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**Supply Chain Risks for SMEs in Construction Projects: A
Structured Literature Review and Research Agenda**

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Research Method:	Literature review
Geography:	Europe

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Supply Chain Risks for SMEs in Construction Projects: A Structured Literature Review and Research Agenda

Abstract:

Purpose: Whilst there has been much research examining risk management in construction supply chains, there is a relative dearth of knowledge concerning Small and Medium-sized Enterprises (SMEs) in this context. SMEs are considered vulnerable economic agents due to their financial constraints and reduced viability compared to large firms. This study aims to fill this gap by providing a comprehensive review, identifying key challenges in the research, and generating a future research agenda.

Design/methodology/approach: A structured literature review was conducted in this study, resulting in the identification of 106 articles that relate to construction SME risks. Thematic analysis was then employed to determine the supply chain risk themes. Additionally, VOSviewer was employed to depict content frequency and most recently trends based on the timeline.

Findings: This paper uncovers eight distinct supply chain risk pertinent to construction SMEs, arranging these into three themes from the standpoint of supply chain risk management. Moreover, it identifies six gaps in the existing body of research on construction SMEs and puts forth prospective research directions and questions to address each of these identified gaps.

Originality/value: The practical significance of this study is to provide SMEs in the construction industry with a comprehensive framework for identifying and categorising risks related to management and strategy, operations and processes, and sustainability. With this framework, SMEs can systematically assess potential risks at all stages of a project.

Keywords: Supply chain risk; Construction; SMEs; Supply chain risk management; Thematic analysis

1. Introduction

While the construction sector makes a significant contribution to economic wellbeing, it faces many challenges such as labour shortages, fluctuating material costs, and environmental issues (Harris et al. 2021). For example, delays in the delivery of critical materials can lead to project delays, increased costs, and time constraints. These issues, in turn, affect the deployment of subsequent projects and may even lead to project failure and company bankruptcy. According to The Insolvency Service (2023), the UK construction sector experienced 4,262 bankruptcies in the 12 months up to Q2 2023, accounting for 18 percent of industrial cases. Therefore, effective management of these challenges is crucial.

Construction refers to industrial activity associated with the built environment: buildings, structures, infrastructure; and their production, repair, renovation, and maintenance (Hussain et al. 2022). A construction project encompasses multiple phases: conceptualization, design, construction, maintenance, replacement, and decommissioning, with risks present throughout each phase (Taroun 2014; Dubois et al. 2019). Given its intricate supply chain system and extensive integration, the construction industry is vulnerable to numerous potential risks (Manuj and Mentzer 2008). Supply chain risk management involves applying risk management techniques, either individually or in collaboration with supply chain partners, to address uncertainties and risks stemming from supply chain activities and resources (Gurtu and Johny 2021).

To date, research on supply chain risk management in the construction sector has predominantly centred, either explicitly or implicitly, on large companies, often with an international presence (Soinio et al. 2012; Cataldo et al. 2022). SMEs in the construction industry are defined in this study as focal companies with fewer than 250 employees, often playing the role of contractors or subcontractors in the supply chain. These companies are

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3 often susceptible to adverse risk events due to their constrained financial resources and a
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5 general absence of strategic management (Hemilä and Vilko 2015). Often, the shortage of
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7 financial resources creates procurement uncertainty and logistical risks for construction SMEs.
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10 Additionally, due to financial constraints, they are less likely to be early adopters of new
11
12 technologies or processes. Moreover, this lack of strategic focus is evident in sustainable
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14 development, as SMEs prioritise current projects and often neglect the planning of
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16 subsequent projects (Verboven and Vanherck 2016). Effective supply chain risk management
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18 can enhance a company's ability to control its capital and increase its resilience, enabling
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20 better performance when risks emerge (Schlegel and Trent 2014).
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26 In reviews on construction supply chain risk management, scholars tend to focus on risk
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28 identification and categorisation within the general construction industry (Shojaei and Haeri
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30 2019). However, such reviews tend to overlook the specifics of SMEs in areas such as safety,
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32 technology, and strategy in practice (Kamal and Flanagan 2014). Liao et al. (2023) found that
33
34 construction supply chain resilience plays an important role in ensuring the stability of the
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36 construction supply chain in uncertain environments by quantitatively analysing 465 related
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38 articles. Their study focused more on methodological aspects and did not break down the risk
39
40 factors in the construction industry. Aloini et al. (2012) investigates the risk factors affecting
41
42 the implementation of supply chain management principles but does not fully consider all
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44 aspects of supply chain management such as new technology and safety perspectives. Work
45
46 by Pham et al. (2022) has conducted an extensive review of construction supply chain risk, but
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48 do not fully address SMEs. Also, Fan and Stevenson (2018) reviewed supply chain risk
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50 management but does not specifically address its application in the construction sector.
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52 Hence, there is a pressing need for both conceptual and empirical research in this complex
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54 and under-explored area. Comprehensive studies are crucial to facilitate a swift and thorough
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3 recovery and to return the field to its desired state of understanding and efficiency (Naim and
4
5 Gosling 2023).
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10 The objective of this paper is to examine the current state of research on supply chain risk in
11
12 construction SMEs and to highlight the remaining gaps in this area. The lack of supply chain
13
14 risk awareness in construction SMEs impacts not only their competitive innovation, but also
15
16 contributes to the economic instability of the construction industry as a whole (Lenny Koh et
17
18 al. 2007). Since SMEs are present in all parts of the construction supply chain alongside larger
19
20 organisations, this deficiency can lead to frequent supply and sourcing problems, resulting in
21
22 passivity in the marketplace. For the construction industry, widespread bankruptcy among
23
24 SMEs can precipitate an overall economic downturn and increase disruptions (The OECD
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26 Structural and Demographic Business Statistics 2024). To address these challenges, this paper
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28 proposes two research questions:
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32 RQ1: What supply chain risks do construction SMEs face in the context of construction
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34 projects?
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37 RQ2: What are the current gaps in research concerning supply chain risk management for
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39 construction SMEs in the context of construction projects?
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42
43 This paper systematically explores the risks faced by construction SMEs in the supply chain
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45 and summarises the specific forms of supply chain risk unique to these firms. We focus
46
47 exclusively on construction SMEs and do not consider upstream suppliers or downstream
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49 customers, which may serve many different markets. Additionally, the contribution of this
50
51 study is that it is the first literature review to focus exclusively on the management and
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53 strategy, operations and processes, and sustainability perspectives of SMEs in the
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55 construction industry. The structure of this paper is as follows: Section 2 provides the reader
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57 with background information about the characteristics of construction SMEs. Section 3
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demonstrates the research design, including the structured literature review process and thematic analysis. Section 4 presents the results and discussion. Section 5 suggests a future research agenda based on the findings. Section 6 concludes the paper and discusses its limitations.

2. Characteristics of construction SMEs

SMEs in the construction industry account for a significant proportion of the overall number of businesses. In the UK in 2021, SMEs accounted for 99.69 percent of construction businesses, a situation similar to that in Europe (OECD 2023). The definitions and sizes of SMEs across various countries are detailed in Table I. There are two primary methods to categorize SMEs: firstly, the European Commission's definition based mainly on numerical limits (Muller et al. 2015). The second method is the U.S.' adoption of the North American Industry Classification System (NAICS). This system provides guidelines for small businesses across industries and facilitates their applications for government contracts and funding (US Census Bureau 2022). Notably, both classifications tailor the SME definitions to determine eligibility for governmental support, grants, and tax incentives (Kumar and Singh 2023). Considering the varied scales of SMEs and aiming to encompass as many as possible, this study adopts a position that an SME has fewer than 300 employees and/or a turnover of less than \$45m.

Table I: Comparison of SMEs in Different Countries (US Census Muller et al. 2015; National Bureau of Statistics of China 2017; Bureau 2022)

Country	Scale	Definition
USA	For construction small business, usually have less \$45 million dollar earnings.	Defined by ownership structure, number of employees, earnings, and industry.
EU	Micro businesses: <10 employees Small businesses: <50 employees	Defined by Staff headcount, Turnover or Balance sheet total

Country	Scale	Definition
	Medium businesses: <250 employees	
China	SMEs businesses: <300 employees or < £111 million revenue	Defined by revenue, number of employees, or total assets.
Developing Countries	Countries have their own scale based the staff number or earnings	Defined by scale or structure.

Many literatures offer diverse interpretations on the distinct characteristics of construction SMEs. To bridge this gap, this paper organizes these characteristics, based on existing literature, into Table II. By comparing the differences between SMEs and large-scale construction enterprises, this study aims to illuminate the distinct nuances of SMEs.

Table II: Characteristics of Construction SMEs compared to large Construction Enterprises
adapted from (Kheni et al. 2008; Bak et al. 2023)

Characteristics	Construction SMEs	Large Construction Enterprises
Organizational Structure	Generally simpler, fewer hierarchies	Typically, more complex, with clear hierarchies
Product Line	May be limited, focusing on certain types of projects	Diversified, covering a variety of projects
Geographical Presence	Typically operate within a local or regional scope	Operate across multiple regions, nationwide or even globally
Ownership	Likely to be private, family-owned, or partnership-based	Possibly publicly listed, with diversified equity structures
Position in the Supply Chain	Likely to be a smaller link in the supply chain	Likely to be a major or key link in the supply chain
Operational Flexibility	High, due to smaller size and less bureaucracy.	Lower, due to larger size and more complex decision-making processes.
Risk Management	May have less formal risk management strategies.	Likely to have formalized risk management strategies in place.

Information resources	Single, often from other company	Multiple, from government or their own sources
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Supply chain management systems were incorporated into the construction sector aiming to enhance the overall efficiency of the supply chain and foster better collaboration between the upstream and downstream parts of the chain (Khan and Burnes 2007; Gadde and Dubois 2010). While there is growing recognition for the important role of supply chain management within the construction sector, certain aspects might not fully align with SMEs. The cost of implementing a management system and the lack of labour resources are major reasons for the reluctance of construction SMEs to adopt a supply chain management system (Vaaland and Heide 2007). Additionally, the lack of flexibility due to the generic design of supply chain management systems further prevents many construction SMEs from adopting such systems. Finally, barriers to the implementation of supply chain management in SMEs also include a lack of understanding of supply chain management theories (Thakkar et al. 2008).

This paper explores risks for construction SMEs from multiple perspectives: management and strategy, operation and process, and sustainability. These perspectives were selected due to their significant impact on the construction industry literature (Klewitz and Hansen 2014). Specifically, management and strategy involve resource allocation within the organisation, operations and processes, ensure efficient daily operations, and sustainability addresses current market and demands for advanced technology and environmental care. We acknowledge that many of these perspectives overlap and interact, however this broad delimitation is useful in helping to structure our exploration of construction SMEs.

From a management and strategy perspective, construction SMEs are more vulnerable to risk due to their limited resources and lack of strategic management (Hasan et al. 2021).

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2
3 Management frameworks used by large companies are frequently not suited for SMEs, given
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5 their constrained management skills (Pereira et al. 2015). Workers at SMEs often take on
6
7 multiple roles, which may limit their ability to conduct thorough risk management analyses
8
9 (van de Vrande et al. 2009); in many SMEs, a single individual often manages and owns the
10
11 company (Britzelmaier et al. 2015). This might lead to weak risk management or even strategic
12
13 risks. Empirical evidence shows that 50% of SMEs fail before their fifth year of existence
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15 (Crovini et al. 2021). These studies underscore the necessity for management systems that
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17 holistically manage supply chain risks within construction SMEs.
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23 SMEs in the construction industry, often crucial subcontractors in the building process, face
24
25 unique operational challenges (Björnfot and Torjussen 2012). Financial constraints, largely
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27 due to reliance on limited funding sources such as banks or personal networks, frequently
28
29 restrict their operational flexibility (Kamal and Flanagan 2014). Fundamentally, SMEs can
30
31 seldom leverage the financial opportunities that are available to larger companies. This
32
33 financial bottleneck can impede the adoption of new technologies and slow the response to
34
35 technological advancements in the sector. Beyond technology, funding constraints
36
37 significantly impact day-to-day operations, project bidding, and long-term strategic planning
38
39 (Cooke and Williams 2013). Impacts on day-to-day operations include overstretched leasing
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41 of project equipment and personnel hiring. In project bidding, financial constraints can lead
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43 to cash flow pressures and competitive pricing challenges, which may hinder project wins and
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45 subsequently affect long-term strategic planning. Whilst there are challenges that may not be
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47 felt by larger organisations, other SMEs are less well equipped to absorb such difficulties.
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51 Recent studies have highlighted the necessity of robust operational risk processes within
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53 these enterprises. For example Hsu et al. (2019) introduced a mathematical model that
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55 outperforms traditional methods in designing risk-averse logistics for modular construction
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3 projects. Yet, such research typically focuses on common risks, leaving a gap in understanding
4
5 the nuances of more complex or interrelated risks that SMEs might encounter.
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10 From a technology and environmental perspective, SME growth can be inhibited by strict
11 regulations or the advent of emerging technologies (Rezazadeh 2017). For instance,
12 technology risks include requirements for new technology, skills, and staff. Without proper
13 adoption of new technology, this could lead to decreased supply or challenges in coordinating
14 with other companies. The introduction of advanced technologies, such as blockchain,
15 prefabricated construction, and innovations from Industry 4.0 (e.g. 3D printing), presents
16 significant sustainability challenges for SMEs (Mansour et al. 2021; Kayikci et al. 2022; Lu et
17 al. 2023). A well-known case is an apartment building in Germany, designed and constructed
18 using 3D printers (Youssef and Abbas 2023). Due to the high technical standards of 3D printing,
19 finding workers skilled in both 3D printing and construction is a major challenge for
20 construction SMEs, which tend to favour larger construction companies. The specific nature
21 of this work tends to attract skilled workers to larger companies. Additionally, it is well known
22 that many 3D printing workflows differ significantly from traditional construction processes
23 (Johns et al. 2024), which smaller organisations may struggle with.
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43 Environmental risks and technological innovations are important for supply chain
44 sustainability, impacting corporate strategic planning, operational efficiency, and
45 environmental and social impacts. Specifically, supply chains are vulnerable to natural
46 disasters, theft, extreme weather, cyber-attacks, and unexpected quality issues, which can
47 lead to delays in raw material delivery and schedule delays (Hasan et al. 2021).
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56 These recent studies demonstrate the ongoing efforts to optimize risk management processes
57 for construction SMEs, as well as the potential for new techniques and approaches to improve
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3 supply chain risk management in this context. However, the existing literature on supply chain
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5 risk within construction SMEs is not only scant but also fragmented. As discussed in this
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7 section, the characteristics of construction SMEs are quite different from those of larger
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9 construction company, and consequently, their sources of supply chain risk differ as well.
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12 Therefore, there is a need to consolidate the disparate supply chain risks encountered by
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14 construction SMEs to establish a foundation for future risk management research in this area.
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19 **3. Research design**

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21 Given the dispersed and multidisciplinary nature of the existing literature pertaining to supply
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23 chain risks in construction SMEs, a structured literature review was employed as an effective
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25 means to consolidate and summarise these diverse sources of information. This paper
26
27 employs the procedures of Burgess et al. (2006), Seuring and Müller (2008), and Farooque et
28
29 al. (2019) to inform the structured review process. Figure 1 illustrates the main process of the
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31 structured literature review. Database searches were conducted to find all relevant literature
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33 from 2005 through to November 2023. This period was selected due to an emergence in
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35 relevant publications, reflecting heightened interest from both academia and industry
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37 (Briscoe and Dainty 2005). Additionally, the emerging technologies such as BIM and the rapid
38
39 development of the construction industry have profoundly impacted traditional supply chain
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41 management models, making research during this period of great practical significance and
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43 application value (Howell and Batcheler 2005).
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50 We first conducted a pilot study using keyword searches on Google Scholar, Scopus, Science
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52 Direct and Emerald databases. We chose these as they contain multidisciplinary research from
53
54 around the world, including various types of articles. [As the focus of our study is construction](#)
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56 [SMEs, the pilot study also reviewed SME-related journals and identified a noticeable lack of](#)
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58 [risk assessment mechanisms in the existing literature. Current research on construction SMEs](#)
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3 primarily focuses on business performance and related risks (e.g. Booltink and Saka-
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5 Helmhout 2018; Eze et al. 2020), which differs from the focus of this study. Our exploration of
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7 different databases and the use of multiple keyword combinations helped us gain a deeper
8
9 understanding of this subject area. This helped us further understand the subject area, though
10
11 did highlight that there was i) significant variation in research quality, ii) an extremely large
12
13 number of potential studies to consider, but with iii) mostly irrelevant studies returned in our
14
15 results. To conduct a useful, relevant, and focused review we therefore followed the
16
17 procedure prescribed by Gosling and Naim (2009), who demonstrated how the Chartered
18
19 Association of Business School's Academic Journal Guide (AJG) may be used as a proxy for
20
21 quality and integrity of the screening process. The AJG's ratings are based on the judgments
22
23 of peer reviewers, editors, and experts who evaluate hundreds of publications regarding
24
25 citation-related statistics from the Association of Business Schools list (ABS 2021). Journals are
26
27 ranked according to a five-point scoring system, where 4* is the highest and 0 is the
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29 unclassified.
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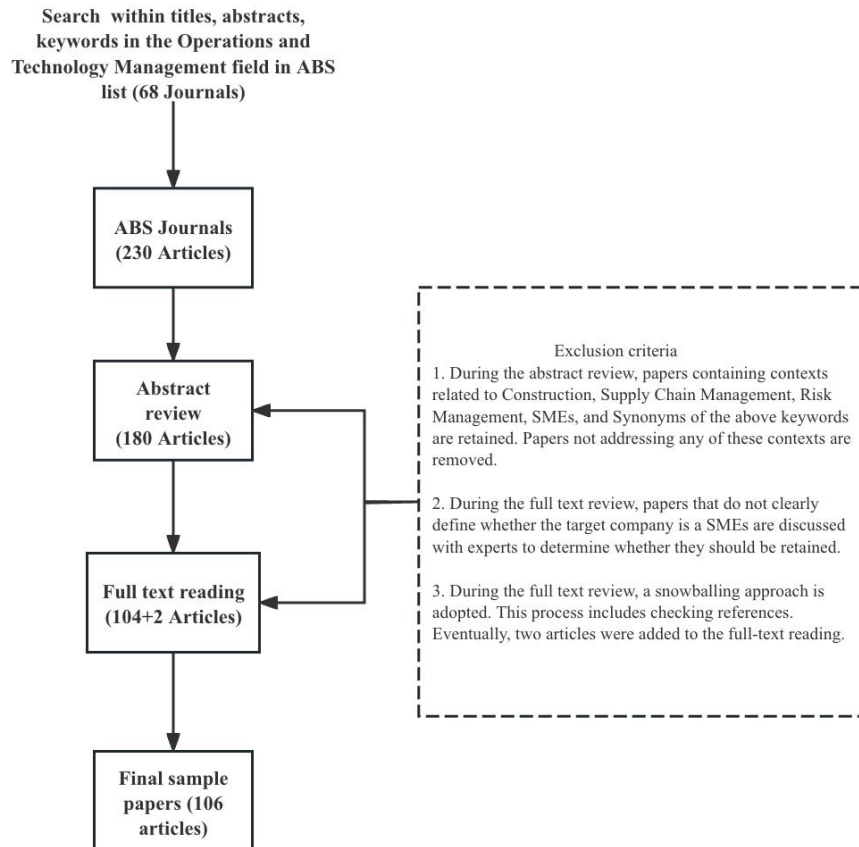


Figure 1: Structured literature review process.

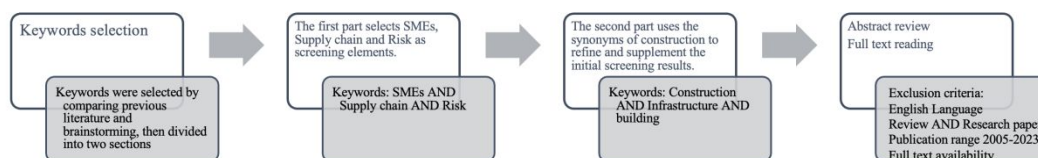


Figure 2: Keywords selection process

3.1 Screening the articles

The screening process commenced with conducting keyword searches across 68 journals listed under the Operations and Technology Management field in the ABS list. After obtaining search results from each journal, the articles were reviewed to determine whether they met

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3 the inclusion criteria for the study. Out of the initial pool of 1,142 articles, 230 were deemed
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5 relevant for this study.
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10 In the second screening process, the abstract and conclusion of the articles were checked to
11
12 identify those that proposed potential supply chain risks for construction SMEs. Ultimately,
13
14 106 articles were included in the paper list. This is because many papers did not explicitly
15
16 mention SMEs, or their research content did not align with the supply chain risks faced by
17
18 SMEs in the construction industry.
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23 **3.2 Synthesis of the articles**

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25 This study uses thematic analysis to classify codes and create themes. For a systematic coding
26
27 and generation of themes within the literature, we employed the NVivo 12 software tool. All
28
29 106 articles were imported into the tool, and codes were inductively developed. Based on a
30
31 comprehensive understanding of the article, initial codes were generated to outline the risks.
32
33 These codes were then categorised based on their attributes and shared characteristics. As
34
35 shown in figure 3, collaboration risks, contractual risks, strategy risks, and stakeholder risks
36
37 fall under the management and strategy themes due to their relation to management
38
39 concepts. Implementation risk and safety Risk occur during operations, categorised under the
40
41 operations and process theme. Technology risks and environmental risks impact
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43 organisational sustainability and are classified under the sustainability theme. The lead
44
45 authors reviewed, defined, and generated the SME supply chain risk report for these themes.
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47 These themes are ultimately reflected in the SME's supply chain risk report.
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54 During the thematic analysis, the authors iteratively reviewed and discussed the coding
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56 framework during fortnightly progress meetings. The authors shared their interpretations and
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58 collaboratively decided on the inclusion and exclusion of specific codes and themes, ultimately
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3 reaching a consensus to ensure a consistent and comprehensive approach to data analysis.

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5 Utilising the six-step process of thematic analysis, this study was able to identify eight
6
7 significant supply chain risks within the three themes encountered by SMEs in the
8
9 construction industry, which are discussed in detail in the results section. It is notable that the
10
11 identified themes and codes in phase 6 are relevant to the construction industry in general,
12
13 affecting firms both large and small. In our analysis of the literature we focus specifically on
14
15 how SMEs are affected, allowing the development of a clear understanding of the specific
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17 challenges faced by these organizations.
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23 This approach has been used by other researchers in the field of supply chain management
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25 (Gosling and Naim 2009; Aloini et al. 2012; Pham et al. 2022) and is effective in highlighting
26
27 the key research areas and summarising knowledge topic. In addition to thematic analysis,
28
29 descriptive analysis has been adopted in the research. The advantage of this approach is that
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31 it reveals recent publication trends among scholars, geographical distribution of research, and
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33 popular research methods and strategies used in the field of supply chain research (Ansari and
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35 Kant 2017). Moreover, the three themes identified in this study align with the latest research
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37 trends, and few studies have comprehensively reviewed these themes in the literature. In the
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39 section 4, we present each of these three categories in detail.
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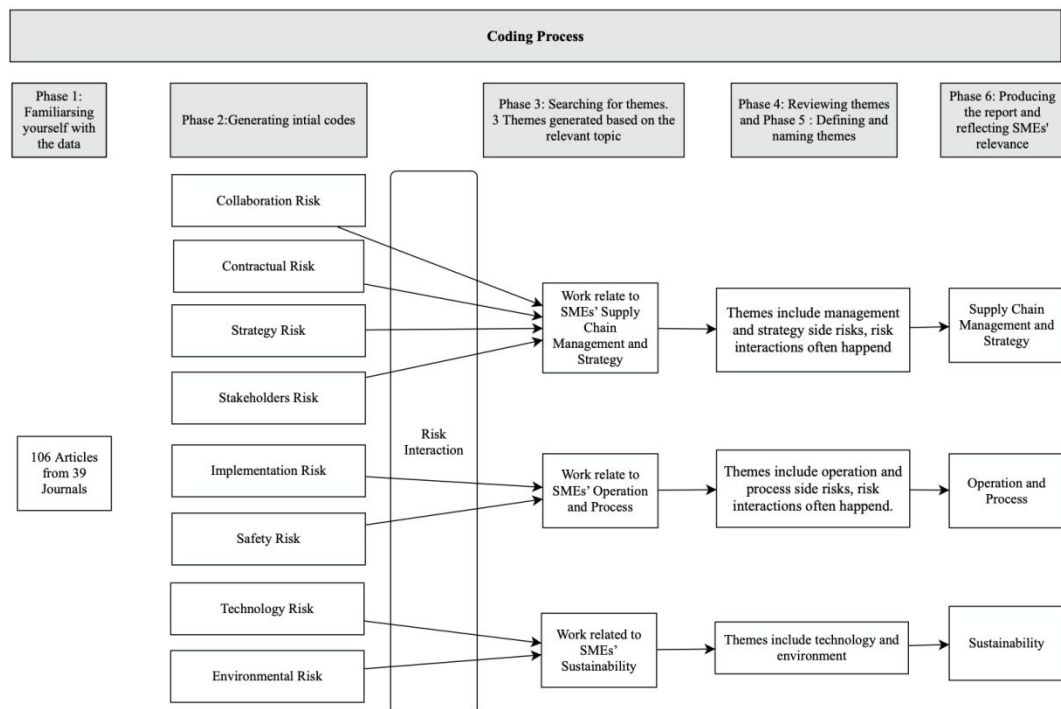


Figure 3: Coding process

4. Results and discussion

In this section, we commence with a descriptive analysis of the literature, which includes a synthesis organized by year of publication, region, type, and methodology. Subsequently, in section 4.2, we explore the eight risks associated with the three identified themes. Section 4.3 summarises and presents the literature on the risks associated with these themes.

4.1 Descriptive analysis

The following content is divided into two parts. The first part discusses the collected articles from the year, region, and content. This exploration aims to chronical the evolution of the research topic, and provide current themes of interest in the field, and highlight potential trends for future research. In the second part, the research types and methods are discussed. Figure 4 shows the statistical results of the number of papers directly related to supply chain risk management that were published from 2005 to November 2023. These results indicate that there has been an increase in construction supply chain risk management research.

Notably, supply chain construction management related papers have increased most significantly since 2016. Figure 5 reflects the number of papers published by country, most academic papers have been published in the UK, China, USA, and Australia.

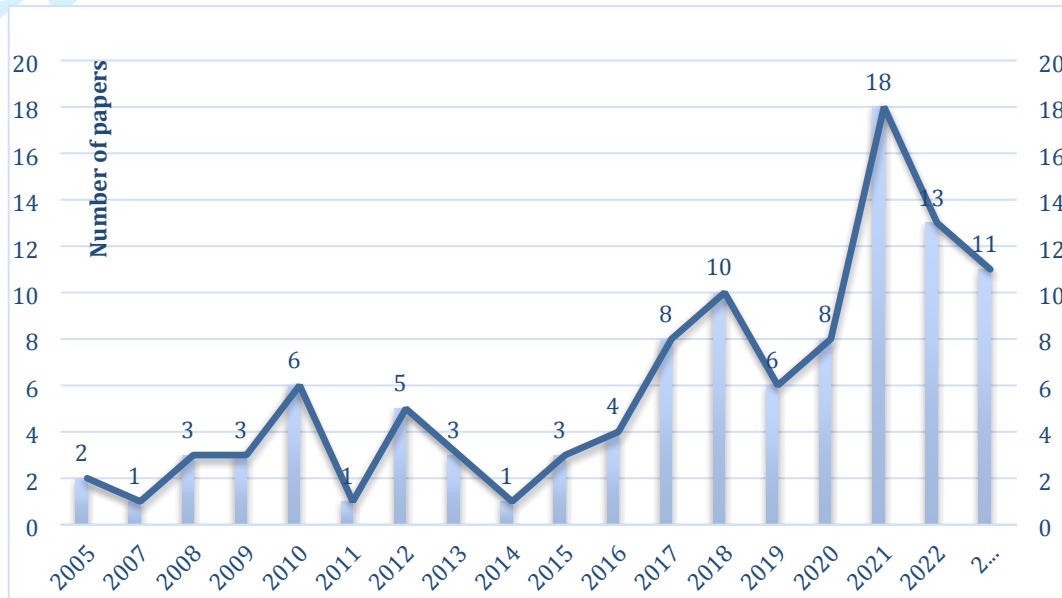


Figure 4: Year of publication

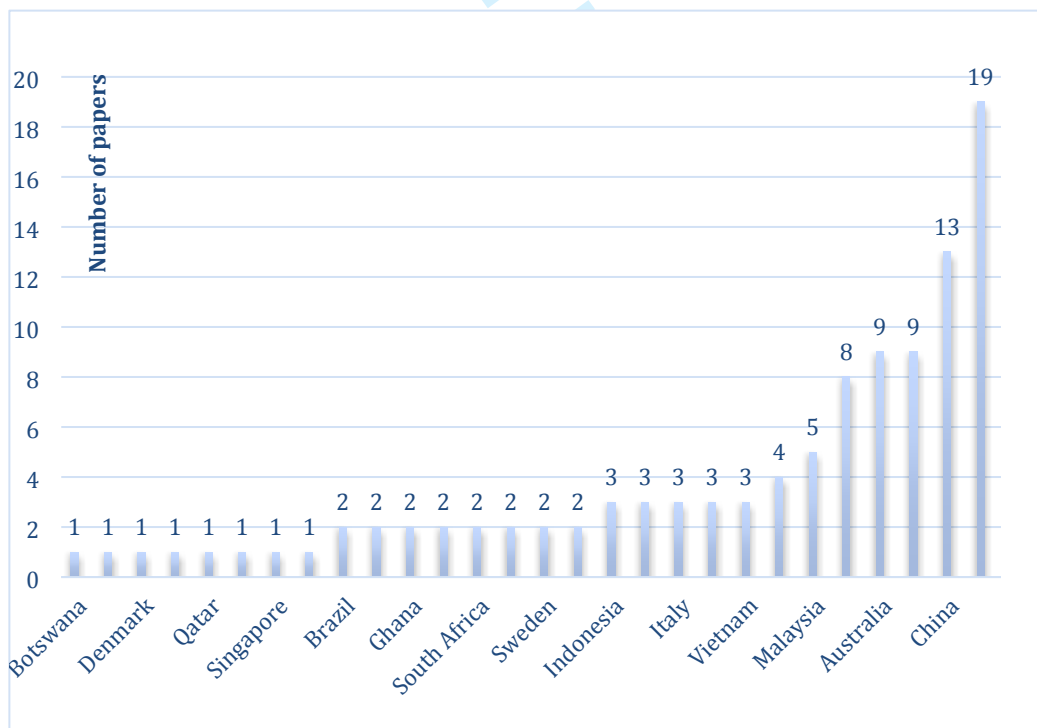


Figure 5: Distribution for selected articles by country.

Figure 6 and Figure 7 show the research methods employed in the focal studies, presented cumulatively. From the results provided in Figure 6 indicate that most of the current studies related to supply chain risks of construction SMEs are empirical research. From 2005 to November 2023, the number of conceptual papers and articles combining empirical and conceptual methods increased steadily and slowly. This suggests that scholars have not abandoned theory development in pursuit of empirical research. Continuous developments in science and technology, and the changing environment, such as the technological innovations brought about by Industry 4.0, create a multitude of opportunities and challenges for theoretical research.

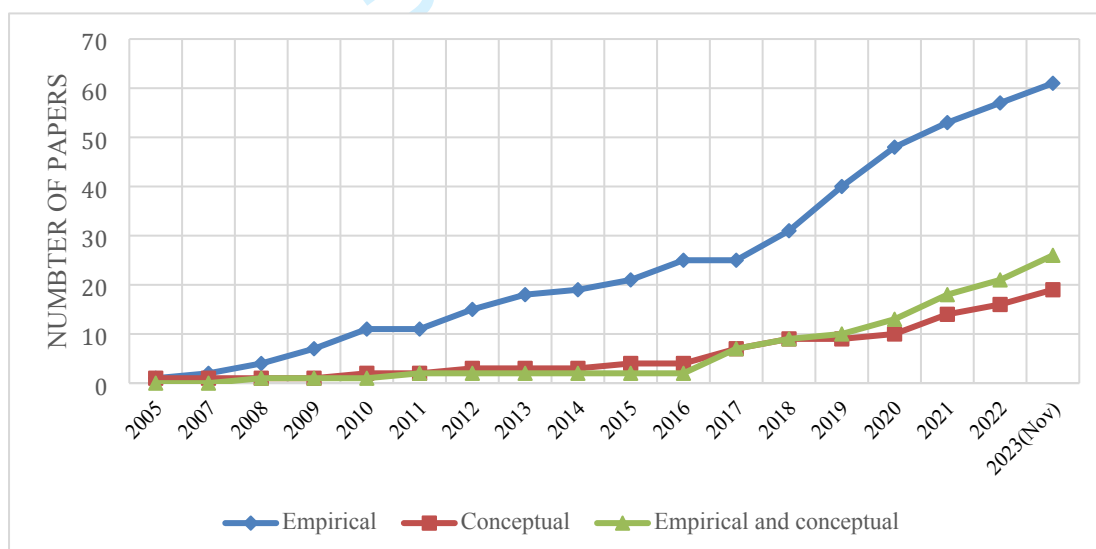


Figure 6: Research type for selected articles

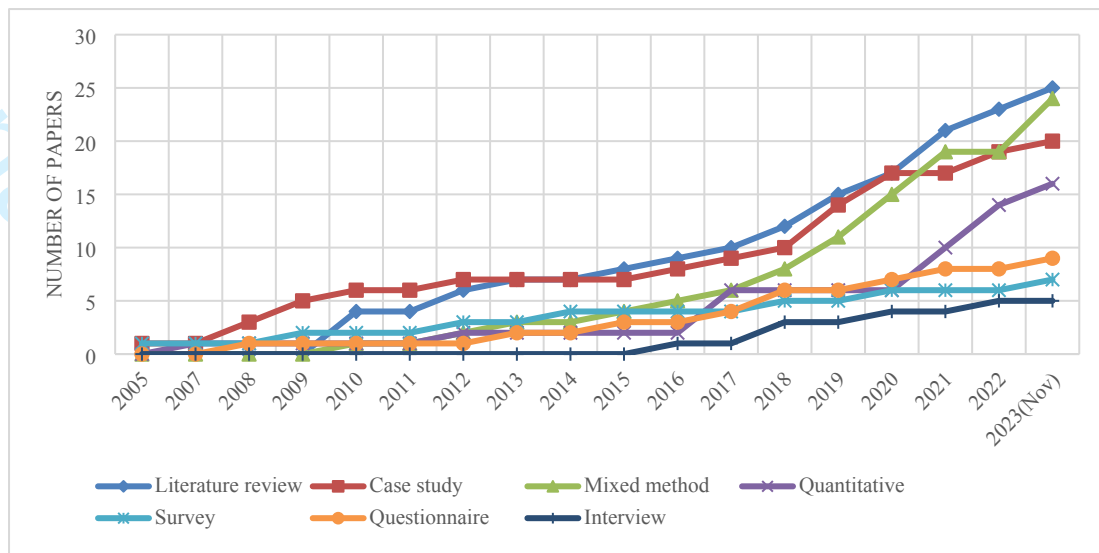


Figure 7: Research method for selected articles

To have a better understanding of the overall nature of the papers, the results of the titles and abstracts of the 106 articles using the VOSviewer software as shown in Figure 8, where each node represents a keyword or research topic. The size of the node indicates the importance or frequency of the keyword, and a network diagram was generated accordingly. The colour of the nodes and connecting lines typically indicates the time or classification. The gradation of colours from blue to red indicates the passage of time, with blue representing earlier studies and red representing more recent studies. In Figure 8, 'construction supply chain', 'innovation', and 'strategy' are prominent keywords and are connected to many other keywords, indicating the main concepts in current research. Other keywords such as 'collaboration', 'contract', and 'quality' are related to supply chain management and appear to be popular research topics in recent years.

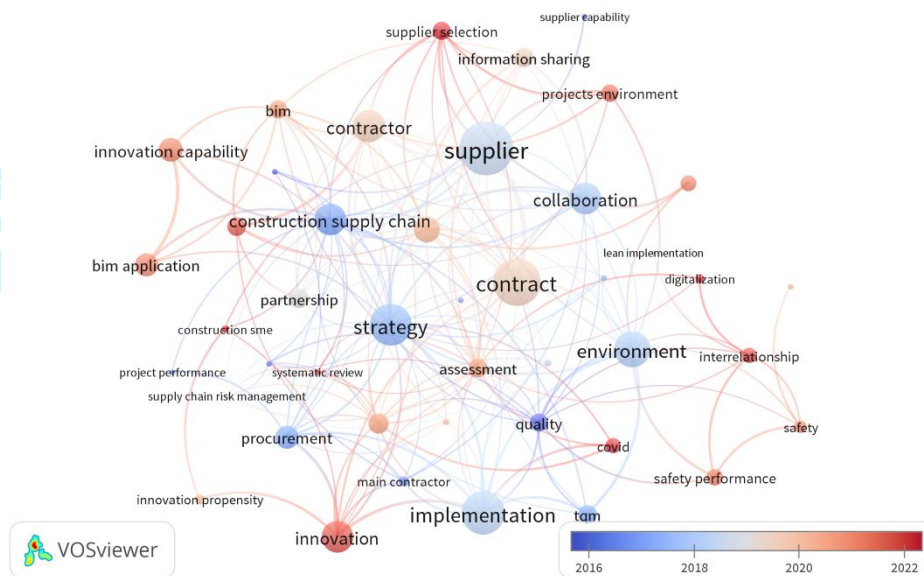


Figure 8: Network of selected article based on the title and abstract.

4.2 SMEs supply chain risk themes

Based on the analysis carried out using NVivo 12 software, the risks were categorised into three main themes, with each category representing a different aspect of supply chain risk for SMEs in the construction industry. In the following subsections we explore each in detail, presenting notable findings and apparent gaps pertinent for future research endeavours.

It is worth noting that these risks do not exist independently; some risks span various themes and can impact multiple dimensions, potentially even producing risk propagation. For instance, Salami et al. (2021) investigated strategies construction businesses use to mitigate litigation from potential COVID-19 contract breaches, involving three interacted risk elements: COVID-19, strategy, and contract risks. Indeed, the literature reveals gaps in addressing interaction risks within these themes for construction SMEs (Gap 1). Furthermore, many researchers are prioritising risks under these three themes, employing various research methods across fields. For example, Bajpai et al. (2023) ranked critical risks associated with digitalising India's construction industry, yet gaps remain in prioritising risks for construction SMEs (Gap 2).

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3 Compared to their larger counterparts, SMEs typically face constraints in resource availability,
4 making it challenging to address green supply chain risks. These challenges can lead to
5 financial repercussions and potential breaches of sustainability regulations. While there is
6 considerable literature on green supply chain practices in construction supply chains, research
7 specifically focusing on construction SMEs appears to be lacking (Gap 3).
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17 **4.2.1 Risks related to supply chain management and strategy.**

18
19 The first research theme focuses on supply chain risks associated with collaboration, contracts,
20 strategies, and stakeholders. General deficiencies in the management approaches and
21 strategies of SMEs are evident from the incomplete discussions of collaboration risks,
22 inadequate summaries of contractual risks, and a lack of understanding of strategic risk
23 management (Garengo et al. 2005). This deficiency in managing these key risks leads to
24 vulnerabilities in the supply chains of construction SMEs, where collaboration, contractual,
25 and stakeholders' risks can increase costs and decrease revenue for projects. Additionally,
26 strategic risks further hinder business growth, particularly in terms of sustainability. This
27 theme aims to provide an up-to-date overview of existing management practices and
28 strategies for construction SMEs (Table III).
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43 It is worth to mention that although current research on SME supply chain risks emphasizes
44 public procurement, there is a noticeable lack of comprehensive studies specifically
45 addressing these risks within the construction industry (Gap 4). For example, from an
46 economic perspective, Stefanov et al. (2015) explored the risk of corruption in the
47 construction sector under the Bulgarian public procurement market. From a political
48 perspective, policymakers see legal constraints and policy limitations on the participation of
49 construction SMEs in public procurement (Preuss 2011). An interdisciplinary study also
50 highlights this gap: many studies tend to portray SMEs as homogeneous entities when
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3 exploring the role of public procurement in supporting SMEs (Loader and Norton 2015).
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5 Additionally, scholars are increasingly recognising the role played by SMEs in responding to
6
7 green requirements embedded in green public procurement (Acosta Bogran and Džaja 2015;
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9 Strømmen 2021). However, there is still a lack of comprehensive research on the impact of
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11 construction SMEs in public procurement.
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16 *Collaboration risk*

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18 The supply chain in the construction industry is complex, with many associated risks remaining
19
20 elusive (Donato et al. 2015). Collaboration comprises 90% of projects, making subcontractors
21
22 and supply chains vital to the industry (Humphreys et al. 2003; Eriksson et al. 2007; Donato et
23
24 al. 2015). Construction SMEs often collaborate on projects due to resource limitations.
25
26 Consequently, SMEs frequently partner with larger company (OECD 2023). The literature
27
28 indicates researchers are developing frameworks for corporate collaboration where factors
29
30 like strategy, culture, and risk-sharing attitudes influence trust dynamics. (Fraser et al. 2005)
31
32 analysed partnership maturity in UK SMEs through a study of 12 collaborative development
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34 projects. However, communication problems and a lack of trust between parties can hinder
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36 collaboration, particularly in complex and risky projects (Laan et al. 2011). Conflicts may also
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38 arise due to factors such as the pricing of orders (Chan et al. 2003).
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Table III: Supply Chain Management and Strategy

<p>Scope: The scope of the study encompasses the various risks posed to SMEs in the context of supply chain management and strategy, including those risks associated with collaborations, contract, strategy, and disruption.</p>	
<p>Risks under this theme:</p>	<p>Publications (23 articles)</p>
<p>1. Collaboration Risk</p>	<p>Khalfan et al (2008) examined UK construction procurement initiatives aimed at integrating the supply chain, highlighting the role of clients and critical success factors through two case studies.</p> <p>Bygballe et al (2010) delved into the diverse interpretations of partnering in construction, comparing them to the Construction Industry Institute's definition, and suggests incorporating insights from Supply Chain Management and the Industrial Network Approach to better understand long-term, multi-party relationships.</p> <p>Crespin-Mazet et al (2010) analysed the slow uptake of construction partnering in France, concluding organizational factors like purchasing strategy and culture impact procurement more than project nature.</p> <p>Gadde and Dubois (2010) explored the challenge of extending partnering benefits beyond individual projects, proposing a differentiated approach due to industry norms.</p> <p>Laan et al (2011) delved into the dynamics of trust in partnering projects between clients and contractors, examining the connection between trust, risk, control, and performance, and illustrating with a case from a railroad construction project in the Netherlands, emphasizing the importance of deliberate actions to foster trust, especially in industries with historically adversarial relationships.</p> <p>Friday et al (2018) reviewed collaborative risk management literature, introducing a precise definition and suggesting a comprehensive approach for integrating collaboration into supply chain risk management.</p> <p>Elsayegh and El-adaway (2021) analyzed collaborative planning in construction, identifying 50 key elements from three decades of literature and stressing the need for holistic models and realistic simulations.</p>

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	<p>Song et al (2021) investigated the potential drawbacks of risk-sharing partnerships in project management, revealing that such collaborations might lead to delays and cost overruns, with insights on information asymmetry's role.</p>
<p>2. Contractual risk</p>	<p>Ling et al (2014) compared relational contracting in Beijing and Sydney's public construction projects, finding both cities value relationship quality but face different barriers: training and industry culture in Beijing, and public sector accountability in Sydney.</p> <p>Manu et al (2015) explored trust factors between contractors and subcontractors, identifying change management, economic climate, payment practices, and job performance as key, and highlighted the importance of actual trustworthiness.</p> <p>Rahmani et al (2016) focused on the Early Contractor Involvement system in construction, aiming to explore its appealing characteristics for clients.</p> <p>Oyegoke (2016) studied the role of small contracts in construction, emphasizing transparency and legal rights understanding during the tendering stage.</p> <p>Farahani et al (2021) found that supply-flexibility contracts enhance supply chain efficiency and profits, and integrating these with buyback contracts further coordinates risks.</p> <p>Salami et al. (2021) examined strategies to prevent COVID-19 related litigation in construction, suggesting maintaining good relationships and addressing disputes early.</p> <p>Tang et al. (2023) combined transaction cost economics and resource-based view to show how a general contractor's governance capabilities affect subcontracting in construction, impacting subcontracting extent and diversity based on project goals.</p>
<p>3. Strategy Risk</p>	<p>Setijono (2010) presented a conceptual framework of construction supply chain states based on strategic dimensions of industrial 'modes' and partnership integration levels, emphasizing the role of improvement methodologies like Total</p>

	<p>Quality Management (TQM) and lean thinking. It underscores the importance of benchmarking and the need for value-related performance measures to foster trust and collaboration among supply chain partners.</p> <p>Nagarajan and Bernstein (2012) reviewed two decades of operations management, synthesizing non-cooperative game theory and cooperative strategies in supply chains to optimize efficiencies and profits, providing a comprehensive overview and future research directions.</p> <p>Seth and Rastogi (2019) illustrated how vendor rationalization strategy can optimize supplies and reduce manufacturing cycle time in Indian engineer-to-order (ETO) firms, using Kraljic's matrix and case-based observations, and emphasizes the broader benefits of this approach beyond just minimizing the supplier base in the context of ETO operations in rapidly developing nations.</p> <p>Crovini et al (2021) used the Advanced, Reasoned and Organised (ARO) literature review method to examine risk management in SMEs, finding that many overlook comprehensive risk strategies due to managerial attitudes and lack of awareness, underscoring the need for better risk understanding.</p>
4. Stakeholders Risk	<p>Khalfan et al (2008) examined innovative procurement in the UK construction industry, emphasizing early involvement of suppliers and manufacturers for better project planning and the benefits of enhanced supply chain integration.</p> <p>Oppong et al (2017) developed a flexible conceptual model for construction stakeholder management, including performance objectives and indicators, allowing for tailored application to projects and comprehensive success measurement.</p> <p>Abas et al. (2020) identified key risk and success factors in Pakistan's construction supply chain, such as funding issues and stakeholder communication, providing valuable industry insights.</p> <p>Aladag and Isik (2020) analyzed stakeholder-related risks in mega-engineering projects, underlining the significance of partner selection and the necessity of risk management for enhanced project performance.</p>

Contractual risk

The contract is considered the cornerstone of collaboration among companies in supply chain management. It outlines the obligations and tasks of both parties and serves as the foundation for communication and, importantly, risk sharing. This research predominantly focuses on relational contracts, with some scholars highlighting their benefits in synchronizing the interests of stakeholders, thus enhancing cost and time management in construction projects (Ling et al. 2014). Nonetheless, there is skepticism about their efficacy, with concerns such as potential corruption due to overly close relationships that might priorities relational over contractual value (Ling et al. 2014). Contractual risk in construction SMEs is often linked to financial risk, primarily the challenge of securing funding within contractual deadlines (Maemura et al. 2018). Current research shows a gap in a systematic review of these financial risks in the construction SME sector **(Gap 5)**.

Strategy risk

Supply chain strategy risk is a comprehensive topic that encompasses subsidiary themes. This study focusses on the relationship between the characteristics of construction SMEs and their competitive strategies. The strategic risks in construction SME supply chains are commonly linked to their rudimentary business practices and lack of robust organizational frameworks, a direct consequence of their competitive approaches (Parnell et al. 2015). A notable problem is the tendency of construction SMEs to treat partnerships as ephemeral engagements, which often leads to overlooking sustainable practices and contractual awareness, thereby introducing secondary risks.

Stakeholders risk

Supply chain stakeholder management as part of supply chain management is the process of endeavouring to manage stakeholder expectations and include stakeholders in actual

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2
3 activities (Olander and Landin 2005; Yang and Shen 2015). In practice, key suppliers are often
4
5 overlooked in commercial circumstances, leading to delays in project schedules or the failure
6
7 to identify all relevant parties across different regions. Neglecting stakeholders can also result
8
9 in legal and cultural risks (Aladag and Isik 2020). However, in SMEs, stakeholder issues are
10
11 often unforeseen due to the limited resources available. As a result, construction SMEs may
12
13 struggle to meet the diverse interests of stakeholders (Oppong et al. 2017). In addition, SMEs
14
15 may lack the necessary information to identify the parties involved in subcontracting
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17 operations.
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23 **4.2.2 Risks related to operation and process.**

24
25 The second theme of the construction SME study pertains to the impact of operational and
26
27 process risks on the supply chain. This theme encompasses safety risks and implementation
28
29 risks. The classification of this group is grounded in the understanding that operational and
30
31 process risks in the supply chain may be a source of other risks and that these risks are often
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33 hidden within the daily activities of construction SMEs.
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Table IV: Supply Chain Operational and Process

<p>Scope: The scope of this study encompasses various aspects of operational and process risk that affect construction SMEs, including safety risk and implementation risk.</p>	
<p>Risks under this theme:</p>	<p>Publications (7 articles)</p>
<p>1. Safety risk</p>	<p>Barreto and Pires (2015) examined occupational hazards in the construction industry, focusing on small and medium-sized residential construction businesses, and offers solutions for risk management to enhance worker safety, health, and overall quality of work life.</p> <p>Yap et al (2019) evaluates the safety awareness in the Malaysian construction industry, identifies the primary safety concerns and underlying factors affecting safety performance through a survey, and recommends measures to enhance safety awareness among construction personnel.</p>
<p>2. Implementation risk</p>	<p>Thomas and Webb (2005) assessed the adoption rate of formal quality management systems in SMEs in South Wales, explores reasons for low implementation, compares findings with studies from other countries, and suggests a conceptual framework for a tailored quality model for SMEs.</p> <p>Deshmukh and Chavan (2012) explored the application of the Six Sigma methodology in SMEs through a systematic literature review, highlighting the importance of management commitment, the limited embrace of quality management culture in SMEs, and the need for SME-specific Six Sigma approaches for quality improvement.</p> <p>Yadav et al. (2019) examined lean implementation barriers in Indian SMEs using case studies and mathematical analysis, highlighting management commitment, leadership, and communication as key challenges.</p> <p>Mohammadi et al. (2022) combined qualitative and quantitative methods to identify nine key factors affecting the success and failure of quality management systems implementation in SMEs, highlighting the importance of addressing both financial and human resource challenges, as well as technical knowledge gaps and employee indifference.</p>

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	Mansour et al. (2021) introduced ConFIRM, a unique model for assessing the strategic readiness of construction firms for Industry 4.0, emphasizing the crucial role of human capital, particularly the expertise of construction professionals, in successful implementation, validated using a Malaysian case study.
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Safety risk

The construction industry has rigorous operational demands and substantial risks. Consequently, the supply chain of construction SMEs imposes added responsibilities on workers, making them less replaceable. While workers in the construction sector frequently depend on their experience, the evaluation of personal protective equipment in SMEs is not rigorous (Saunders et al. 2016). Despite the growing emphasis on safety improvements, construction SMEs supply chain often overlooks safety risks due to inadequate management practices and disregard of workers for standard procedures and safety awareness. As highlighted in Table IV, numerous researchers have identified safety concerns for SME workers (Barreto and Pires 2015; Yap and Lee 2020). Larger organisations have more regulated control procedures and managerial involvement to address safety risks compared to SMEs (Okonkwo and Wium 2020).

Implementation risk

In this research, implementation risk is defined as the risk associated with executing a strategy, plan, process, or framework. While many of the risk mitigations highlighted are more applicable to large construction corporations, the inherent flexibility and streamlined structure of SMEs equip them to be cognisant of risks during the implementation process (Laforet 2013). Consider implementation risk is relative new topic emphasized in the construction SMEs supply chain. There is a need for a clearer distinction between implementation risks based on their scale and associated risks, such as strategic, sustainability, and technological risks which reflect the importance of research gap 1.

4.2.3 Risks related to sustainability

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3 The third research theme focuses on the technological and environmental risks that influence
4
5 the supply chain of construction SMEs as shown in the Table V. Notably, in this study,
6
7 technology refers to the technological requirements introduced by Industry 4.0 and BIM etc.
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10 11 12 *Technological risk*

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14 The emergence of technologies such as Industry 4.0 and BIM has introduced significant
15
16 technological advancements and led to shifts in managerial practices. Despite the
17
18 opportunities these advancements present, SMEs face distinct challenges when adopting
19
20 these technologies, including a lack of expertise and a tendency towards short-term planning
21
22 (Moeuf et al. 2019; Mansour et al. 2021). Furthermore, when factoring in strategy risk, many
23
24 construction companies are hesitant to integrate new technologies due to associated costs
25
26 and the need for employee training (Setijono 2010). Nevertheless, these technologies can
27
28 provide considerable benefits to SMEs, particularly in enhancing employee health and safety
29
30 (Yap and Lee 2019). Although many studies have highlighted the impact of technologies such
31
32 as Industry 4.0 on supply chains, there is a need for research exploring the specific risks they
33
34 pose to the supply chains of construction SMEs (Gap 6).
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Table V: Supply Chain Sustainability

<p>Scope: The study scope encompasses the technological and environmental risks that SMEs face in their supply chains, including risks related to technology and the environment.</p>	
<p>Risks under this theme:</p>	<p>Publications (9 articles)</p>
<p>1. Technological risk</p>	<p>Moeuf et al. (2020) evaluated Industry 4.0's impact on SMEs, identifying risks such as lack of expertise, emphasizing the importance of training and managerial roles, and suggesting it can transform SME production and business models.</p> <p>Patrucco et al (2020) delved into the potential of Industry 4.0 technologies to optimize supply chain processes in construction, emphasizing enhanced communication, data sharing, and the need for organizational changes, using a unique materials management case study approach.</p> <p>Mansour et al (2021) presented ConFIRM, a model assessing construction firms' strategic readiness for Industry 4.0, emphasizing the crucial role of human capital in successful implementation.</p> <p>Sadeh et al (2021) examines the feasibility of Building Information Modeling (BIM) adoption for SMEs in the construction sector, comparing the attitudes of contractors and subcontractors towards innovative technology, using a structured online questionnaire and various statistical tests, revealing differing rankings in technological feasibility between the two groups when considering partnerships.</p> <p>Yilmaz et al. (2023) identified 58 digital solution areas for UK construction SMEs using the Digital Shoestring Approach, with the top fifteen prioritized for different operational needs of on-site and off-site SMEs, offering cost-effective digitalization pathways tailored to their specific needs.</p>
<p>2. Environmental risk</p>	<p>Klein and Todesco (2021) investigated the impact of COVID-19 on SMEs, recommending knowledge management to boost organizational resilience and digital transformation, helping SMEs adapt to pandemic challenges.</p>

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5 Al-Mhdawi et al. (2023) assessed risk management challenges in Iraq's construction industry during COVID-19, using
6 various methods to identify 34 significant barriers.

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8 Arsawan et al. (2023) analyzed the relationship between green economic incentives and environmental commitment
9 in SMEs, finding a positive correlation and the role of commitment in practices like eco-design and asset recovery.

10
11 Salami et al (2021) examined strategies by construction firms to avoid COVID-19 related contractual disputes,
12 emphasizing measures like positive partner relationships and early decision-making, providing insights for risk
13 minimization and partnership maintenance during the pandemic.
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Environmental risk

Environmental risks can be categorised into endogenous and exogenous facets. The endogenous side stems from an inside of the company activities throughout its supply chain, while the exogenous facets arises from external factors when companies interact with the broader environment in which they operate (Giannakis and Papadopoulos 2016). This theme predominantly addresses the exogenous aspect, particularly considering the profound effects of COVID-19. These risks are often linked with green supply chains and predominantly focus on natural threats such as the consequence of COVID-19. The supply chains of construction SMEs are particularly susceptible to external factors and unforeseen events. In comparison to other larger, well-established counterparts, SMEs typically lack the robust ability to counter unforeseen risks effectively. The outbreak of the COVID-19 pandemic offers a clear illustration of this vulnerability. At the pandemic's onset, numerous countries instituted lockdowns, limiting non-essential functions and urging residents to self-isolate (Klein and Todesco 2021). Therefore, many researchers are exploring the impact of COVID-19 on construction supply chains as shown in the Table V.

4.3 Summary of SMEs supply chain risk themes

This section presents a supply chain risk framework for construction SMEs, outlining the risks these enterprises face. These risks are categorised into management and strategic theme, operational and process theme, and sustainability theme. Specifically, the management and strategic risk theme includes collaboration risk, contractual risk, strategy risk, and stakeholders risk. The literature under these specific risks showcases collected articles and their research topics, providing the reader with a visual perspective on the literature. In addition to the management and strategy risk theme, the operations and process risk theme corresponds to safety risk and Implementation risk, while the sustainability risk theme corresponds to technology and environmental risk. Among the identified risks, the literature

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3 lacks discussion on areas such as the interaction between risks and risk prioritisation, which
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5 are crucial steps for construction SMEs to manage risks effectively. Additionally, the academic
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7 literature currently lacks coverage of certain supply chain risks for construction SMEs, notably
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9 in areas like procurement and financial risks. These gaps prompt this paper to summarise the
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11 research gaps, pose potential research questions for subsequent sections, and discuss the
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13 practical implications of these gaps.
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19 **5. Research agenda for future research**

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21 Based on the structured literature review, this paper has identified six research gaps in supply
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23 chain risk management for SMEs in the construction industry, as outlined in Table VI. First,
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25 in conducting the thematic analyses, we found that the interactions of risks are rarely
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27 discussed in the construction SME sector. Therefore, there is a need to explore the
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29 interactions of various risks within these supply chains, as different risks may interact and
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31 exacerbate each other. A case in point is the delays in the construction of Crossrail (Elizabeth
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33 Line), which faced extended schedules and cost overruns due to a failure to timely address
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35 the scale of systems integration work required to bring the railway into operation. (London
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37 Assembly 2019). One possible approach to understanding risk interactions is to categorise the
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39 relationships of risks (multiple factors acting together or individual risks reacting to each
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41 other). Additionally, system dynamics methodology can be used to simulate risk reactions
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43 (Ghadge et al. 2022). Understanding the interdependencies and mutual influences of these
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45 risks is crucial step for construction SMEs.
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53 Second, this paper finds that construction SME have significant gaps in the categorisation and
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55 prioritisation of risks that are specific to SMEs. This stems from the unique characteristics of
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57 construction SMEs, whose limited information and traditional strategies have led to their
58
59 inability to classify and prioritise risks in terms of importance (Ferreira de Araújo Lima et al.
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2020). For example, Wedawatta et al. (2011) used case studies to assess how construction SMEs are affected by extreme weather events (EWEs). It was found that most construction SMEs (75 percent), whether they had experienced a previous EWE, had no coping mechanisms in place to protect their business from such events. One possible solution is to use multi-criteria decision-making techniques to develop specific risk differentiation levels for construction SMEs, employ methods such as interviews or focus groups.

Third, green supply chains are typically associated with large organisations. However, this paper finds that due to the significant number of SMEs in the construction sector, their environmental impact should not be underestimated. Therefore, there is a clear research gap in green supply chain management among SMEs in the construction industry. One possible research direction is for academics to use case studies in practical areas to understand the level of awareness among practitioners regarding green supply chains. For example, Namagembe et al. (2021) conducted a study of owners/managers of 200 manufacturing SMEs in Uganda, Africa, which assessed the relationship between five green practices and business performance. They found that eco-design and in-house environmental management practices had a significant impact on environmental performance. Additionally, the observation method can be used to understand the environmental practices SMEs adopt at work.

Fourth, this paper finds that construction SMEs are often perceived as mere recipients of policies, with limitations on the role they can play in procurement. Consequently, there is a gap in comprehensively studying procurement risks specific to construction SMEs. These risks are especially significant in the areas of supplier selection, contract management, and digital procurement solutions. A notable example is the cancellation of the HS2 project (Austin et al. 2023), which disrupted an otherwise stable supply chain, resulting in many ordered materials and services not being delivered as planned. This disruption highlighted several procurement

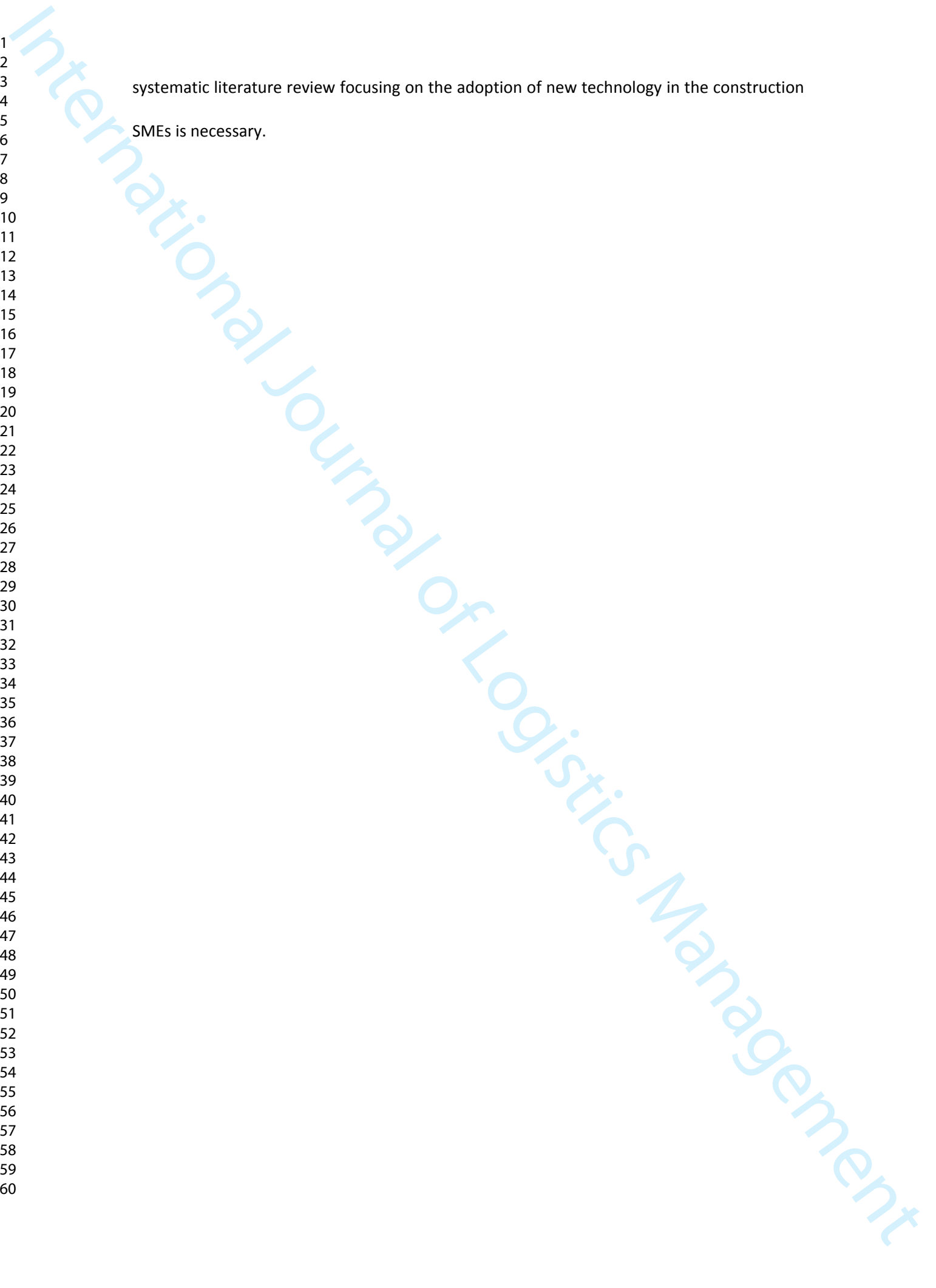
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3 challenges for SMEs, including choosing the right suppliers to reduce costs and maintain
4 stability, understanding contract details and terms, and adopting digital procurement
5 techniques. It is vital for academics to conduct empirical research through interviews or
6 surveys to explore these risks and find solutions.
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14 Fifth, this paper finds that the consequence of contractual risk often leads to financial risk.
15 While academics and practitioners have acknowledged the significance of financial risk for
16 SMEs in the construction industry, there is little research on the leading factors of financial
17 risk, which may arise from uncertainty about its sources. For example, the Central
18 Artery/Tunnel Project (The Big Dig), the most expensive highway project in the United States,
19 was initially completed nine years later than planned, with a cost overrun of \$11.8 billion
20 (Greiman 2013). It was plagued by cost overruns, design flaws, and the use of poor-quality
21 materials. By understanding the dynamic relationship between financial risk and other risks
22 (e.g. procurement risk), scholars can build on this foundation to further investigate how to
23 mitigate risks. Simulation is an appropriate option in this case, as the balance between
24 financial risk and other risks can be understood through system dynamics.
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41 Sixth, this paper highlights the innovations in management styles and strategies introduced
42 by emerging technologies. However, there is a need for a more comprehensive understanding
43 of the opportunities and challenges that these technologies pose for construction SMEs, as
44 their applicability to the SME context remains unclear. A well-known example is the
45 construction of the largest single-terminal airport in the world, Beijing Daxing International
46 Airport, where BIM was used in planning, design, construction supervision, and maintenance
47 to improve the efficiency and overall effectiveness of the project (Zhou et al. 2024). However,
48 for construction SMEs, it is vital to explore how these firms are using new technologies to
49 improve sustainability and minimise the environmental impact of their supply chains. A
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systematic literature review focusing on the adoption of new technology in the construction
SMEs is necessary.



3 Table VI: Research agenda for construction SMEs supply chain risks

Research gap	Pertinent research questions	Practical implication
1. Research on Revealing Risk Interaction in Construction SMEs	<p>What is the difference between risk propagation (Ripple Effect) and risk interaction among supply chain risks in construction SMEs?</p> <p>Which mitigation strategies are effective in managing the interaction of supply chain risks within construction SMEs?</p>	Develop comprehensive frameworks to aid construction SMEs in identifying and evaluating the potential for interactions among various risks.
2. Systematic Work on Risk Prioritization for Construction SMEs	How can the impacts of various supply chain risks be quantified and compared within the context of construction SMEs?	Demonstrate to construction SMEs how to prioritize risks, enabling them to focus on the most severe threats.
3. Work on Green Supply Chain Focused on Construction SMEs	Which supply chain risks are associated with sustainable practices in construction SMEs, and how can these be effectively managed?	Create a framework to guide construction SMEs in managing risks associated with the growth of a green supply chain, thus promoting sustainability, and preventing financial loss or legal issues.
4. Research on Procurement Risks in Construction SMEs	What is the current state of procurement practices in construction SMEs?	Assist construction SMEs in formulating procurement policies that mitigate potential risks.
5. Systematic Work on Financial Risks in Construction SMEs	What are the sources of financial risks in construction SMEs and what are the consequences?	Help construction SMEs by identify and manage potential factors that causes financial risks.
6. Research on the Impact of Technology in Construction SMEs	What are the implications of emerging technologies on the supply chain risks faced by construction SMEs, and what mitigation strategies can be implemented?	Provide construction SMEs with a thorough understanding of the benefits and drawbacks of new technologies.

6. Conclusion

Despite the increasing number of reports on supply chain risk in the construction industry, there is considerably less research focused on SMEs. This paper aims to explore the current state of research on supply chain risk among SMEs in the construction industry and to highlight the gaps that still exist in the field. By searching the rated journal based on the AJG's ratings, this paper then adopted thematic analysis to generate themes. This research concludes by identifying three themes: management and strategy, operations and process, and sustainability which encompass eight supply chain risks faced by construction SMEs.

The existing literature in this paper predominantly focuses on the inherent risks faced by construction SMEs and overlooks their roles within the broader supply chain (Pham et al. 2022). To fill this gap, this paper systematically explores the risks faced by SMEs in the construction industry, both within their operations and in the supply chain. The current literature review of construction supply chains by scholars focuses primarily on the risk management process, while providing different insights on risk delineation and mitigation specific to the construction industry. This paper highlights the differences between construction SMEs and SMEs in other industry, such as manufacturing and services. Our characterisation of the research objectives defines a research framework that can be applied more broadly to other industries.

Another scholarly contribution of this study is to summarise the supply chain risks specific to SMEs in the construction industry. The study clearly distinguishes between the impact of these risks on SMEs and large enterprises. In addition, by exploring the daily operations and processes of construction SMEs and their management strategies, this paper reveals that traditional risk management frameworks are inadequate to meet the nuanced needs of construction SMEs. Scholars should first segment specific construction subsectors, such as

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3 home building and renovation. By conducting empirical studies on target firms in these
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5 subsectors and exploring the practical problems they encounter, a suitable management
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7 framework for construction SMEs can be further developed.
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12 The practical significance of this paper is to provide SMEs with a comprehensive framework
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14 for identifying and categorising risks associated with management and strategy, operation
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16 and process, and sustainability in the construction industry. This framework can be used by
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18 SMEs to systematically assess potential risks at all stages of a project, leading to more
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20 proactive risk management. SMEs can develop more comprehensive strategies for resources
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22 control and contract management. Furthermore, SMEs can achieve operational
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24 improvements through the implementation of advanced project management tools and
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26 techniques. Finally, SMEs can enhance their competitiveness by integrating sustainability into
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28 their normal management processes.
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34 For policymakers, construction SMEs can be supported through regulatory reforms, financial
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36 incentives, and education and communication programmes. Specifically, policymakers can
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38 adopt more simplified and transparent standard contract management procedures to reduce
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40 the waste of time and resources associated with complex steps. In addition, financial
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42 incentives and support, such as low-interest loans and tax incentive subsidies, can be actively
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44 provided. Finally, the awareness and capacity of SMEs to apply modern risk management tools
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46 and techniques can be enhanced through educational programmes. Also, peer-to-peer
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48 support sessions can be conducted to promote information exchange among construction
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50 SMEs.
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56 While this paper identified supply chain risks at construction SMEs and presented possible
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58 research directions. However, some limitations remain. First, only few numbers of studies that
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have focused on supply chain risk in construction SMEs may have impacted the richness of the literature. Second, the structured literature review methodology deliberately focuses on academic journal articles listed in the ABS to ensure the quality of the reviewed publication. While the structured literature review methodology with ABS has been well used (Gosling and Naim 2009), other methodologies such as the systematic literature review (Tranfield et al. 2003) could potentially produce a wider range of results, albeit with output quality tools.



Appendix: Distribution of articles across AJG-rated journals

	Journal Title	Frequency	ABS Rating 2021
1	Journal of Construction Engineering and Management	12	2
2	International Journal of Construction Management	12	1
3	International Journal of Procurement Management	8	1
4	Journal of Purchasing and Supply Management	6	3
5	Production Planning & Control	6	3
6	International Journal of Project Management	4	2
7	IEEE Transactions on Engineering Management	4	3
8	International Journal of Lean Six Sigma	3	1
9	Journal of Public Procurement	3	1
10	Journal of Manufacturing Technology Management	3	1
11	Business Process Management Journal	3	2
12	International Journal of Productivity and Performance Management	3	1
13	Manufacturing & Service Operations Management	2	3
14	Benchmarking	2	1
15	International Journal of Engineering Business Management	2	1
16	International Journal of Physical Distribution & Logistics Management	2	2
17	Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture	2	1
18	Computers & Industrial Engineering	2	2
19	Computers in Industry	2	3
20	International Journal of Productivity and Quality Management	2	1
21	The TQM Journal	2	1
22	International Journal of Quality & Reliability Management	2	2
23	Supply Chain Management	2	3
24	Knowledge and Process Management	1	1
25	Flexible Services and Manufacturing Journal	1	1
26	International Journal of Logistics-Research and Applications	1	1
27	International Journal of Production Research	1	3
28	International Journal of Industrial Engineering and Management	1	1
29	International Journal of Services and Operations Management	1	1
30	International Journal of Logistics Management	1	1
31	Supply Chain Forum	1	1
32	Journal of Manufacturing Systems	1	1
33	Total Quality Management & Business Excellence	1	2
34	International Journal of Business Performance and Supply Chain Modelling	1	1
35	Foundations and Trends in Technology, Information and Operations Management	1	1
36	International Journal of Agile Systems and Management	1	1
37	International Journal of Value Chain Management	1	1
38	IEEE Transactions on Engineering Management	1	3

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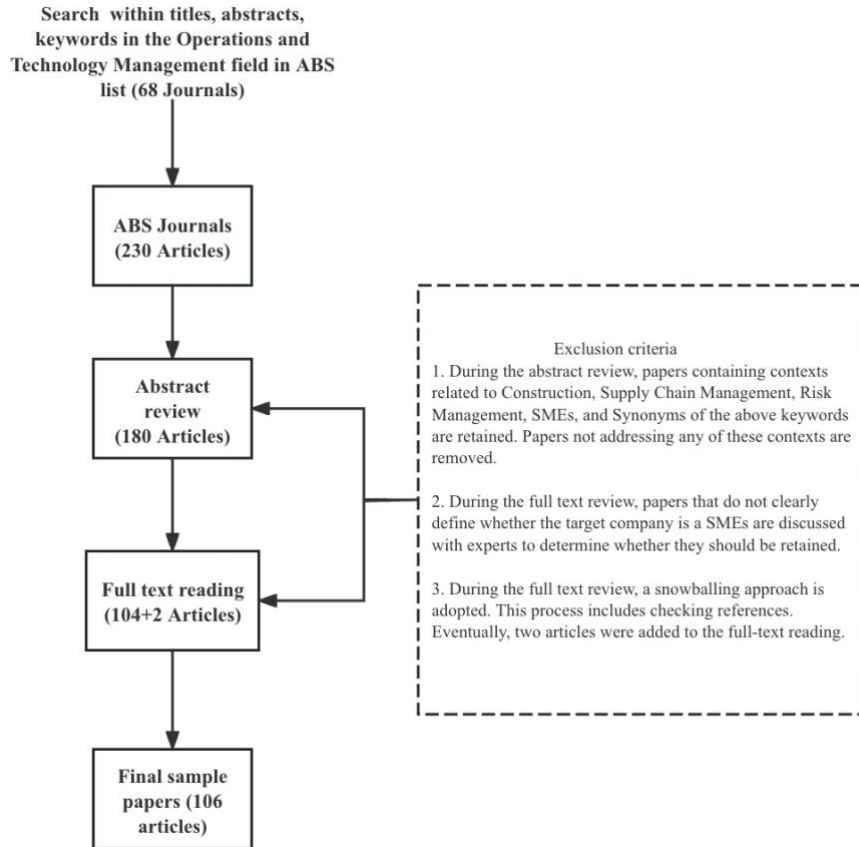


Figure 1: Structured literature review process.

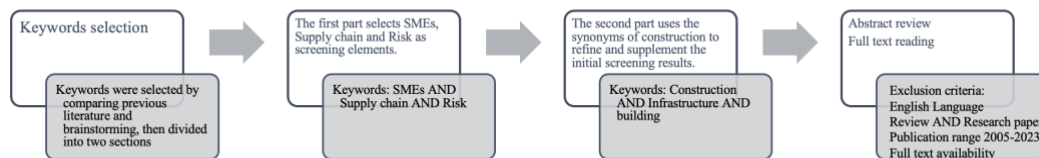


Figure 2: Keywords selection process

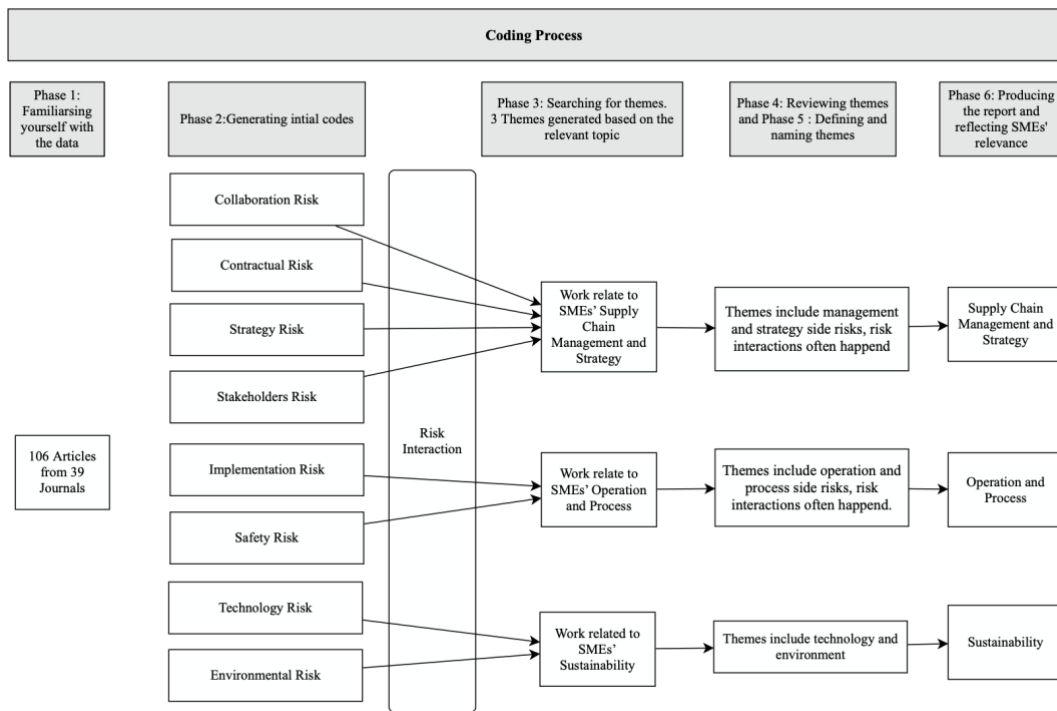


Figure 3: Coding process

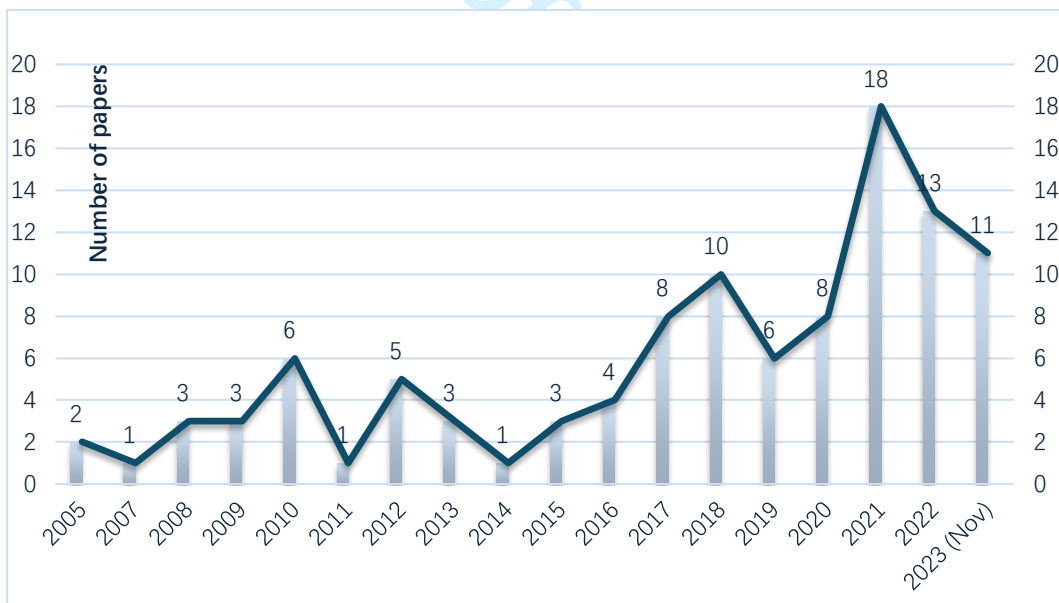


Figure 4: Year of publication

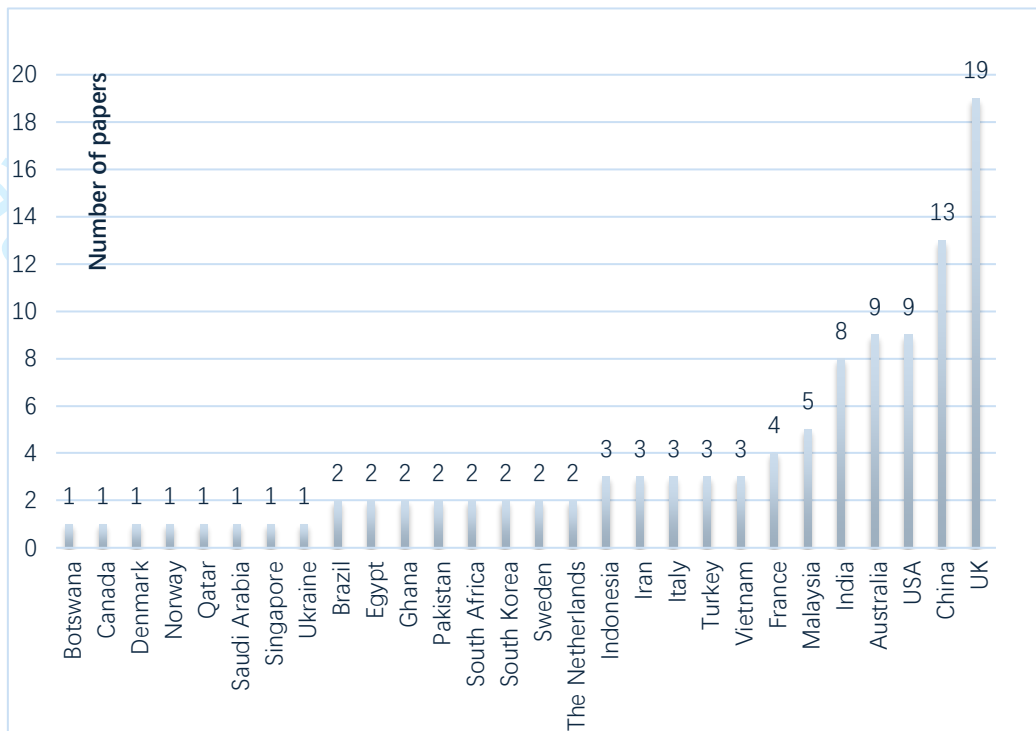


Figure 5: Distribution for selected articles by country.

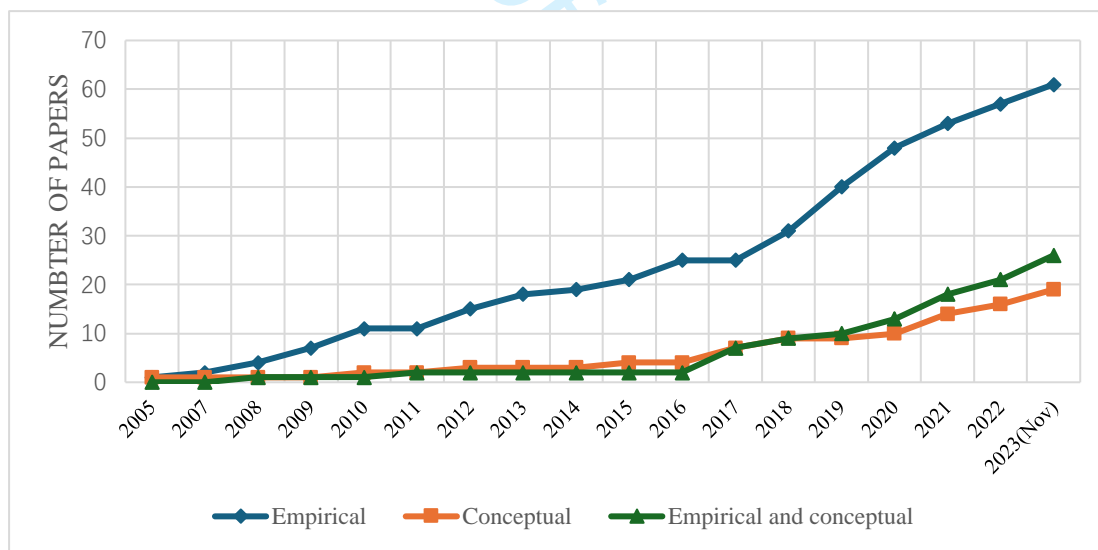


Figure 6: Research type for selected articles

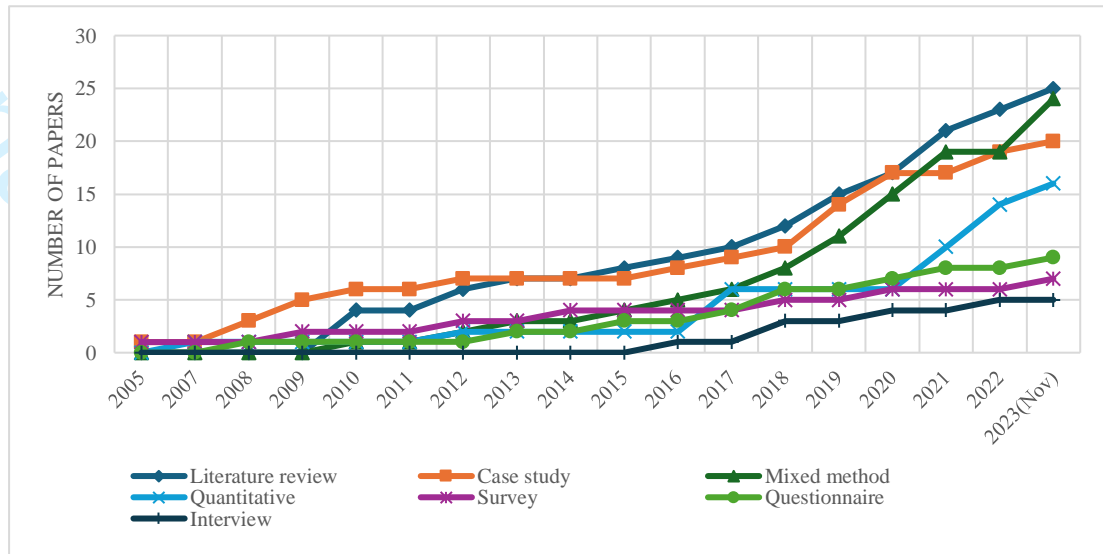


Figure 7: Research method for selected articles

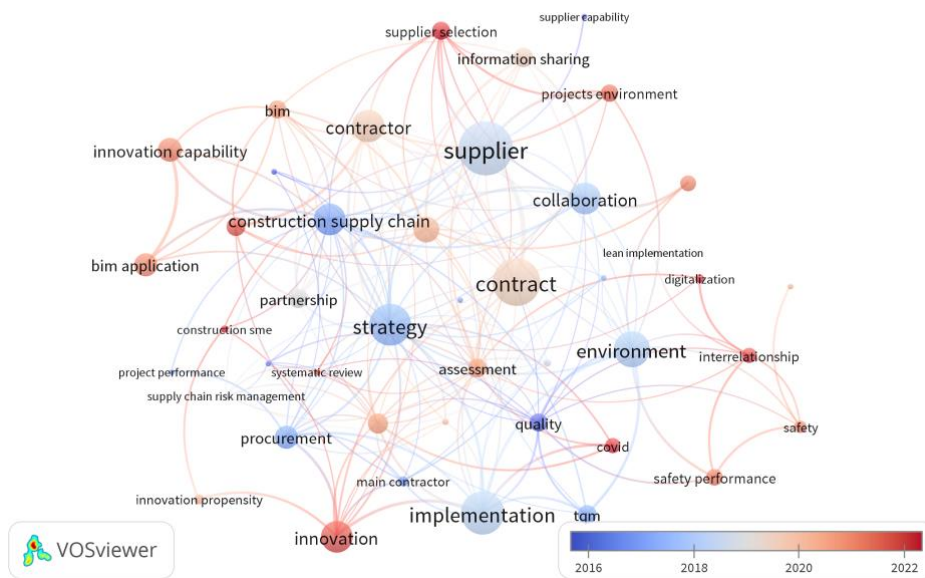


Figure 8: Network of selected article based on the title and abstract.

Table I: Comparison of SMEs in Different Countries (US Census Muller et al. 2015; National Bureau of Statistics of China 2017; Bureau 2022)

Country	Scale	Definition
USA	For construction small business, usually have less \$45 million dollar earnings.	Defined by ownership structure, number of employees, earnings, and industry.
EU	Micro businesses: <10 employees Small businesses: <50 employees Medium businesses: <250 employees	Defined by Staff headcount, Turnover or Balance sheet total
China	SMEs businesses: <300 employees or < £111 million revenue	Defined by revenue, number of employees, or total assets.
Developing Countries	Countries have their own scale based the staff number or earnings	Defined by scale or structure.

Table II: Characteristics of Construction SMEs compared to large Construction Enterprises adapted from (Kheni et al. 2008; Bak et al. 2023)

Characteristics	Construction SMEs	Large Construction Enterprises
Organizational Structure	Generally simpler, fewer hierarchies	Typically, more complex, with clear hierarchies
Product Line	May be limited, focusing on certain types of projects	Diversified, covering a variety of projects
Geographical Presence	Typically operate within a local or regional scope	Operate across multiple regions, nationwide or even globally
Ownership	Likely to be private, family-owned, or partnership-based	Possibly publicly listed, with diversified equity structures
Position in the Supply Chain	Likely to be a smaller link in the supply chain	Likely to be a major or key link in the supply chain

Operational Flexibility	High, due to smaller size and less bureaucracy.	Lower, due to larger size and more complex decision-making processes.
Risk Management	May have less formal risk management strategies.	Likely to have formalized risk management strategies in place.

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Table III: Supply Chain Management and Strategy

Scope: The scope of the study encompasses the various risks posed to SMEs in the context of supply chain management and strategy, including those risks associated with collaborations, contract, strategy, and disruption.	
Risks under this theme:	Publications (23 articles)
1. Collaboration Risk	<p>Khalfan et al (2008) examined UK construction procurement initiatives aimed at integrating the supply chain, highlighting the role of clients and critical success factors through two case studies.</p> <p>Bygballe et al (2010) delved into the diverse interpretations of partnering in construction, comparing them to the Construction Industry Institute’s definition, and suggests incorporating insights from Supply Chain Management and the Industrial Network Approach to better understand long-term, multi-party relationships.</p> <p>Crespin-Mazet et al (2010) analysed the slow uptake of construction partnering in France, concluding organizational factors like purchasing strategy and culture impact procurement more than project nature.</p> <p>Gadde and Dubois (2010) explored the challenge of extending partnering benefits beyond individual projects, proposing a differentiated approach due to industry norms.</p> <p>Laan et al (2011) delved into the dynamics of trust in partnering projects between clients and contractors, examining the connection between trust, risk, control, and performance, and illustrating with a case from a railroad construction project in the Netherlands, emphasizing the importance of deliberate actions to foster trust, especially in industries with historically adversarial relationships.</p> <p>Friday et al (2018) reviewed collaborative risk management literature, introducing a precise definition and suggesting a comprehensive approach for integrating collaboration into supply chain risk management.</p>

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	<p>Elsayegh and El-adaway (2021) analyzed collaborative planning in construction, identifying 50 key elements from three decades of literature and stressing the need for holistic models and realistic simulations.</p> <p>Song et al (2021) investigated the potential drawbacks of risk-sharing partnerships in project management, revealing that such collaborations might lead to delays and cost overruns, with insights on information asymmetry's role.</p>
2. Contractual risk	<p>Ling et al (2014) compared relational contracting in Beijing and Sydney's public construction projects, finding both cities value relationship quality but face different barriers: training and industry culture in Beijing, and public sector accountability in Sydney.</p> <p>Manu et al (2015) explored trust factors between contractors and subcontractors, identifying change management, economic climate, payment practices, and job performance as key, and highlighted the importance of actual trustworthiness.</p> <p>Rahmani et al (2016) focused on the Early Contractor Involvement system in construction, aiming to explore its appealing characteristics for clients.</p> <p>Oyegoke (2016) studied the role of small contracts in construction, emphasizing transparency and legal rights understanding during the tendering stage.</p> <p>Farahani et al (2021) found that supply-flexibility contracts enhance supply chain efficiency and profits, and integrating these with buyback contracts further coordinates risks.</p> <p>Salami et al. (2021) examined strategies to prevent COVID-19 related litigation in construction, suggesting maintaining good relationships and addressing disputes early.</p> <p>Tang et al. (2023) combined transaction cost economics and resource-based view to show how a general contractor's governance capabilities affect subcontracting in construction, impacting subcontracting extent and diversity based on project goals.</p>

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<p>3. Strategy Risk</p>	<p>Setijono (2010) presented a conceptual framework of construction supply chain states based on strategic dimensions of industrial 'modes' and partnership integration levels, emphasizing the role of improvement methodologies like Total Quality Management (TQM) and lean thinking. It underscores the importance of benchmarking and the need for value-related performance measures to foster trust and collaboration among supply chain partners.</p> <p>Nagarajan and Bernstein (2012) reviewed two decades of operations management, synthesizing non-cooperative game theory and cooperative strategies in supply chains to optimize efficiencies and profits, providing a comprehensive overview and future research directions.</p> <p>Seth and Rastogi (2019) illustrated how vendor rationalization strategy can optimize supplies and reduce manufacturing cycle time in Indian engineer-to-order (ETO) firms, using Kraljic's matrix and case-based observations, and emphasizes the broader benefits of this approach beyond just minimizing the supplier base in the context of ETO operations in rapidly developing nations.</p> <p>Crovini et al (2021) used the Advanced, Reasoned and Organised (ARO) literature review method to examine risk management in SMEs, finding that many overlook comprehensive risk strategies due to managerial attitudes and lack of awareness, underscoring the need for better risk understanding.</p>
<p>4. Stakeholders Risk</p>	<p>Khalfan et al (2008) examined innovative procurement in the UK construction industry, emphasizing early involvement of suppliers and manufacturers for better project planning and the benefits of enhanced supply chain integration.</p> <p>Oppong et al (2017) developed a flexible conceptual model for construction stakeholder management, including performance objectives and indicators, allowing for tailored application to projects and comprehensive success measurement.</p> <p>Abas et al. (2020) identified key risk and success factors in Pakistan's construction supply chain, such as funding issues and stakeholder communication, providing valuable industry insights.</p> <p>Aladag and Isik (2020) analyzed stakeholder-related risks in mega-engineering projects, underlining the significance of partner selection and the necessity of risk management for enhanced project performance.</p>

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Table IV: Supply Chain Operational and Process

Scope: The scope of this study encompasses various aspects of operational and process risk that affect construction SMEs, including safety risk and implementation risk.	
Risks under this theme:	Publications (7 articles)
1. Safety risk	<p>Barreto and Pires (2015) examined occupational hazards in the construction industry, focusing on small and medium-sized residential construction businesses, and offers solutions for risk management to enhance worker safety, health, and overall quality of work life.</p> <p>Yap et al (2019) evaluates the safety awareness in the Malaysian construction industry, identifies the primary safety concerns and underlying factors affecting safety performance through a survey, and recommends measures to enhance safety awareness among construction personnel.</p>
2. Implementation risk	<p>Thomas and Webb (2005) assessed the adoption rate of formal quality management systems in SMEs in South Wales, explores reasons for low implementation, compares findings with studies from other countries, and suggests a conceptual framework for a tailored quality model for SMEs.</p> <p>Deshmukh and Chavan (2012) explored the application of the Six Sigma methodology in SMEs through a systematic literature review, highlighting the importance of management commitment, the limited embrace of quality management culture in SMEs, and the need for SME-specific Six Sigma approaches for quality improvement.</p> <p>Yadav et al. (2019) examined lean implementation barriers in Indian SMEs using case studies and mathematical analysis, highlighting management commitment, leadership, and communication as key challenges.</p> <p>Mohammadi et al. (2022) combined qualitative and quantitative methods to identify nine key factors affecting the success and failure of quality management systems implementation in SMEs, highlighting the importance of addressing both financial and human resource challenges, as well as technical knowledge gaps and employee indifference.</p>

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	Mansour et al. (2021) introduced ConFIRM, a unique model for assessing the strategic readiness of construction firms for Industry 4.0, emphasizing the crucial role of human capital, particularly the expertise of construction professionals, in successful implementation, validated using a Malaysian case study.
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Table V: Supply Chain Sustainability

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<p>Scope: The study scope encompasses the technological and environmental risks that SMEs face in their supply chains, including risks related to technology and the environment.</p>	
<p>Risks under this theme:</p>	<p>Publications (9 articles)</p>
<p>1. Technological risk</p>	<p>Moeuf et al. (2020) evaluated Industry 4.0's impact on SMEs, identifying risks such as lack of expertise, emphasizing the importance of training and managerial roles, and suggesting it can transform SME production and business models.</p> <p>Patrucco et al (2020) delved into the potential of Industry 4.0 technologies to optimize supply chain processes in construction, emphasizing enhanced communication, data sharing, and the need for organizational changes, using a unique materials management case study approach.</p> <p>Mansour et al (2021) presented ConFIRM, a model assessing construction firms' strategic readiness for Industry 4.0, emphasizing the crucial role of human capital in successful implementation.</p> <p>Sadeh et al (2021) examines the feasibility of Building Information Modeling (BIM) adoption for SMEs in the construction sector, comparing the attitudes of contractors and subcontractors towards innovative technology, using a structured online questionnaire and various statistical tests, revealing differing rankings in technological feasibility between the two groups when considering partnerships.</p> <p>Yilmaz et al. (2023) identified 58 digital solution areas for UK construction SMEs using the Digital Shoestring Approach, with the top fifteen prioritized for different operational needs of on-site and off-site SMEs, offering cost-effective digitalization pathways tailored to their specific needs.</p>
<p>2. Environmental risk</p>	<p>Klein and Todesco (2021) investigated the impact of COVID-19 on SMEs, recommending knowledge management to boost organizational resilience and digital transformation, helping SMEs adapt to pandemic challenges.</p>

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5 Al-Mhdawi et al. (2023) assessed risk management challenges in Iraq's construction industry during COVID-19, using
6 various methods to identify 34 significant barriers.

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8 Arsawan et al. (2023) analyzed the relationship between green economic incentives and environmental commitment
9 in SMEs, finding a positive correlation and the role of commitment in practices like eco-design and asset recovery.

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11 Salami et al (2021) examined strategies by construction firms to avoid COVID-19 related contractual disputes,
12 emphasizing measures like positive partner relationships and early decision-making, providing insights for risk
13 minimization and partnership maintenance during the pandemic.
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5 1 Table VI: Research agenda for construction SMEs supply chain risks

Research gap	Pertinent research questions	Practical implication
1. Research on Revealing Risk Interaction in Construction SMEs	What is the difference between risk propagation (Ripple Effect) and risk interaction among supply chain risks in construction SMEs? Which mitigation strategies are effective in managing the interaction of supply chain risks within construction SMEs?	Develop comprehensive frameworks to aid construction SMEs in identifying and evaluating the potential for interactions among various risks.
2. Systematic Work on Risk Prioritization for Construction SMEs	How can the impacts of various supply chain risks be quantified and compared within the context of construction SMEs?	Demonstrate to construction SMEs how to prioritize risks, enabling them to focus on the most severe threats.
3. Work on Green Supply Chain Focused on Construction SMEs	Which supply chain risks are associated with sustainable practices in construction SMEs, and how can these be effectively managed?	Create a framework to guide construction SMEs in managing risks associated with the growth of a green supply chain, thus promoting sustainability, and preventing financial loss or legal issues.
4. Research on Procurement Risks in Construction SMEs	What is the current state of procurement practices in construction SMEs?	Assist construction SMEs in formulating procurement policies that mitigate potential risks.
5. Systematic Work on Financial Risks in Construction SMEs	What are the sources of financial risks in construction SMEs and what are the consequences?	Help construction SMEs by identify and manage potential factors that causes financial risks.
6. Research on the Impact of Technology in Construction SMEs	What are the implications of emerging technologies on the supply chain risks faced by construction SMEs, and what mitigation strategies can be implemented?	Provide construction SMEs with a thorough understanding of the benefits and drawbacks of new technologies.

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