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SUPPLY CHAIN RISK MANAGEMENT MEASUREMENTS: A CRITICAL LITERATURE REVIEW

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ABSTRACT

Supply Chain (SC) risk refers to any unwanted deviation from the expected SC outcome that can adversely affect SC operations and result in negative consequences for the focal firm. Supply Chain Risk Management (SCRM) measurements are effective tools for identifying, assessing, mitigating, and controlling SC risks. Hence, this paper aims to critically review the literature on existing SCRM measurements, identify their limitations, and outline future research directions. The review revealed that most scholars developed SCRM measurements based on risk identification assessment, ranking, and prioritization, combining qualitative and quantitative techniques, most of which require company-specific risk-related data. The majority employed traditional tools such as the risk matrix approach and the Analytic Hierarchy Process for risk assessment, while a few used more advanced hybrid and network-based models, machine learning, and optimization models for risk assessment, ranking, and prioritization. Despite numerous risk identification and assessment measurements, an extremely limited number of SCRM capability measurements were found in the existing literature. Furthermore, there is a lack of a standardized, universally applicable framework/measurement for SCRM that balances accuracy, usability, and context-specific applicability. This research has significant implications, as it consolidates recent literature on investigation in one place and enhances practitioners' awareness of the measurements.

Keywords: Supply Chain Risk Management, Supply Chain Risk, Risk Management capability measurements, Critical Literature Review

INTRODUCTION

Supply chains are highly vulnerable to unpredictable disruptions, which are manifestations of supply chain (SC) risk (Ivanov & Dolgui, 2020). There are many different classifications of SC risk, such as operational risk, internal company risk, external SC risk, purchasing risk, demand risk, process risk, control risk, etc. (Christopher & Lee, 2004; Kleindorfer & Saad, 2005; Ozdemir et al., 2022; Tang, 2006), which differ across industries. In this instance, Supply chain risk management (SCRM) can address the likelihood of risks and their consequences by analyzing risk sources and implementing appropriate tools (El Baz & Ruel, 2021). Therefore, various tools and measurements (e.g., indices, models, and frameworks) developed by scholars in dynamic, contextual settings help evaluate current risk assessment and mitigation capabilities and inform proactive actions.

Although several studies authored by (Fan & Stevenson, 2018; Gurtu & Johny, 2021; Vanany et al., 2009) have reviewed SCRM, these reviews primarily focused on definitions of SC risk, SC risk classification, risk identification, and mitigation strategies. Only a limited number of studies authored by (Heckmann et al., 2015; Hosseini et al., 2019; Tang, 2006) have addressed quantitative approaches to develop SCRM measurement. However, they do not provide a comprehensive synthesis of both qualitative and quantitative measurement approaches. Moreover, existing reviews tend to examine measurement approaches in isolation, resulting in fragmented knowledge without an integrated framework. Therefore, there remains a clear gap in systematically consolidating and comparing qualitative and quantitative SCRM measurement approaches within a single platform. Hence, the primary objectives of the present study are to identify existing SCRM measurements and their limitations, to identify research gaps, and to outline future research directions.

The remainder of this paper is organized as follows: the methodology used in the review is presented in the materials and methods section. Next, the critical reviews of the literature on the methods and strategies employed by prior scholars to develop SCRM measurements, along with their importance, applications, and limitations, are presented. Finally, the research gaps and the possible directions for future research are discussed.

MATERIALS AND METHODS

This study adopts a critical literature review approach; however, to enhance methodological clarity, a structured and transparent multi-stage procedure (sourcing, screening, and analysis) was followed, informed by prior review guidelines (Tranfield et al., 2003; Tukamuhabwa et al., 2015). In the sourcing stage, articles were retrieved from multiple databases, including Emerald, Taylor & Francis Online, and Science Direct. A set of predefined search terms, such as "Supply Chain Risk", "Risk Identification", "Risk Assessment", "Supply Chain Risk Management", "Risk Mitigation Index" and "Composite Index", was applied across all fields. The search was limited to peer-reviewed journal articles and refereed conference papers published in English between 2011 and 2022. In the screening stage, duplicate records were first removed (n = 174). The remaining articles were then screened using title and keyword searches to assess their relevance to the research focus. This was followed by a review of the abstract and conclusion, and, where necessary, a full-text screening to ensure conceptual alignment. At this stage, 72 articles were retained. To further enhance relevance and coverage, backward reference searching was conducted on these articles, identifying additional relevant studies. Following this process, a final set of 13 articles (11 journal articles and 2 conference papers) was selected. The final selection was guided not only by relevance but also by the studies' conceptual richness, methodological contributions, and direct applicability to supply chain risk management measurement. This reflects the interpretive and depth-oriented nature of a critical review. In the analysis stage, key information was systematically extracted from each selected study and critically synthesized to address the research objectives.

SCRM process

SCRM is a process that assesses risk likelihood and consequences by analyzing sources and implementing appropriate tools, thereby helping to eliminate, reduce, and control SC risk (Ritchie & Brindley, 2007). Risk identification is the first step in SCRM, enabling the identification of SC risk sources through regular screening of potential risks (El Baz & Ruel, 2021). Risk assessment is the second step, which involves identifying potential losses, evaluating their likelihood, and assigning significance to them (El Baz & Ruel, 2021). Risk mitigation is the third step of the SCRM process that seeks to address SC risks through appropriate measurements, either before a disruption occurs or after the event unfolds, using contingency plans (El Baz & Ruel, 2021; Liu et al., 2014; Sodhi et al., 2012). Risk control is the last step in SCRM; it can reduce the frequency and impact of SC risks (Saghafian & Van Oyen, 2011). Risk control is ensured through systematic processes, preparedness, risk awareness of employees, articulated procedures, and elaborated plans (El Baz & Ruel, 2021).

SCRM measurements

In this study, the measurements (e.g., indices, models, frameworks) used to evaluate a particular organization's SCRM capability are broadly referred to as SCRM capability measurements. However, some of these SCRM measurements consist of combining two or more steps of the SCRM process (SC risk identification, risk assessment, risk mitigation, and risk control). Scholars such as (Alora and Barua (2022); Mithun Ali et al. (2021); Raghuram et al. (2020)) Helmi and Masri (2017) considered the first two stages of the SCRM process (SC risk identification and assessment), and a few other scholars considered additional stages (risk identification, assessment, mitigation) to develop these measurements.

SCRM measurements through risk identification and assessment

Manthirirathna et al. (2019) considered risk identification and risk assessment as two crucial steps in developing an SCRM measurement, emphasizing the pivotal role of risk assessment in the risk management process. By contrast, the Institute of Risk Management (2018) and Sugathadasa et al. (2020) noted that risk identification, risk analysis, and risk evaluation are subcategories of risk assessment that should be considered when quantifying risk in business entities. However, the capability to rank possible results, indicating the more critical risks that require urgent attention and those that can be ignored, is among the main benefits of such risk assessment measurements (Ni et al., 2010).

Risk assessment methods

Markowski and Mannan (2008) mentioned that there are three main ways of performing a risk assessment, namely the qualitative way (risk evaluation based on compliance assessment), the semi-quantitative way (after component categorization, the risk score is calculated using dynamic methods), and the quantitative way (risk measure assessment using quantitative risk analysis). However, the Risk Matrix Approach (RMA) is known as a typical semi-quantitative risk assessment tool. Nevertheless, risk monitoring, risk identification, data collection, and estimation are the initial steps to be conducted before developing a risk matrix using RMA (Ni et al., 2010). However, according to Markowski and Mannan (2008), several steps are involved in developing a risk matrix using the RMA method. First, categorize and scale the severity, consequences, and probability, then categorize and scale the output risk index. Thereafter, it should build up knowledge of risk-based rules. Finally, a graphical edition of the risk matrix should be created.

Applications of SC risk identification and assessment measurements

According to the review, applications of risk assessment using a RMA across different contextual settings are available (Alora & Barua, 2022; Helmi & Masri, 2017; Manthirirathna et al., 2019; Sugathadasa et al., 2021). For instance, Manthirirathna et al. (2019) developed an SC risk matrix using RMA for apparel SCs in Sri Lanka. They conducted a risk assessment and investigated the most critical SC risks for Sri Lankan apparel manufacturing organizations using multiple case study methods (selecting five cases from medium-scale apparel manufacturing organizations in the Western Province). Data were collected through semi-structured interviews and analyzed using content analysis, and a risk matrix was developed, yielding the identification of 12 most critical risk factors facing Sri Lankan apparel manufacturing organizations. Similarly, Kodithuwakku and Wickramarachchi (2014) identified SC risk through a literature review and subsequently assessed it using the RMA method for large-scale apparel manufacturers in Sri Lanka. Furthermore, Sugathadasa et al. (2021) conducted a literature survey that included both overseas and Sri Lankan studies to identify SC risk. They applied the RMA to assess SC risk, employing the Borda count methodology (a methodology that gives ranking by comparing each factor in pairs considering each respondent's ranking) and the 'As Low as Reasonably Practicable (ALARP)' approach for risk ranking. ALARP is a tool used to identify high-, medium-, and low-risk regions within the risk matrix. It recommends the Borda count as one of the most suitable risk-ranking methods, prioritizing risks with higher scores across multiple respondents.

Contrarily, Sharma and Bhat (2012) identified and assessed risk in the Automotive SC in India. To identify SC risk, they conducted an extensive literature review and a few interviews with industry experts. Then, to assess and prioritize SC risk, they applied the analytic hierarchy process (AHP), a structured approach for multi-criteria for decision making. The findings revealed that the most critical risks in the automotive SC in India are volatile demand, supplier financial failure, supplier quality issues, and failure to achieve cost reductions. However, although AHP is a structured and flexible technique for assessing and prioritizing risk, it can only prioritize homogeneous variables, and pairwise comparisons yield low accuracy. Moreover, Mithun Ali et al. (2021) developed a framework to identify and assess the factors and drivers of SC disruption in Bangladesh's ready-made garment industry. Four disruption factor categories — natural, human-made, system accidents, and financial — along with a total of sixteen disruption drivers, are identified in the particular industry. They employed an integrated approach that combined the Delphi method and the fuzzy analytic hierarchy process (FAHP) to prioritize factors and drivers of SC disruption. Furthermore, they conducted a sensitivity analysis in real-world settings to assess the validity and robustness of their framework. Furthermore, Martino et al. (2017) conducted a comprehensive literature review to identify risks in the Italian fashion and apparel industry, using Process Analysis and the Analytic Network Process (ANP) to prioritize risks. The ANP approach is a tool for risk prioritization based on experts' decisions. Identification of the primary target, risk factor identification, clusterization, network definition, pairwise comparison, and prioritization are the primary steps of ANP.

Handfield et al. (2020) evaluated regional supply-based risk in low-cost countries (LCCs) for the apparel sector using news feed data. They developed a machine-learning algorithm that converts data from multiple news feeds into numerical risk scores and visual maps of SC risk. Findings revealed that the long-term risks of apparel supply disruption in LCC include human resource regulatory risks, workplace issues, inflation costs, safety violations, and social welfare violations. Additionally, some other scholars have employed dynamic methods to develop SCRM indices and models. For instance, Venkatesh et al. (2015) analyzed SC risk in the Indian apparel retail chains. They proposed a risk prioritization model (Risk Priority Number (RPN)) based on Interpretive Structural Modeling (ISM) and Fuzzy MICMAC (Matriced Impacts, Crises, Multiplication Appliquée à un Classement). First, they identified and analyzed the risk in terms of frequency of occurrence and severity in terms of cost, as well as the potential for other disruptions it could lead to. Subsequently, they prioritized risk by analyzing interdependencies among them using the ISM and fuzzy MICMAC methods. The ISM results are further extended using fuzzy MICMAC analysis to identify the driving and dependent powers of each variable.

Table 1 summarizes the risk identification, risk assessment, risk ranking, and prioritization methods discussed in the previous sections, along with their advantages and disadvantages.

Table 1: Risk identification, assessment, and ranking methods

Task	Method	Advantage	Disadvantage	Authors
Identification of risks	Extensive literature reviews and semi-structured interviews	Cost-effective method	Time consuming	(Alora and Barua (2022); Giannakis and Papadopoulos (2016))
	Delphi method	Eliminate bias, forecasting honest, independent input	High time consumption, risk of participant drop-out	(Manthirirathna et al. (2019); Mithun Ali et al. (2021); Venkatesh et al. (2015))
Assessment of risks	Risk Matrix Approach (RMA)	Visual, user-friendly, and systematic tool	Oversimplify simple risk	Markowski and Mannan (2008)
Assess the relative importance of the risks	Failure Mode and Effects Analysis (FMEA)	Can compare various risks using a standard pivoting variable	Time-consuming, subjective, resource-intensive process	(Giannakis and Papadopoulos (2016); Helmi and Masri (2017))
Prioritization of risks	Order of Magnitude Analytic Hierarchy Process (OM-AHP)	Can handle subjective judgments, ensure consistency	Susceptibility to rank reversal	Raghuram et al. (2020)
	Analytic Hierarchy Process (AHP)	Structured and flexible technique	Prioritizes only homogeneous variables, and the low accuracy of the pairwise comparison, when the number of variables increases beyond seven	Dong and Cooper (2016)
	Fuzzy Analytic Hierarchy Process (FAHP)	More reliable and accurate tool	High computational complexity	Mithun Ali et al. (2021)
	Interpretive Structural Modeling (ISM) and Fuzzy MICMAC	Can handle the subjectivity and vagueness inherent in human expert judgments	Highly dependent on experts' opinions	Venkatesh et al. (2015)
	Process Analysis and the Analytic Network Process (ANP)	Can handle qualitative and quantitative data	A complex method that requires significant time and effort for pair-wise comparisons	Martino et al. (2017)
Ranking of risk	As Low as Reasonably Practicable (ALARP) Approach	Most suitable risk-ranking methods that can prioritize risks with higher scores across multiple respondents	Requires complex analysis	Sugathadasa et al. (2021)

similar risk assessment methods, they employed different risk-ranking and prioritization approaches. However, many risk assessment, ranking, and prioritization methods combine qualitative and quantitative techniques, most of which require company-specific risk-related data, which are not always publicly available. Further, the comparison of risk management methods across studies reveals several important patterns. First, there is a consistent trade-off between methodological rigor and practical applicability, where techniques such as Delphi, FMEA, and ANP provide deeper analytical insights but require significant time and expert involvement, whereas simpler tools like RMA offer ease of use at the expense of analytical depth. Second, most methods rely heavily on expert judgment, with fuzzy-based approaches such as FAHP and Fuzzy MICMAC attempting to structure, rather than eliminate, subjectivity. Third, there is a clear methodological evolution from traditional tools like AHP toward more advanced hybrid and network-based models that better capture uncertainty and interdependencies among risks. However, these advanced methods introduce computational complexity, limiting their adoption in practice. Overall, the literature suggests that no single method is universally optimal, highlighting the need for integrative frameworks that balance accuracy, usability, and context-specific applicability.

Applications of SC risk mitigation measurements

Some risk mitigation measures and frameworks were among the set of papers used for this review. For instance, Helmi and Masri (2017) identified measurements to mitigate risks at each stage of the Supply Chain Operations Reference (SCOR) (Plan, Source, Make, Delivery). First, they employed the House of Risk Approach (HOA) to identify risks at each stage of the SCOR model. Then, determined the possibility of risk (occurrence) and the impact of risk (severity) using the Failure Mode and Effects Analysis (FMEA). Then, through a sample risk matrix, they mapped the risk. Next, they analyzed the level of risk based on certain standards. Finally, they used some benchmarks to determine the impact of risk. Giannakis and Papadopoulos (2016) developed an analytical process to manage sustainability-related SC risks after exploring the nature and differentiating them from typical SC risks. First, they conducted an extensive literature review and personal interviews across the three pillars of sustainability (environmental, social, and economic) and identified 30 risks. Then, to assess the relative importance of the selected risks, they utilized the Failure Mode and Effects Analysis (FMEA). Data were collected from a broad survey including various industrial sectors. Two exploratory empirical case studies were developed for two textile manufacturing companies. The study revealed that internal environmental risk is the most important type of risk across industries, and that there is high interconnectedness among sustainability-related risks.

Applications of SCRM indices

Several attempts have been made to develop SCRM indices (SCRMI) in various contextual settings. SCRMI can evaluate the company's risk-mitigation level and preparedness for SC risk by considering the risk type and severity. For instance, Raghuram et al. (2020) developed an SCRMI based on a risk mitigation maturity framework for a distillery in southern India. In the methodology, they first conducted an extensive literature review and collected information from experts using questionnaires to identify the risk in that context. They then applied a multi-criteria decision-making approach, including the Order of Magnitude Analytic Hierarchy Process (OM-AHP), to assess and prioritize SC risks. Dong and Cooper (2016) noted that a primary limitation of AHP is that it prioritizes only homogeneous variables, and that the accuracy of pairwise comparisons is lost as the number of variables increases beyond seven. As a solution, Raghuram et al. (2020) applied OM-AHP to compare various risks using a standard pivoting variable. Furthermore, they clustered risks by their impact on information, material, and financial flows (severity and probability). They developed the Capability Maturity Model (CMM) for risk management and identified five primary levels of risk mitigation, and accordingly developed a risk mitigation framework. Based on this framework, they have derived the SCRM index (SCRMI) as given in Equation 1.

$$SCRMI = \sum R_i \times M_i \qquad \text{(Equation 1)}$$

Where Ri – Normalized priority of the particular risk

Mi – Risk mitigation level (always be in the range of 1-5)

Alora and Barua (2022) identify, classify, and prioritize SC risk for the Indian Micro Small and Medium Enterprises (MSME) by developing an SC disruption risk index for manufacturing SC. They identified and finalized risks through an extensive literature review followed by expert interviews. Then they employed an AHP to identify and rank the key SC risks. Next, they employed the Fuzzy Technique for Order of Preference by Similarity to the Ideal Solution (Fuzzy TOPSIS) to develop the SC risk index. Finally, to check the robustness and consistency of the results, they conducted a sensitivity analysis. They listed 26 SC risks under five categories for the MSME. This study was recognized as the first to incorporate financial risk into the development of an SC risk index, highlighting the importance of supply-side and financial-side risks faced by manufacturing SC. A summary table of the steps and methods used to develop risk-mitigation measurements and SCRM indices is presented in Table 2, followed by a critical analysis.

Table 2: Steps and methods used to develop risk mitigation measurements and SCRM indices (summary)

Se. No	Author	Measurement	Steps	Method
1.	Helmi and Masri (2017)	Measurement to mitigate SC risk at each stage of the SC Operations Reference (SCOR) (Plan, Source, Make, Delivery)	To identify risks at each stage of the SCOR model	House of Risk Approach (HOA)
			Determine the possibility of risk (occurrence) and the impact of risk (severity)	Failure Mode and Effects Analysis (FMEA)
			Mapped the risk	Sample risk matrix
			Analyzed the level of risk	Based on some standards
			Determine the impact of risk	Used some benchmarks
2.	Giannakis and Papadopoulos (2016)	Analytical process to manage sustainability-related SC risks	To identify risk	Extensive literature review, Personal interviews
			To assess risk	Failure Mode and Effects Analysis (FMEA)
3.	Raghuram et al. (2020)	SCRMI based on a risk mitigation maturity framework	To identify the risk	Conducted an extensive literature review and collected information from experts using questionnaires
			To assess and prioritize SC risks	Order of Magnitude Analytic Hierarchy Process (OM-AHP)
			by their impact (severity and probability) on information, material, and financial flows	Clustered risks
			for risk management	They developed the Capability Maturity Model (CMM)
4.	Alora and Barua (2022)	SC disruption risk index for identifying, classifying, and prioritizing SC risk	Identified and finalized risks	An extensive literature review followed by expert interviews
			to identify and rank the key SC risks	AHP
			for developing the SC risk index	Fuzzy Technique for Order of Preference
			robustness and consistency of the results, they conducted a	Sensitivity analysis

According to Table 2, despite a few risk mitigation measures being developed, only a single attempt was found to develop the SCRM index. However, no SCRM capability index developed considering all the steps of the SCRM process was found in the review. Further, a comparative analysis of the selected studies reveals several important patterns in supply chain risk measurement. First, there is a clear shift from single-method approaches toward integrated frameworks that combine multiple techniques, such as FMEA, AHP, and fuzzy-based methods, to enhance analytical robustness. Second, while all studies emphasize risk identification through literature review and expert input, they differ significantly in how risks are assessed and prioritized, with earlier studies relying on probability–impact models and more recent ones adopting multi-criteria decision-making approaches. Third, the handling of uncertainty has improved over time, with fuzzy techniques increasingly used to capture the ambiguity inherent in expert judgments. Additionally, the studies vary in their outputs, ranging from operational risk prioritization tools to strategic maturity models and risk indices. However, despite these advancements, the lack of a standardized and universally applicable framework highlights an important gap in literature.

Limitations of extant SCRM measurements

Several limitations of some of the above-mentioned SCRM measurements can be highlighted. For instance, the SCRM index developed by Alora and Barua (2022) was not generalizable to large populations because it was based on a small sample and a single company. Similarly, the SC risk assessment index developed by Kodithuwakku and Wickramarachchi (2014) and Sugathadasa et al. (2021) considered only extra-large-scale apparel manufacturing firms; therefore, it excluded small- and medium-scale firms. Furthermore, the new model proposed by Venkatesh et al. (2015), based on Interpretative Structural Modeling (ISM), may be biased by expert opinions and limited to its industry. Sharma and Bhat (2012) did not consider together the two parameters of risk assessment, the probability of risk and its impact, when developing their risk assessment index.

The summary of the above-mentioned literature on SCRM measurements is presented in Table 3.

Conceptual categorization of SCRM, methods, and applications

The conceptual categorization of SCRM measurement approaches across three dimensions: SCRM stages, methods, and application contexts is given in Figure 1.

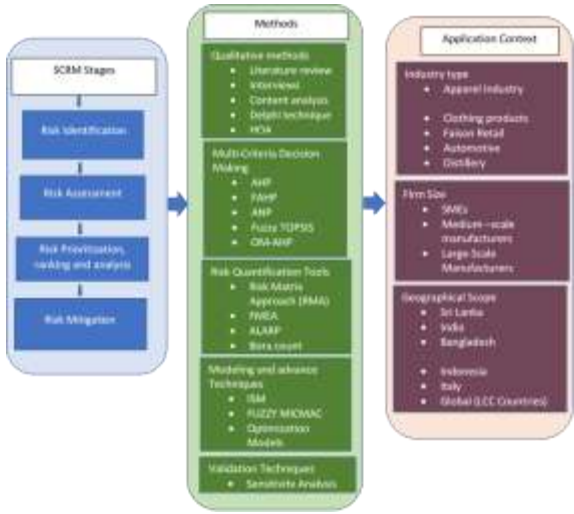

Figure 1: The conceptual categorization of SCRM measurement approaches by SCRM stages, method, and application contexts

As per Figure 1, SCRM measurements used in the current review were developed for one or more SCRM stages (risk identification, risk assessment, risk prioritization, ranking, and analysis). Most studies that developed SCRM measurements focus on the risk identification and assessment stages, with limited attention to risk monitoring. Further, these studies employed dynamic methods, including qualitative methods, multi-criterion decision-making methods, risk quantification tools, modeling and advanced techniques, and validation techniques, to develop SCRM measurements. However, across the reviewed studies, there is a clear shift from traditional qualitative approaches toward hybrid and fuzzy-based multi-criteria decision-making techniques to better capture uncertainty in supply chain risks. Moreover, in terms of application context, the SCRM measurements were developed in dynamic industries and firm sizes in different geographical contexts. Moreover, most studies are concentrated in the apparel industry.

Table 3: Summary table of literature on SCRM Indices

No	Author (s)	Objective	Method		Context	Limitations
1.	Manthirirathna et al. (2019)	To identify and assess SC risk	Risk identification	Semi-structured interviews and content analysis	Medium-scale apparel manufacturing organizations in Sri Lanka	Limited to the medium-scale apparel manufacturers in Sri Lanka
			Risk assessment	RMA		
2.	Sugathadasa et al. (2021).	To identify and assess SC risk	Risk identification	Literature survey (Secondary data)	Large-scale apparel manufacturers in Sri Lanka	Limited to the Large-scale apparel manufacturers in Sri Lanka
			Risk assessment	RMA		
			To identify high, medium, and low-risk regions in the risk matrix	ALARP		
			For risk ranking	Bora count methodology		
3.	Kodithuwakku and Wickramarachchi (2014)	To identify and assess SC risk	Identification of risk drivers	Literature review	Large-scale apparel manufacturers in Sri Lanka	Most of the selected companies did not have a specific SC department/ SC manager
			Risk assessment	RMA		
4.	Mithun Ali et al. (2021)	To identify, analyze, and assess SC disruption factors	Risk identification-	Literature review	The ready-made garment industry in Bangladesh	Conducted as a cross-sectional study
			Prioritizing SC disruption factors and drivers	Delphi method, FAHP		
			Ensure the robustness and viability of the framework in practical settings	Sensitivity analysis		
5.	Helmi and Masri (2017)	To identify, measure, and mitigate SC risk at each stage of SC operations, reference (SCOR)	Identification of SC risk for each SC activity based on SCOR	HOA	SME Clothing Products, Indonesia	Consider only the SME clothing products
			Identify the possibility of risk (occurrence) and its impact (severity)	FMEA		
			Risk mapping	RMA		
			Analyzed the level of risk	Based on some standards		
			Determined the impact of risk	Used some benchmarks		

No	Author (s)	Objective	Method		Context	Limitations
6.	Handfield et al. (2020)	To assess regional supply base risk	To convert data from multiple news feeds into numerical risk scores and visual maps of SC risk.	A machine-based learning algorithm	10 low-cost countries (LCC) in the apparel sector	The lack of a complete and combined approach for considering short-term risks, Reactive risk analysis does not consider
7.	Martino et al. (2017)	To identify and prioritize risks	Risk identification	Deep literature analysis	The Italian Fashion and Apparel Industry	Considered only the fashion and retailed industry
			Risk assessment and prioritization	ANP		
8.	Venkatesh et al. (2015)	To analyze SC risk	To analyze the interdependencies between risks spread across various SC functions	Interpretative Structural Modeling (ISM)	Indian apparel retail industry	The ISM model developed is based on expert opinion, may be biased and limited to a particular industry
			To establish relationships	Delphi technique, followed by the ISM modeling technique, and Fuzzy MICMAC analysis		
9.	Raghuram et al. (2020)	Development of the SCRM Index	Risk identification	An extensive literature review and questionnaire-based information collection	Distillery in the southern part of India	If risk identification and assessment are not properly done, they do not yield the desired results.
			Assess and prioritize risk.	Multi-criteria decision-making approach, including the OM-AHP		
10.	Alora and Barua (2022)	To identify, classify, and prioritize SC risk and develop the SC risk index	Risk identification	An extensive literature review followed by an expert interview	Indian micro, small, and medium enterprises (MSMEs)	The study is limited to the scope of an emerging market, and as a single company case study
			Applied for data analysis	The hybrid methodology consists of an AHP and Fuzzy TOPSIS.		
			Risk ranking	AHP		
			To develop the SC risk index	Fuzzy TOPSIS		
			To check the robustness and consistency of the results	Sensitivity analysis		

No	Author (s)	Objective	Method		Context	Limitations
11.	Shahed et al. (2021)	To develop an optimization model to mitigate the disruption risk	Using two heuristic algorithms: the genetic algorithm (GA) and pattern search (PS). Sensitivity analysis to ensure the applicability of the model in a practical setting.		A manufacturer that has a single supplier and a single retailer in Bangladesh	Only considered a single supplier for a manufacturer
12.	Giannakis and Papadopoulos (2016)	To develop an analytical process to manage sustainability-related SC risk	Risk identification	Through an extensive literature review and personal interviews	Two textile manufacturing companies	The causal relationship between risk factors/ risk categories is not investigated in a systematic way
			To assess the relative importance of the selected risks, to identify their potential causes and effects, and to test potential correlations between the identified risks.	Failure mode and effect analysis (FMEA) technique		
13.	Sharma and Bhat (2012)	To assess SC risk	To identify SC risk	In-depth literature review, experts' opinions	Automotive SC in India	Did not consider the parameters of risk assessment (probability and impact) together
			To assess risk factors	Analytical Hierarchical Process (AHP)		

Source: Developed by a researcher after referring to the literature

Literature gaps identified and future research directions

The above critical review identifies methodological and contextual gaps, as outlined in the sections below.

Firstly, though most of the prior scholars developed SCRM measurements only to identify, assess and prioritize SC risk using different techniques such as RMA (Alora & Barua, 2022; Helmi & Masri, 2017; Manthirirathna et al., 2019; Sugathadasa et al., 2021), Fuzzy TOPSIS (Alora & Barua, 2022), FMEA (Helmi & Masri, 2017), ANP (Martino et al., 2017), Bora count methodology, AHP (Alora & Barua, 2022; Sharma & Bhat, 2012; Sugathadasa et al., 2021), Delphi method, FAHP, fuzzy MICMAC, and OM-AHP (Mithun Ali et al., 2021; Raghuram et al., 2020; Venkatesh et al., 2015), there are scarce attempts to address all or more than two steps of the SCRM process (risk identification, assessment, mitigation, and control) and develop SCRM capability measurements which can evaluate the ability of a particular organization to manage the risk.

Secondly, except for some applications of machine learning algorithms (Handfield et al., 2020), interpretive structural modeling (Venkatesh et al., 2015), and model optimization (Shahed et al., 2021), few studies have developed SCRM measurements using fully quantitative methods. Though there is a clear shift in SCRM measurements from traditional qualitative approaches toward hybrid and fuzzy-based multi-criteria decision-making techniques to better capture uncertainty in SC risks, there is a lack of a standardized, universally applicable framework, highlighting an important gap in the literature. This paved the path for future researchers to develop integrative SCRM frameworks/ measurements that balance accuracy, usability, and context-specific applicability.

Thirdly, most SCRM indices are developed for a single organization and rely on company-specific confidential data (Alora & Barua, 2022; Mariano et al., 2017; Venkatesh et al., 2015). Hence, there is a clear gap in the literature: the absence of an objective SCRM measurement scale to evaluate an organization's SCRM capability without using any company-specific confidential data.

Fourthly, the COVID-19 pandemic has had a significant negative impact on global SCs. Hence, in the post-pandemic era, there is a tendency towards researching SCRM measurements by incorporating SC analytics (e.g., AI, Big Data analysis, machine learning algorithms). However, as per this review, although past scholars have developed dynamic SCRM measurements, there are few attempts to integrate data analytics (Handfield et al., 2020; Venkatesh et al., 2015) to develop SCRM capability measurements, thereby opening a new avenue for future researchers.

Fifthly, the composite index is a widely used approach to index development. Hence, in this information era, with the availability of data-driven decision-making tools in most organizations, the development of a composite index integrating SC analytics to measure SCRM capability would be significant but has largely been ignored in the extant SC literature, thereby opening avenues for novel knowledge generation.

Next, although scholars have developed dynamic SCRM measurements in empirical settings, contextual gaps remain, as the review's findings indicate. For instance, the SCRM measurements were developed considering a particular industry in the manufacturing sector, such as readymade garment industry in Bangladesh (Mithun Ali et al., 2021),apparel manufacturing industry in Sri Lanka and India (Manthirirathna et al., 2019b; Sugathadasa et al., 2021; Venkatesh et al., 2015), SME clothing products in Indonesia (Helmi & Masri, 2017), the Italian fashion and apparel industry (Martino et al., 2017), (further refer to Table 3), there are scare studies to validate exact measurements using some other industries with similar features. Moreover, most studies focus on the apparel industry, indicating a lack of diversity across other industrial sectors.

Finally, a common limitation of these studies is insufficient sample sizes. Therefore, it is strongly recommended that future researchers draw large samples to improve the robustness of the indices that they develop.

CONCLUSIONS

This paper provides a comprehensive review of the existing methods and strategies used in prior studies to develop SCRM measurements. It identifies limitations and outlines broad research gaps that explore important future directions listed below:

• There have not been sufficient attempts to develop SCRM measurements that encompass all steps of the SCRM process.

• There is a lack of a standardized, universally applicable framework/measurement for SCRM that balances accuracy, usability, and context-specific applicability

• Absence of a common SCRM measurement scale for evaluating each organization's SCRM capability without using company-specific confidential data.

• It was largely ignored when developing SC analytics-integrated SCRM capability measurements, including a composite index.

• There is a lack of studies that develop SCRM indices using large samples to ensure robustness.

• Most studies focus on the apparel industry, indicating a lack of diversity across other industrial sectors.

Besides showing and analytically discussing the available methods and strategies (both qualitative and quantitative) of SCRM measurements, and identifying the research gaps, the underlying review conceptually categorized the SCRM, methods, and applications within the risk management literature as the review novelty.

However, the main limitation of this review is that it relied on a few databases using predefined search strings and limited time horizons. This may limit the breadth of the search and potentially omit some sources of information.

REFERENCES

Alora, A., & Barua, M. K. (2022). Development of a supply chain risk index for manufacturing supply chains. International Journal of Productivity and Performance Management, 71(2), 477-503. https://doi.org/10.1108/IJPPM-11-2018-0422

Christopher, M., & Lee, H. (2004). Mitigating supply chain risk through improved confidence. International Journal of Physical Distribution & Logistics Management, 34(5), 388-396. https://doi.org/10.1108/09600030410545436

Dong, Q., & Cooper, O. (2016). An orders-of-magnitude AHP supply chain risk assessment framework. International Journal of Production Economics, 182, 144-156. https://doi.org/https://doi.org/10.1016/j.ijpe.2016.08.021

El Baz, J., & Ruel, S. (2021). Can supply chain risk management practices mitigate the disruption impacts on supply chains' resilience an Evidence from an empirical survey in a COVID-19 outbreak era. International Journal of Production Economics, 233, 107972. https://doi.org/10.1016/j.ijpe.2020.107972

Giannakis, M., & Papadopoulos, T. (2016). Supply chain sustainability: A risk management approach. International Journal of Production Economics, 171, 455-470. https://doi.org/https://doi.org/10.1016/j.ijpe.2015.06.032

Handfield, R., Sun, H., & Rothenberg, L. (2020). Assessing supply chain risk for apparel production in low cost countries using newsfeed analysis. Supply Chain Management: An International Journal, 25(6), 803-821. https://doi.org/10.1108/SCM-11-2019-0423

Helmi, M. N., & Masri, M. N. (2017). Risk mapping and mitigation design of small and medium enterprises clothing products using supply chain risk management. IOP Conference Series: Materials Science and Engineering, 277(1), 012061. https://doi.org/10.1088/1757-899X/277/1/012061

Ivanov, D., & Dolgui, A. (2020). A digital supply chain twin for managing the disruption risks and resilience in the era of Industry 4.0. Production Planning & Control, 32(9), 775-788. https://doi.org/10.1080/09537287.2020.1768450

Kleindorfer, P. R., & Saad, G. H. (2005). Managing Disruption Risks in Supply Chains [https://doi.org/10.1111/j.1937-5956.2005.tb00009.x]. Production and Operations Management, 14(1), 53-68. https://doi.org/https://doi.org/10.1111/j.1937-5956.2005.tb00009.x

Kodithuwakku, C., & Wickramarachchi, D. N. (2014). Identifying the risk dynamics of supply chain operations in large scale apparel industry in Sri Lanka. International Journal of Innovation, Management and Technology, 6(4), 272-277.

Liu, L., Li, S., & Wu, Y. (2014). Supply chain risk management in Chinese chemical industry based on Stochastic Chance-Constrained Programming Model. Applied Mathematics & Information Sciences, 8(3), 1201.

Manthirirathna, M. A. K. S., Rajini, D., & Mahendrarajah, G. (2019). Supply Chain Risk Assessment for Sri Lankan Apparel Manufacturing Organisations. 8th International Conference on Management and Economics – 2019, University of Ruhuna, Sri Lanka.

Mariano, E. B., Gobbo, J. A., Camioto, F. d. C., & Rebelatto, D. A. d. N. (2017). CO2 emissions and logistics performance: a composite index proposal. Journal of Cleaner Production, 163, 166-178. https://doi.org/https://doi.org/10.1016/j.jclepro.2016.05.084

Markowski, A., & Mannan, M. S. (2008). Fuzzy risk matrix. Journal of hazardous materials, 159, 152-157. https://doi.org/10.1016/j.jhazmat.2008.03.055

Martino, G., Fera, M., Iannone, R., & Miranda, S. (2017). Supply chain risk assessment in the fashion retail industry: An analytic network process approach. International Journal of Applied Engineering Research, 12, 140-154.

Mithun Ali, S., Kumar Paul, S., Chowdhury, P., Agarwal, R., Fathollahi-Fard, A. M., Jose Chiappetta Jabbour, C., & Luthra, S. (2021). Modelling of supply chain disruption analytics using an integrated approach: An emerging economy example. Expert Systems with Applications, 173, 114690. https://doi.org/10.1016/j.eswa.2021.114690

Ni, H., Chen, A., & Chen, N. (2010). Some extensions on risk matrix approach. Safety Science - SAF SCI, 48, 1269-1278. https://doi.org/10.1016/j.ssci.2010.04.005

Ozdemir, D., Sharma, M., Dhir, A., & Daim, T. (2022). Supply chain resilience during the COVID-19 pandemic. Technology in Society, 68, 101847. https://doi.org/https://doi.org/10.1016/j.techsoc.2021.101847

Raghuram, P., Sandeep, P., Sreedharan, V. R., & Saikouk, T. (2020). Development of a supply chain risk mitigation index for distillery. The TQM Journal, 33(3), 618-639. https://doi.org/10.1108/tqm-01-2020-0008

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

https://doi.org/10.1108/01443570710725563

Saghafian, S., & Van Oyen, M. (2011). The Value of Flexible Backup Suppliers and Disruption Risk Information: Newsvendor Analysis with Recourse. IIE Transactions, 44. https://doi.org/10.2139/ssrn.1323534

Shahed, K. S., Azeem, A., Ali, S. M., & Moktadir, M. A. (2021). A supply chain disruption risk mitigation model to manage COVID-19 pandemic risk. Environ Sci Pollut Res Int, 1-16. https://doi.org/10.1007/s11356-020-12289-4

Sharma, S., & Bhat, A. (2012). Identification and assessment of supply chain risk: Development of AHP model for supply chain risk prioritisation. Int. J. of Agile Systems and Management, 5, 350-369. https://doi.org/10.1504/IJASM.2012.050155

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. https://doi.org/10.1111/j.1937-5956.2011.01251.x

Sugathadasa, P. T. R. S., Senadheera, S. W., & A., T. (2021). Study of Supply Chain Risk Factors of the Large- Scale Apparel Manufacturing Companies –Sri Lanka. Engineer: Journal of the Institution of Engineers, Sri Lanka,, 54(3), 49-58. https://doi.org/http://doi.org/10.4038/engineer.v54i3.7459

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

Venkatesh, V. G., Rathi, S., & Patwa, S. (2015). Analysis on supply chain risks in Indian apparel retail chains and proposal of risk prioritization model using Interpretive structural modeling. Journal of Retailing and Consumer Services, 26, 153-167. https://doi.org/10.1016/j.jretconser.2015.06.001