have a different business environment and have limited resources as compared to MNCs. Therefore, Indian MSMEs face many challenges while implementing the SCRM model. These challenges are as follows:

- Limited financial capabilities for implementation of SCRM
- Lack of skilled workforce to form a specialized SCRM team
- Lack of latest manufacturing technology
- Lack of latest information and communication technology

Over the last two decades, Indian MSMEs faced several risks associated with their supply chain. Therefore, it is a major challenge for SC managers of Indian MSMEs to anticipate these risks. But, it is not feasible to give equal attention to all types of risks due to limited resources. Thus, it creates a strong and justifiable reason to study the SCRM in the context of the Indian MSMEs. This research aims to provide a comprehensive study of SCRM in a small-scale Indian manufacturing enterprise. This study also provides the direction/illustration of the method for implementing SCRM in the Indian MSMEs to enhance their supply chain performance. This study is based on a detailed literature review of supply chain risk management. The main objective of this research is to develop a decision support system for implementing of SCRM in the context of the Indian MSMEs.

Indian MSMEs need to pay conspicuous attention towards the field of supply chain risk management. The need for a comprehensive model of SCRM in the Indian MSMEs context derives the motivation of this study. This will also help SC managers in the decision-making process and implementation of SCRM.

1.7 SCOPE OF THE PRESENT RESEARCH

From the literature, it is observed that several articles are available on risk management and supply chain risk management, but research articles on SCRM in Indian MSMEs perspective are rare. After the initial review and scrutiny of the literature, research gaps and the research objective were identified. The same is discussed in Chapter 2. The main objective of this research is to provide a comprehensive model of SCRM to understand, analyse and mitigate the supply chain risks by providing the guideline to SC managers to implement the SCRM in the Indian MSMEs context. For the purpose, a case study of wire manufacturing firm was considered. This firm is a North-India based small-scale manufacturing company. As a matter of privacy policy of the organisation, this organisation is acknowledged as 'XYZ'. Data related to supply chain risks is a confidential information for the organisations. However, this data has been used for research purposes only, but revealing the risk issues of any organisation makes their supply chain more vulnerable and directly affects the performance of their supply chain. 'XYZ' is a manufacturing company which produces a variety of products in the field of electric wire and cable manufacturing. 'XYZ' is registered as small manufacturing enterprises as per MSMEs classification criteria. Due to globalization, distortions in information sharing, demand uncertainty, supplier failure and advancement in technologies, the case organisations faces several types of supply chain risks such as environmental risk, information technology risk, supply risk, process risk, transportation risk, delay risk and demand risk. For this case and in the current study, following research problem are considered.

Problem 1: Identification of SCR variables.

From the literature review and opinion of Industry experts, seven significant SCR variables associated with the case organisation were identified, namely Environmental risk (ER), Information technology risk (IR), Supply risk (SR), Process risk (PR), Transportation risk (TR), Delay risk (DE), and Demand risk (DR).

Problem 2: To establish interrelationship amongst SCR variables.

Owing local and global competition, poor supply chain coordination, supplies and demand management, Indian MSMEs are facing several risks associated with their supply chain and specially for the case organisation. Therefore, for implementation of SCRM, it is essential for the supply chain managers to understand the interrelationship among them. For example, mitigation of a risk may raise another risk and hence the interrelationship among the risks needs to be analysed. Interrelationship among SCR variables is established using Interpretive Structural Modelling (ISM) technique

Problem 3: To assess and prioritize the SCR variables

Indian MSMEs faces several risks associated with their supply chain and cannot give equal attention to all the risks due to limited resources, such as money, manpower, time etc. Thereby, it creates a strong and justifiable reason for the assessment and prioritization of SCR variables in the context of Indian MSMEs. The relative weights of the variables cannot be obtained from ISM methodology. Therefore, Analytic Hierarchy Process (AHP), a Multiple Criterion Decision Making (MCDM), methodology is used to allocate the relative weight of SCR variables.

Problem 4: To evaluate the risk level and select the risk management strategy

Indian MSMEs face different types of risks associated with their supply chain network. The unpredictable nature of risks, improper evaluation of its impact and selection of imperfect strategy (not related to the risk associated), in turn, lead to an adverse effect on the performance of the supply chain. Therefore, Indian MSMEs are approaching to adopt

SCRM practices to achieve better performance and uninterrupted supplies to ultimate consumer. From here, the problems of SC managers arise, i.e., what exactly the supply chain exposed to risk and how can the risk level measure? To encounter this problem, SC managers need to evaluate the risk level of their supply chain. A case study was conducted on a small-scale manufacturing organisation “XYZ” based in North-India. The fuzzy risk index (FRI) was obtained by using a fuzzy logic approach, which was used to understand the risk level of the supply chain. FRI is calculated based on SCR variables and their attributes. From FRI, it is observed that there are few risk variables/attributes that significantly affect the risk level of the supply chain. Therefore, the fuzzy performance importance index (FPII) of each SCR variable and SCR attribute is calculated, which is used to identify the main SCR variables/attributes. After identification of significant SCR variable and SCR attributes, the next problem was the selection of a suitable risk management strategy to anticipate these risks. Therefore, an ANP approach is used to evaluate and select the most feasible risk management strategy for each risk. SC managers can make the supply chain more robust and can improve its supply chain performance by proactive management of these SCR variables/attributes.

1.8 OBJECTIVES OF THE THESIS

From the literature survey and the discussion in section 1.7, main objectives of this study is broken into three research objectives, which are as follows:

- To identify SCR variables and establish interrelationship amongst these variables associated with small-scale Indian manufacturing organisation.
- To assess and prioritize these SCR variables.
- To assess the risk level of the supply chain and to select the appropriate risk management strategy with respect to each SCR variable.

1.9 THESIS ORGANIZATION

This thesis has been organised in eight chapters. A brief overview of thesis chapters are as follows.

Chapter 1: Introduction

This chapter introduces the concept of supply chain management and supply chain risk management. A brief discussion on the relevance and motivation for this research is discussed in this chapter. Supply chain risk variables and SCRM in the Indian perspective are explained in another section. A brief overview of research problems, objectives, scope and organization of this thesis is included at the end of this chapter.

Chapter 2: Literature review

This chapter starts with a literature review on supply chain risk management, SCRM practices in the global and Indian context. For the literature review, research papers published during the last 20 years were collected from reputed publishers like Sage, Taylor and Francis, Emerald, John Wiley and Sons, IEEE Xplore, Science Direct, Springer, and Inderscience. Risk management, Supply Chain Risk Management (SCRM), Supply chain risks, SCRM strategies, risk prioritization, risk assessment, risk index are the keywords used to search related articles. Besides, conference papers, books and blogs are also considered for better insight into the subject area. From the literature review, the research gaps were identified. This provided motivation for the research work and also helped in finalizing the research objectives.

Chapter 3: Tools and Techniques used in this research

The methodology, tools and techniques used in this research are described in this chapter. To achieve the objectives of this research, four methodologies are used. Interpretive Structural Modelling (ISM) is used to develop a structural interrelationship model amongst supply chain risk variables. Further, by using MICMAC analysis, these SCR variables are classified into four categories; autonomous, dependent, linkage and independent SCR

variables. AHP methodology is used to allocate the relative weight to SCR variables. These weights are further used for assessment and prioritization of SCR variables. Fuzzy logic and ANP approach is used to understand the significant sub-risk attributes and to select a suitable risk management strategy to overcome their impact. This model helps in optimum utilization of available resources for the implementation of SCR practices in the Indian MSMEs context.

Chapter 4: Development of interrelationship structural model of SCR variables.

This chapter presents the development of interrelationship structural model of supply chain risk variables using Interpretive Structural Modelling (ISM) in the Indian MSMEs context. From the discussion and experts' opinions, seven significant SCR variables were identified for the development of this model. Further by using MICMAC analysis, these SCR variables are classified into four categories: (i) autonomous, (ii) dependent, (iii) linkage and (iv) independent risk variables.

Chapter 5: Assessment and prioritization of SCR variables

This chapter describes the assessment and prioritization of SCR variables by using the AHP methodology. Five criteria were identified to evaluate these variables: (i) probability of occurrence, (ii) severity of risk, (iii) detectability of risk, (iv) risk management cost, and (v) risk controllability. With the help of AHP, relative weights of SCR variables were obtained, and these weights were further used for assessment and prioritization of SCR variables.

Chapter 6: Evaluation of risk-level and selection of risk management strategy

This chapter describes the case study to evaluate the risk-level of the supply chain. A fuzzy risk index (FRI) is obtained by using a fuzzy logic approach to understand the risk-level of the supply chain. Fuzzy logic and ANP approach are used to identify the significant sub-risk attributes and to select a suitable risk management strategy to overcome their impact.

The main objective of this research is to develop a decision support system for the implementation of SCRM in the context of the Indian MSMEs.

Chapter 7: Conclusion

The summary of key findings and managerial implications are presented in this chapter.

Limitations and future scope of this research are also presented at the last in the chapter.