CHAPTER-2

LITERATURE REVIEW

In the current volatile market conditions, supply chains are bound to face different type of risks. According to (BS 4778, 1991) risk is defined as a "*combination of probability or frequency of occurrence of a defined hazard and magnitude of the occurrence*". In the literature, there are several research articles available on this concept in different fields such as marketing, finance, economics, marketing, logistics and operations. A number of definitions of risk are given by researchers with a variety of meanings in different perspectives. There are two types of events i.e. positive events, which are treated as an opportunity for the organisation and can pose great challenges while another as a negative event, which has adverse effects on the performance of organisation, are known as risks. A large number of SCR variables directly or indirectly affect the supply chain performance. It creates a need to understand and implement the SCRM practices to anticipate various supply chain risks and their effects. SCRM is defined as a combined study of supply chain management and risk management. It also facilitates how to achieve supply chain targets, speed up supply chain operations and, ultimately, increase the supply chain performance.

The present research work is focused on the risks associated with supply chain in the Indian MSMEs perspective. A literature review on SCRM and its various aspects are discussed in this chapter. An extensive literature review on SCRM, was carried out on the research work from 2001 to 2020, to identify the research gaps. Keywords such as SCRM, risk management, supply risk, supply chain disruption, supply chain risk process, risk mitigation strategies, uncertainty in supply chain, etc., were used in this search process. Various academic database of reputed publishers is referred to identify relevant journal

articles including Science Direct, Emerald, Springer, Taylor and Francis, Inderscience. The literature review on SCRM is grouped under two broad topics namely SCRM in the global perspective and SCRM in the Indian perspective. Further, this literature review explored the classification of supply chain risk (SCR) variables, assessment and prioritization of SCR variables and SCRM process in detail. This chapter also describes the relationship among the SCRM and supply chain concepts such as resilience, agility and flexibility.

2.1 EVOLUTION OF SUPPLY CHAIN RISK MANAGEMENT

The word 'risk' derives from the early Italian word '*risicare'*, which means 'to dare'. In this sense, "risk is a choice rather than a fate" (Bernstein, 1996). The concept of risk explored in the late seventeenth century in several fields of study. A good understanding of supply chain risks helps in better decision making in supply chain operations, and also reduce the risks of a firm (Hallikas *et al.*, 2004). Management of risks is important to have smooth operations of SC. A large number of definitions of Supply chain risk management (SCRM) are available in the literature. 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*".

Modern supply chain operates in an uncertain environment such as uncertain demand, frequent changes in product design and advancement of technology etc.. This makes the supply chain more vulnerable forcing SC managers to ensure delivery of the product of the right quality, of the right quantity and at the right place within a stipulated delivery period in a cost-effective manner. SCRM enables a firm to respond efficiently and more quickly to disruption on supply chains. However, SCRM is incepted in the late nineteenth century, but it has become more popular among the researchers and practitioners from the last two decades. Tang (2006) defined SCRM as "*the management of supply chain risks through coordination or collaboration among the supply chain partners so as to*

ensure profitability and continuity". There are several definitions of supply chain risk (SCR) and supply chain risk management (SCRM) available in the literature. However, the meaning of all these definitions is almost the same in context to SCRM. The main definitions are tabulated in Table 2.1.

Table 2.1: Definitions of SCR/SCRM

Author	**Definition of SCR/SCRM**
Zsidisin (2003)	"*Supply risk is defined 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*".
Jüttner *et al.* (2003)	"*SCRM is defined 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*."
Norrman and Jansson (2004)	"*SCRM is to understand and reduce the probability of risk events, and try to avoid the disasters as well as minor disruptions, in order to increase the resilience of the organisation*."
Tang, C. S (2006)	*"SCRM is defined as "the management of supply chain risks through coordination or collaboration among the supply chain partners so as to ensure profit- ability and continuity*.''
Ritchie and Brindley (2007)	"*SCRM is an assessment of the perceived risk and performance outcome of the organisation, which formulates the appropriate strategies for risks*."
Goh *et al.* (2007)	SCRM is defined as "*the identification and management of risks within the supply network and externally through a co-ordinated approach amongst supply chain members to reduce supply chain vulnerability as a whole*".
Manuj and Mentzer (2008)	"*Identification and evaluation of risks and its losses, formulate and implementation of appropriate strategies to reduce the probability, losses, exposure and detection time of such risk events*."
Tummala and Schoenherr	"*SCRM is a comprehensive and coherent approach for the management of risks and uncertainties to help in decision-making for*

(2011)	*the supply chain manager*."
Lavastre *et al.* (2012)	"*It refers to the strategic and operational management of risks to ensure the efficient flow of materials and information within the supply chain as well as among the global supply chain partner*."
Diehl and Spinler (2013)	"*SCRM is broadened management than enterprise risk management, it not only focuses within the organisation, it also focuses the upstream and downstream partners of the supply chain*."
Ho *et al.* 2015	SCRM is defined as "*An inter-organisational collaborative endeavour utilizing quantitative and qualitative risk management methodologies to identify, evaluate, mitigate and monitor unexpected macro and micro level events or conditions, which might adversely impact any part of a supply chain*".

From the above definitions, we can understand the concept of SCRM and its objectives. Viewing these definitions, SCRM can be visualized as the identification and management of risks for the supply chain through

i. a coordinated approach amongst supply chain members (Jüttner *et al.,* 2003),
ii. to reduce supply chain vulnerability as a whole (Jüttner *et al.,* 2003, Tang, 2006),
iii. in order to ensure profitability and continuity (Tang, 2006) and
iv. to help in decision-making for the supply chain manager (Tummala and Schoenherr, 2011).

The main objective of SCRM is to proactively enable the organisations for the anticipation of these risks, respond quickly to disruptions and to maintain the supply chain performance before, after and during a disruption.

2.1.1 SCRM in Global Perspective

To expand the business and to increase market share, organisations are expanding their business from the domestic market to the global market. The organisations are extending their manufacturing facility and supply chain network globally. This increases the number of supply chain partners and makes its supply chain longer and complex with, more

vulnerability. Harland *et al.* (2003) also emphasized that increasing globalization makes the supply chain more complex, which leads to an increase in exposure to supply chain risks. These risks are not only limited to a particular supply chain partner but also affect the entire global supply chain. Management of such global SC risk become a great challenge for SC managers. Jüttner *et al.* (2003) explained the supply chain risk management concept in four aspects, understanding of risks and their consequences, identification of risk drivers, assessment of risk sources and mitigation of supply chain risks. They considered three supply chain risk sources namely, environmental, organisational and network, and suggested four generic risk-mitigating strategies namely, avoidance, control, cooperation and flexibility strategies to anticipate the supply chain risks. Zsidisin *et al.* (2004) conducted a survey on the global purchasing companies. They found supply base, availability, environmental, safety aspects, supply base, quality and information sharing as main factors for supply risk assessment process.

Tang (2006) reviewed several SCRM models in the global context and suggested four basic approaches, demand, supply, product and information management for managing supply chain risks. Li and Barnes (2008) conducted research on five Western-based manufacturing companies. They defined proactive risk management and suggested risk mitigation practices for supplier selection to reduce the supply risks efficiently. Manuj and Mentzer (2008) showed that a global supply chain has numerous supply chain links and a wider network compare to local supply chains, hence these are more vulnerable than local supply chain. They developed a comprehensive risk management model for global supply chain risk management to provide guidelines for SC managers to identify, assess and manage the global supply chain risks. Literature on SCRM in the Global perspective is summarised in table 2.2.

Table 2.2: Summary of Literature on SCRM in Global perspective

Author	Key points/Remarks
Harland *et al.* (2003)	A holistic view of risk assessment and management in UK electronics sector supply networks
Jüttner *et al.* (2003)	Considered three supply chain risk sources namely, environmental, organisational and network, and suggested four generic risk-mitigating strategies namely, avoidance, control, cooperation and flexibility strategies to anticipate the supply chain risks
Zsidisin *et al.* (2003)	Conducted a research on the seven global purchasing companies and found supply base, availability, environmental, safety aspects, supply base, quality and information sharing as main factors for supply risk assessment process.
Tang (2006)	He reviewed several SCRM models in the global context and suggested four risk mitigation strategies related to demand, supply, product and information management for better supply chain risk management.
Goh *et al.* (2007)	An algorithm is designed using the Moreau–Yosida regularization, for risk minimization and profit maximization for global supply chain network.
Ritchie and Brindley (2007)	Categorised risk drivers and developed a Framework for integration of performance and risks of global supply chain
Manuj and Mentzer (2008)	Applicability of six risk management strategies: speculation, postponement, security, hedging, avoidance and control/share/transfer with respect to three risks; supply, demand and operational risks.
Rao and Goldsby (2009)	They demonstrated how risk sources/factors such as environmental, industry, organisational, problem-specific, and decision-maker related factors contribute to overall supply chain risk.
Wagner and Neshat (2010)	They developed a graph theory based quantitative model to quantify and mitigate the supply chain vulnerability and evaluate the effectiveness of risk mitigation strategies.

Tse et. al. (2010)	They Explored the quality and safety issues, and introduced an SCRM framework for global supply chain
Olson and Wu (2011)	An integrated DEA simulation and Monte Carlo simulation model was developed to evaluate the vendor performance considering strategies of outsourcing to China
Sofyalıoğlu, and Kartal (2012).	An AHP approach for assessment of supply chain risks; supply, operational and environmental risk, and risk mitigation strategies; sharing/transfer/ control, speculation, postponement and hedging was adopted for the iron and steel industry.
Prakash *et al.* (2015)	A grey-based approach for Identification and assessment of the risk factors to select a new facility location associated with the global supply chain
Chen *et al.* (2016)	Defined risks in terms of uncertainty, variability and trust. Goal concurrence, building trust, commitment, and information-knowledge sharing is useful to mitigate supply risk and improve the buyer-supplier relationship
Wang *et al.* (2017)	Proposed a fuzzy set theory and MCDM approach based integrated framework to compare and rank the supply chain risks and risk management strategies and in aiding dimension in decision making in the global environment
Rostamzadeh *et al.* (2018)	Considered seven risk criteria and forty-four risk sub-criteria for developing a framework for the sustainable supply chain risk management (SSCRM) using an integrated fuzzy multi-criteria decision-making, TOPSIS and CRITIC approach
Kilubi and Rogers (2018)	Explored relationships linking supply chain risk management (SCRM) and strategic technology partnering (STP)
DuHadway *et al.* (2019)	Explored the sources of disruptions; intentional or inadvertent, endogenous or exogenous and developed to evaluate the risk mitigation strategies for supply chain risks

2.1.2 SCRM in Indian Perspective

In the late 1990s, due to Industrialization and the advancement in information and communication technology revolution, new markets and new opportunities had developed for the Indian MSMEs. Indian MSMEs have been growing continuously and are contributing significantly towards the economic and social development of the country. For business expansion, India MSMEs extended its supply chain to multiple locations by adding multiple supply chain partners. It not only maximized their profit but also exposed their supply chain to various supply chain risks. Since 1990's, SCRM emerged as an important area for researchers and SC professionals. Indian MSMEs are also facing several risks associated with their supply chain. Maintaining uninterrupted supply chain flow is the primary concern of the supply chain managers. But due to risks involved in the supply chain, its sometime becomes difficult for managers to maintain such flow. Several articles and researches were conducted on supply chain risks and SCRM, most of the articles were focused on large companies or MNCs. The literature on SCRM in the Indian perspective is summarised in Table 2.3.

Table 2.3: Summary of Literature on SCRM in Indian perspective

Author	Key points
Faisal *et al.* (2006b)	Identified 11 significant barriers to risk management of the Indian SMEs supply chain, and presented an ISM based hierarchy model to understand the interrelationships among risk mitigation enablers
Sharma and Bhat (2012)	Using the analytic hierarchy process (AHP) methodology, analysed, classified and ranked the risks of an automotive supply chain
Samvedi *et al.* (2013)	Used an integrated fuzzy AHP and fuzzy TOPSIS approach for quantification of supply chain risks and proposed a comprehensive risk index to evaluate the supply chain risks in Indian steel and textile companies

Faisal (2013)	Using QFD approach, developed supply chain house of risk to understand the interrelationships among supply chain risks and risk mitigation strategies in Indian SMEs
Kumar *et al.* (2014)	Analysed various strategies used by Indian SMEs for improvement in the supply chain coordination with respect to emerging opportunities and challenges in the global supply chain
Sharma and Bhat (2014)	Using exploratory factor analysis and multiple regression analysis to establish the interrelationship among various risk sources and supply chain risks of Indian automobile industry.
Kumar and Routroy (2014)	Proposed a comprehensive risk management framework to rank the risk impact and analyse risk plan by using Failure Mode and Effect Analysis
Venkatesh *et al.* (2015)	Used Interpretative Structural Modeling (ISM) to establish the interrelationship among supply chain risks in Indian apparel retail chains. Also proposed Risk Priority Number (RPN) for prioritization of risks
Shenoi *et al.* (2016)	Explored the strategies such as risk sharing, risk avoidance, risk plan, risk financing, risk monitoring and risk transfer to mitigate the risk impact.
Chand *et al.* (2017)	Used an integrated ANP and MOORA approach to select the best supply chain for Indian industries
Gautam *et al.* (2018)	Performed analysis of SCRM enablers and prioritized the most critical supply chain risks, to identify the most suitable risk mitigation strategy
Alora and Barua (2019)	Established Interrelationship among supply chain risks and classified them by using ISM-MICMAC methodology

Only a few numbers of research works were focused on the SCRM practices in the Indian context and rare articles are available especially Indian MSMEs context.-From the literature review on SCM and SCRM, it is observed that researchers and SC professionals have also used some similar concepts such as resilience, flexibility, agility interchangeably for risk management. Therefore, it creates a need to understand these concepts and their reciprocity

with SCRM. The following section briefly explains the SCRM and related concepts.

2.2 INTERACTION OF SCRM WITH OTHER SUPPLY CHAIN CONCEPTS

SCRM is a broader concept and interrelated to the different approaches of managing SCR. Like resilience, flexibility and agility are few of them explained as following.

2.2.1 SCRM and Supply Chain Resilience (SCRES)

The word resilience can be defined as the ability of a substance to return to its original shape after it has been bent, stretched, or pressed. It contains the same meaning in context to supply chain management. Supply chain resilience (SCRES) is defined as "*the ability of a system to return to its original state or move to a new or more desirable state after being disturbed*" (Christopher and Peck, 2004). Modern supply chains are long and complex in nature and thus faces various types of supply chain disruptions. To reduce the impact of these disruptions, SC managers must adopt suitable strategies. A simple SCRES process consists of four basic steps; preparation, response, recovery and growth after the disruptive event. From the literature, it is observed that many researchers have tried to explore the reciprocity between SCRES and SCRM. For efficient supply chain risk management, an organisation has to be more resilient. Both SCRM and SCRES are interrelated areas and both the concepts deals with management of supply chain disruption/risk. Both SCRM and SCRES are deployed simultaneously to enhance supply chain performance.

SCRES and SCRM are the two important aspects of modern supply chain management. Researchers used and suggested both the concepts for improving the supply chain performance. Ponomarov and Holcomb (2009) found SCRES is a critical component of SCRM, and defined supply chain resilience as "*the adaptive capability of the supply chain to prepare for unexpected events, respond to disruptions, and recover from them by maintaining continuity of operations at the desired level of connectedness and control over structure and function*". Colicchia *et al.* (2010) proposed a framework to evaluate the

effectiveness of the SCRM approaches in order to enhance supply chain resilience in the global sourcing context. This study showed that a better understanding of risk sources and SCRM approaches (operational buffers, mitigation actions and contingency plans) enables the SC manager to make the supply chain more resilient. Supply chains faced several types of risks, which directly or indirectly affects the supply chain operations and their performance. Therefore, to overcome these risks, supply chains must be more resilient. SC managers must adopt the strategies which reduce the impact and probability of a disruptive event in order to make the supply chain more resilient (Barroso *et al.* 2015). Zineb *et al.* (2017) studied the impact of SCRM strategies on supply chain resilience in the Moroccan manufacturing industry context. They explored various dimensions of SCRM such as flexibility, redundancy and collaboration, and their impact on SCRES by using exploratory and confirmatory factor analysis. The findings of this study showed that flexibility and collaboration practices have a positive effect on SCRES, whereas redundancy practices have a negligible effect. SCRM approach consists of both proactive and reactive strategy but it mainly focus on proactive strategies to respond to the supply chain risks. On the other hand, SCRES is defined as the firm's ability to recover from the disruptive event, thus we may say SCRES is more focused on reactive approach to mitigate the risks.

2.2.2 SCRM and Supply Chain Agility (SCA)

Agility is defined as the organisation's ability to how quickly they respond to the changes such as demand (Christopher, 2000). SCRM is a broader concept than Agility. SCRM approach is a combination of a proactive and reactive approach while agility mainly focuses on reactive approach. Prater *et al.*, (2001) explained the agility in context to uncertainty sources such as lead-time, demand, quality of material and information delay. Through this study, they tried to link both the concept of uncertainty and agility. They introduced the concept of supply chain exposure and identified the main factors for determining the degree

of exposure such as the number of political areas, technical structure, distribution system, and environmental issue. Supply chain exposure has a negative effect on agility, which means more the exposure lesser the agility of the supply chain. To make the supply chain agile, it must respond quickly to the changes in the business environment. Wieland *et al.* (2012) used structural equation modeling approach to understand the relationship between SCRM and agility. They found that both robustness and agility have a significant effect on supply chain performance. The findings of their study also explained that robustness deals with supplier-side risks, while agility deals with customer-side risks. Some authors recognized agility as a supply chain strategy to enhance the performance of the supply chain. Charkhab *et al.* (2014) considered agility and robustness as supply chain strategy and studied their effect on the SCRM, customer values and business performance by using structural equation modelling. Findings of their study proved that both strategies have a positive effect on the supply chain's customer value and business performance. Jajja *et al.* (2018) conducted an empirical research to understand the impact of supplier and customer integration on the supply chain risk. They explored the relationship between the SCRM and agility on the basis of supplier and customer integration. Findings of this research proved that the supplier and customer integration is helpful to mitigate the supply chain risk and enhance their agility performance. Literature suggests that SCRM focuses on whole SC while agility deals downstream side of SC.

2.2.3 SCRM and Supply Chain Flexibility (SCF)

Flexibility is defined as the ability to change to the environment uncertainty with minimum effort, time and cost. Due to globalization, competition, advanced technology, SC become more vulnerable and faces several supply chain uncertainties/disruptions. To overcome this uncertainties/disruption, supply chain flexibility is considered as a key solution. In the literature, supply chain flexibility is classified by different types. Swafford *et al.* (2006)

classified supply chain flexibility into five components namely, manufacturing flexibility, product development flexibility, sourcing flexibility, information technology flexibility and logistics flexibility. Many researchers and SC professionals surveyed supply chains of different industries to understand the relationship between supply chain risk and supply chain flexibility. They explored the various types of flexibility which help in mitigating the supply chain risks.

SCRM and SCF both are emerging concepts of supply chain management, where SCF is an antecedent of SCRM. Tang *et al.* (2008) studied the role of various flexibility strategies for the mitigation of supply chain risks. They focused on the importance of cost-benefit analysis of flexibility in the SCRM context. Research findings showed that a low level of flexibility is required to obtain most of the benefits to mitigate the demand, process and supply risks. Avelar-Sosa *et al.* (2014) proposed a structural equation model for the assessment of risk factors to ensure the supply chain performance. They considered suppliers, processes and demand as risk factors, and flexibility and customer service as two constructs of performance. They identified that flexibility has a direct positive effect on suppliers and customer service factors.

Empirical research also showed that operational flexibility and operational efficiency are positively related to supply chain risk management (Kauppi *et al.* 2016). Sreedevi and Saranga (2017) analyzed the supply chain flexibility and investigated its relationships with supply chain flexibility and environmental uncertainty. This study revealed that manufacturing and supply flexibility is helpful to mitigate the manufacturing and supply risks respectively. From this literature review, clear understanding of SCRM and SCF concept is explained. It is also clear that these two concepts are interrelated concepts and SCF is a dimension of SCRM.

2.3 LITERATURE REVIEW ON SCRM PROCESS

The conceptual framework of risk management consists of four stages: risk identification, risk assessment, risk mitigation and risk control and monitoring. Based on this conceptual framework and approach to the research problem of this study, the literature on SCRM is classified into four categories namely; identification and classification of supply chain risks, assessment and prioritization of supply chain risks, conceptual models on SCRM and risk management strategies. These are briefly explained as under:

2.3.1 Identification and Classification of Supply Chain Risks

Supply chain risks are those events, which negatively affect the supply chain performance. The unpredictable nature of risks and improper evaluation of the impact, lead to an adverse effect on the performance of the supply chain. To overcome the consequences of supply chain risks, SC managers need to identify and classify them. Many researchers and SC professionals have classified the supply chain risks based on their characteristics such as; impact, occurrence, or the source of risks. Based on risk sources, Jüttner *et al.* (2003) classified the supply chain risks into three types; external risks, internal risks, network-related risks. For identification of significant supply chain risks, a clear understanding of characteristics and types of risks is required for SC managers. Based on risk events and their conditions, Chopra and Sodhi (2004) summarised supply chain risks into nine categories related to delays, disruptions, capacity, systems, forecast, procurement, intellectual property, receivables and inventory. Wagner and Bode (2006) classified risks into three categories, supply-side risks, demand-side risks and catastrophic risks. They selected only these three categories because these were the most important issues of SCRM at that time. The next classification of the supply chain risks was given by Ritchie and Brindley (2007) by classifying risks based on their implementation time frame, namely strategic uncertainty, operational disturbance and tactical disruption. Supply Chain Risks are classified into two broad categories, i.e., internal and external risks. Internal supply

chain risks are those risks, which emerge from inside the supply chain and affect the supply chain internally. These risks can be identified and workout with comparatively less effort. Thus, SCRM strategies can be implemented at an early stage to reduce the impact of such internal risks. External Risks are referred to those risks which emerge from outside the supply chain and affect the supply chain externally, such as, the environmental risks. Such risks are uncontrollable in nature and their frequency of occurrence is very low, but they may lead to the potential disruption of the supply chain at any stage. As such, for better management of supply chain risks, a clear understanding of types of risks is required. A comprehensive classification of supply chain risks given by researchers is summarised in Table 2.4.

Table 2.4 Classification of supply chain risks given by researchers

Authors	**Classification of supply chain risks**
Mason-Jones and Towill (1998)	Environmental, supply, process, control and demand risks
Jüttner *et al.* (2003)	External risks, internal risks, network-related risks
Harland *et al.* (2003)	Supply, strategic, customer, operations, asset impairment, competitive, reputation, legal, regulatory, fiscal and financial risks.
Sodhi and Chopra (2004)	Delays, disruptions, capacity, systems, forecast, procurement, intellectual property, receivables and inventory risks
Hallikas *et al.* (2004)	Demand, Customer, financial
Barnes and Oloruntoba (2005)	Strategic, financial, operational, commercial, technical
Tang (2006)	Operational risk and disruption risk
Wagner and Bode (2006)	Supply-side risks, demand-side risks and catastrophic risks
Wu *et al.* (2006)	Internal risk: internal controllable, internal partially controllable, internal uncontrollable

	External risk: external controllable, external partially controllable, external uncontrollable
Byrne (2007)	Controllable and Uncontrollable risks.
Tang and Tomlin (2008)	Supply, demand, process, behavioural, intellectual property, and political/social risks
Manuj and Mentzer (2008)	Supply, operational, and demand risk.
Rao and Goldsby (2009)	Environmental, organisational, industry-specific, problem-specific, and decision makers risk
Trkman and McCormack (2009)	Endogenous and exogenous risks
Tang and Musa (2011)	Material flow, financial flow and information flow risks
Tummala and Schoenherr (2011)	Delay, demand, disruption, manufacturing, physical plant, supply, sovereign, system, transportation, and inventory risks
Hachicha and Elmsalmi (2014)	Supplier, manufacturer, wholesaler, distributor, retailer, consumer and environment risks
Rogers *et al.* (2016)	Supplier, Infrastructure, Operational, Legal, Cultural and social, Labour, Warehouse, Forecasting, Natural disaster, Economic and Transportation risks
Abdel-Basset (2019)	Internal risks (managed risks) and external risks (uncontrolled risks)

2.3.2 Assessment and Prioritization of Supply Chain Risks

Every risk has a different effect on the performance of supply chain, which is mainly due to their different levels of impact and a different probability of occurrence. Some risks have significant consequences, while others have negligible consequences. Therefore, assessment and prioritization of risks are essential activities for supply chain managers for proactive planning for each risk. In the literature, several approaches of the risk assessment are available, which are almost similar and concerned with the determination of likelihood/probability of occurrence and the consequences of the identified risks (Harland

et al., 2003; Norrman and Jansson, 2004; Manuj and Mentzer, 2008; Ritchie and Brindley, 2007; Tummala and Schoenherr, 2011; Kern *et al.*, 2012; Ghadge *et al.*, 2013). Tang and Musa (2011) highlighted that risk assessment and prioritization is an important step of SCRM process to identify the significant supply chain risks. Mathematically, risk assessment can be calculated as the product of the risk probability score and risk impact score, which is known as composite risk score (Harland *et al.*, 2003; Hallikas *et al.*, 2004; Norrman & Jansson, 2004). This composite risk score used to categorize and prioritize the identified risks. Gaudenzi and Borghesi (2006) provided a method to evaluate supply chain risks. An analytical hierarchy process model was proposed by them to identify supply chain risk factors to improve customer value. The two phases of the method are the prioritization of supply chain objectives and the selection of risk indicators. Besides this traditional risk assessment process, Tuncel and Alpan (2010) proposed Risk Priority Number (RPN) for assessment and prioritization of risk, which is a product of severity (S), probability of occurrence (O) and detection difficulty (D); (RPN=O x S x D). Prioritization of SCR variables is not just a prioritization, but it also includes the understanding of interactions among various SCR variables and the external factors that could affect the prioritization of these SCR variables. Venkatesh *et al.* (2015) proposed another replacing the probability of occurrence by a factor of "driving power" and "dependence power" to the RPN. The new RPN proposed by them is as follows.

$$Risk\ Priortization\ Number\ (RPN) = severity\ \times\ detection\ \times \frac{driving\ power}{dependence\ power}$$

A stochastic integer linear programming based SCRM model was presented by Micheli *et al.* (2014). This model explained the relationship between risks and their probable impact. This model also prioritizes the supply chain risks to select the mitigation strategy. Mangla *et al.*, (2015) conducted a study on Green Supply Chain (GSC) and

identified six major risks and twenty-five sub-risks of GSC. They prioritized these risks and sub-risks using the fuzzy Analytic Hierarchy Process (fuzzy AHP), and their results revealed that operational risks/process risks are major risks in GSC. Gautam *et al.*, 2018 conducted a case study on SCRM and quality aspects of Indian automotive industry. They identified critical risks of supply chain and classified them into three categories. Using the survey method, they prioritized and ranked these supply chain risks. They found that process risk and supply risk are the most critical risks of the Indian automotive supply chain.

2.3.3 Conceptual Models on SCRM

In the literature, researchers and SC professionals proposed several conceptual models on SCRM to enhance the supply chain performance. Most of the models are developed for global supply chains. Some models are generic and some are case-specific, they provide deep insights of SCRM practices. A conceptual SCRM process consists of four steps; risk identification, risk evaluation, risk mitigation and risk monitoring (Jüttner *et al.*, 2003). Researchers have developed various SCRM models based on various research methodologies such as Interpretive Structural Modelling (ISM), Analytic Hierarchy Process (AHP), Multi-Objective Optimization by Rational Analysis (MOORA), Structural Equation Modeling (SEM), Failure Mode and Effects Analysis (FMEA) and Analytical Network Process (ANP) (Hallikas *et al.,* 2004; Faisal *et al.,* 2006b; Gaudenzi and Borghesi, 2006; Faisal *et al.,* 2007; Schoenherr *et al.,* 2008, Deane *et al.,* 2009; Wagner and Neshat 2010; Venkatesan and Kumanan 2012; Soni and Kodali 2013; Radivojević and Gajović 2014; Venkatesh *et al.,* 2015; Giannakis and Papadopoulos 2016;; Rostamzadeh *et al.,* 2018).

Millet and Wedley (2002) conducted four case studies for modelling risk by using AHP approach and provided a guideline to decision-makers to select the appropriate

method while dealing with risks or uncertainties. Jüttner *et al.* (2003) proposed a conceptual model of supply chain risk management. For future research, they suggested four main aspects of SCRM, assessment of risk sources, identify the risk drivers, define the risk concept and mitigate the risks of the supply chain. Gaudenzi and Borghesi (2006) analysed the impact and the cause-effect relationship of risk indicators. They proposed an AHP model to prioritize supply chain risk indicators. Manuj and Mentzer (2008), explored the supply chain risks and risk management strategies related to the global supply chain. They identified six risk management strategies and proposed a decision-making model for the selection of best risk management strategy. Diabat *et al.* (2012) identified five major risk categories and developed an SCRM model based on ISM. They validated by conducting a case study on the food manufacturing company. Kumar and Routroy (2014) suggested a methodology for assessment of supply chain risks and also proposed mitigation strategies for such risks. By using cause-effect analysis, they identified major risks associated with manufacturing units and prioritized them with the help of AHP methodology. Mangla *et al.*, (2015) conducted a study on Green Supply Chain (GSC) and identified six major risks and twenty-five sub-risks of GSC. They prioritized these risks and sub-risks using fuzzy Analytic Hierarchy Process (fuzzy AHP), and their results revealed that operational risks/process risks are major risks in GSC. Gautam *et al.*, (2018) conducted a case study on SCRM and quality aspects of Indian automotive industry. They explored critical supply chain risks and classified them into three categories. They used survey to prioritize and rank the identified supply chain risks to highlight the process risk and supply risk as the most critical risks of Indian automotive supply chain. Abdel-Basset *et al.* (2019) also emphasized on risk analysis, mitigation and control for taking suitable decisions. They demonstrated an integrated method with a neutrosophic analytical hierarchy process (N-AHP) and neutrosophic technique to quantify supply chain risks. They categorized risk

management decisions in five categories: (i) Avoidance, (ii) Acceptance, (iii) Compensation, (iv) Transferring, and (v) Reduction. A summary of SCRM model proposed by the researchers in the literature is shown in Table 2.5.

Table 2.5 Summary of SCRM model proposed by the researchers

Author	**Model description**	**Research approach**
Harland *et al.* (2003)	Defined and classified the supply chain risks, and developed a holistic model of SCRM	Case study
Zsidsin *et al.* (2003)	An empirical study of risk assessment and risk mitigation strategies	Case study
Jüttner *et al.* (2003)	Identified four aspects of future SCRM; assessment of risk sources, identify the risk drivers, define the risk concept and mitigate the risks of the supply chain.	Empirical study
Christopher and Lee (2004)	Identified visibility as an important aspect to reduce supply chain risk	Conceptual study
Chopra and Sodhi (2004)	Define nine significant supply chain risk and their mitigation strategies for better understanding of SCRM	Conceptual study
Hallikas *et al.* (2004)	Presented general structure of the risk management process and methods for risk management in a complex network environment.	Conceptual study
Faisal *et al.* (2006a)	Proposed model for the selection of supply chain strategy based on customer sensitivity and risk alleviation competency dimension using graph theory.	Graph Theory
Faisal *et al.* (2006b)	Presented a hierarchy model to understand the interrelationship among risk mitigation enablers using ISM-MICMAC approach	ISM-MICMAC
Gaudenzi and Borghesi (2006)	Proposed a model for prioritization of supply chain objectives and the selection of risk indicator using AHP methodology	AHP

Faisal *et al.* (2007)	Developed an integrated ANP-SCOR model for the selection of best strategy to mitigate the supply chain risks	ANP-SCOR
Manuj and Mentzer (2008)	Explored the phenomenon of risk management and risk management strategies in global supply chains.	Empirical study
Schoenherr *et al.* (2008)	Presented a comprehensive framework for the assessment of supply chain risks and alternatives in international sourcing context	AHP
Deane *et al.* (2009)	Developed a mathematical model for quantification of information security risk in the supply chain	Mathematical Modeling
Wagner and Neshat (2010)	Developed an approach based on graph theory to quantify mitigate supply chain vulnerability and evaluate the effectiveness of risk mitigation strategies	Graph Theory
Tummala and Schoenherr (2011)	Proposed Supply Chain Risk Management Process (SCRMP) model	Conceptual
Venkatesan and Kumanan (2012)	Proposed a hybrid AHP and PROMETHEE approach for prioritization of supply chain risks	Hybrid AHP and PROMETHEE
Soni and Kodali (2013)	By using PROMETHEE-II and goal programming tools, presented a framework for assessment of risk in the global supply chain to select the least risky configuration of suppliers and distributors.	PROMETHEE-II and goal programming
Samvedi *et al.* (2013)	Presented an integrated fuzzy AHP and TOPSIS approach to quantify the supply chain risk and to calculate comprehensive risk index.	fuzzy AHP and TOPSIS
Radivojević and Gajović (2014)	Presented a Used AHP and FAHP based risk assessment model to determine the rank of supply chain risk categories.	AHP and FAHP

Venkatesh *et al.* (2015)	Used ISM to establish the interrelationship among risks in Indian apparel retail chains and also proposed a risk prioritization model using MICMAC approach.	ISM-MICMAC
Chand *et al.* (2015b)	Conducted a comparative study of multi-criteria decision-making approaches, ANP and MOORA for evaluation of order preference in supply chain risks	ANP and MOORA
Faisal (2016)	Proposed a risk index to aid in analysing and benchmarking supply chains on risk susceptibility dimension by using digraph and matrix methods	Digraph and matrix
Giannakis and Papadopoulos (2016)	Used FMEA technique for assessment of sustainability-related supply chain risk and to identify their cause and effect	FMEA
Chand *et al.* (2017)	Demonstrated ANP and MOORA approach to select the best supply chain having minimum supply chain risks	ANP and MOORA
Qazi *et al.* (2017)	Introduced an integrated supply chain risk management process for prioritizing interdependent risks and strategies using Failure Modes and Effects Analysis	FMEA
Rostamzadeh *et al.* (2018)	Developed a framework to evaluate a sustainable supply chain risk management (SSCRM) using an integrated fuzzy TOPSIS- CRITIC approach	fuzzy TOPSIS-CRITIC
Shenoi *et al.* (2018)	Provided guidelines to ensure a robust supply chain risk management using Importance-performance analysis	IPA
Chowdhury *et al.* (2019)	Developed a hierarchical structural model to identify, analyse and classify the supply chain risks by using ISM-MICMAC approach	ISM-MICMAC
Tarei *et al.* (2020)	Developed a conceptual framework to understand the interaction SCRM strategies and SCRRM practices, and designed a supply chain risk	SLA and CA

2.3.4 Supply Chain Risk Management Strategies

The risk mitigation planning mainly focuses on identifying and evaluating significant risks and the treatment of these risks by using appropriate risk management strategies to reduce the impact/probability of a risk event. SCRM strategies are defined as an action plan to mitigate the identified supply chain risks. To mitigate the supply chain risk, Miller (1992) classified risk mitigation approach for two broad categories namely: Financial risk management and strategic risk management, by identifying five generic strategies under strategic as: avoidance, control, cooperation, imitation and flexibility. From these five strategies, Jüttner. *et al.* (2003) adopted four strategies namely; avoidance, control, cooperation, and flexibility and proposed future agenda for supply chain risk management. Supply chain risks can not be completely neutralized, but the consequences/frequency of risks can be reduced by the proactive implementation of suitable risk mitigation strategies. Tarei *et al.* (2020) designed a supply chain risk mitigation plan for the Indian petroleum supply chain. They explored the relationship between five risk management strategies, namely, ignore, control, accept, mitigate, transfer and avoid. A summary of main SCRM strategies in the literature is shown in Table 2.6.

Table 2.6 Summary of supply chain risk management strategies

Generic strategy	**RM strategy**	**Referenecs**
Avoidance	Dropping specific products / geographical markets /supplier and/or customer organisations	Jüttner *et al.* (2003), Novaes and Souza (2005), Thun and Hoenig (2011),
	Delay new market entry	Miller (1992), Sofyalıoğlu and Kartal (2012)
	Vendor selection methodologies	Wu and Olson (2008), Sawik (2011)

Control	Vertical integration	Miller (1992), Jüttner *et al.* (2003), Sofyalıoğlu and Kartal (2012)
	Horizontal mergers and acquisitions	Miller (1992)
	Increased stockpiling and the use of buffer inventory	Jüttner *et al.* (2003), Chopra and Sodhi (2004), Tomlin (2006), Thun and Hoenig (2011), Lavastre *et al.* (2012)
	Maintaining excess capacity in productions, storage, handling and/or transport	Novaes and Souza (2005), Jüttner *et al.* (2003), Chopra and Sodhi (2004)
	Imposing contractual obligations on suppliers and consumers	Jüttner *et al.* (2003), Lavastre *et al.* (2012)
Cooperation	Information transmission/sharing and understanding within supply chain, joint efforts to improve supply chain visibility and understanding	Jüttner *et al.* (2003), Faisal *et al.* (2006b), Lavastre *et al.* (2012)
	Long-term contractual agreements and commitments with suppliers and customers	Miller (1992), Swink and Zsidisin (2006), Lavastre *et al.* (2012), Sofyalıoğlu and Kartal (2012),
	Collaborative relationship management (Alliances or Joint ventures, Licensing and sub-contracting arrangements)	Miller (1992), Faisal *et al.* (2006b), Trkman and McCormack (2009)
	Joint efforts to share risk-related information/ Risk sharing	Jüttner *et al.* (2003), Faisal *et al.* (2006b)
	Joint efforts to prepare supply chain continuity plans	Jüttner *et al.* (2003), Lavastre *et al.* (2012)
	Aligning incentives and revenue sharing policies in a supply chain	Faisal *et al.* (2006b)
	Postponement	Miller (1992), Jüttner *et al.* (2003), Novaes and Souza (2005), Sofyalıoğlu and Kartal (2012)

	Diversification (Product and Global Diversification)	Miller (1992)
Flexibility	Flexible input sourcing (e.g. dual sourcing and multiple sourcing)	Miller (1992), Jüttner *et al.* (2003), Chopra and Sodhi (2004), Tang and Tomlin (2008), Thun and Hoenig (2011), Lavastre *et al.* (2012), Sofyalıoğlu and Kartal (2012)
	Increase overall flexibility	Chopra and Sodhi (2004)
	Flexible plants and equipment, Flexible work force size and skills,	Miller (1992)
	Flexible supply contracts, Flexible manufacturing	Tang and Tomlin (2008)
	Localised sourcing	Jüttner *et al.* (2003),
Financial risk management	Forward or futures contracts and Insurance	Miller (1992)

2.4 RESEARCH GAPS

In the literature, SCRM is identified as an essential and emerging concept of supply chain management. Several research articles are published on SCRM by researchers and supply chain managers. Modern supply chain operates under a dynamic business environment and faced several types of risks associated with its supply chain network. These risks directly or indirectly affect supply chain performance. To ensure the supply chain performance, the firm needs to identify, understand and evaluate the significant risks and to develop the risk management plan to overcome it. From the literature review on SCRM, it has been identified that SCRM in the Indian context is still not specifically addressed. Most of the research studies are conducted on large companies or MNCs and SCRM models are also designed considering the business environment of large companies. There are only few research studies are available on SCRM in the Indian perspective. Indian MSMEs operate in a completely different business environment compare to large companies, as MSMEs

have limited resources to deploy for SCRM. In most of the cases, the SCRM model designed for large companies is difficult to implement in Indian MSMEs. This literature review provides a direction for research in this field, which is briefly explained below.

Due to globalization, competition and rapid change in technology, several supply chain risk variables affect the supply chain performance of Indian MSMEs. SC managers need to identify the major SCR variables having a significant impact on the supply chain. To know how a SCR variable interacts with each other, it is also required to understand the interrelationship among them. Thus, it creates a need of study to identify the main SCR variables and establish the interrelationship among them in relation to Indian MSMEs.

A conceptual risk management process consists of four steps, identification, assessment, mitigation and monitoring. After identification of SCR variables, the next step is to assess them on the basis of their probability of occurrence, detectability and severity. As Indian MSMEs have limited resources, it is not possible for these to deal with all SCR variables at the same time. Some have a negligible impact, some have a significant impact while some other risks have a severe impact on the supply chain. So, it is necessary for the supply chain manager to prioritize these risks for the optimum deployment of resources. Thus, assessment and prioritization of SCR variables are identified as another research gap in case of Indian MSMEs.

A clear understanding of the problem is itself half-solved. Similarly, a complete understanding of supply chain risks is only a half solution of SCRM. For a complete solution of SCRM, SC managers must identify and understand the various risk management strategies with respect to each risk. Every risk has a different effect on the performance of supply chain. This is mainly due to their different levels of impact and a different probability of occurrence. It becomes essential to identify the significant sub-risk attributes and to select a suitable risk management strategy in context to the Indian manufacturing

organisation.

2.5 OBJECTIVES OF THE THESIS

From the literature, the research gaps and problems related to SCRM in the Indian MSMEs perspective, were identified and discussed in the earlier section. An effort has been made toward these research gaps/problems by conducting an empirical research on a small-scale manufacturing company, based in North-India. The main purpose of this work is to provide a comprehensive understanding of SCRM so as to respond efficiently and more quickly towards disruption on supply chain for such type of companies. The objectives of this study are broken into three research objectives in relation to the case organisation. These are mentioned in Chapter 1 and reproduced for ready reference as follows.

- To identify SCR variables and establish interrelationship amongst such variables,
- 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 risk.

The tools and techniques that are used towards these objectives are discussed in the next chapter.