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Continuity & Resilience Review

Manufacturing SME risk management in the era of digitalisation and artificial intelligence: a systematic literature review

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Abstract

Purpose – The purpose of this paper is to explore companies' business risks and challenges across macro- and micro-environments, as well as how small and medium-sized enterprises (SMEs) can benefit from digital technologies, including artificial intelligence (AI), as part their risk-management (RM) strategies in the face of recent disruptive events.

Design/methodology/approach – We perform a literature review on risk management and business continuity (BC) in the context of SMEs, both in general and specifically in the manufacturing sector.

Findings – The critical importance of RM and BC for SMEs is highlighted. The review underscores the significant impact of recent disruptions on SMEs and reveals a range of risk factors affecting their BC. Moreover, the review recognises how SMEs, in general, and manufacturing SMEs, in particular, can benefit from using digital technologies and AI as essential components of their RM.

Originality/value – The review highlights transformative role of digital technologies and AI in enhancing RM. Through a systematic classification of risk factors within macro- and micro-environments, this novel approach provides a structured foundation for future research. It provides practical value by enabling SMEs to integrate dynamic capabilities and adaptive capacities through the adaption of digital technologies and AI into their RM.

Keywords SMEs, Manufacturing industry, Risk management, Business continuity, Digital technologies, Artificial intelligence, Disruptive events, Supply networks, Resilience

Paper type Literature review

1. Introduction

In today's volatile and increasingly challenging business environment, RM plays an integral role in management practices. The quantity of overall risk factors has increased, and companies must proactively consider vulnerability mitigation strategies and their implementation (Engemann, 2019; Ali *et al.*, 2023). To comprehensively understand the forces influencing a company's operations, it is crucial to examine them from multiple dimensions (Fred and Forest, 2023, p. 95). In this review, we elaborate on this subject at the micro and macro levels. A company's external environment encompasses a wide range of macro-level factors, which may present both opportunities and threats (Whittington *et al.*, 2020, pp. 14, 35), while factors at the microlevel are evaluated from a company's internal perspective (Birnleitner, 2013).

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In the RM process, risk factors should be analysed within both macro-dimensions and micro-dimensions, categorising these dimensions into external and internal risk environments (Ashby, 2022, pp. 232–235; Rasheed *et al.*, 2015). At both levels, the primary objective of RM is to reduce risk and mitigate the impact of potential losses (Bajo *et al.*, 2012). Given the unpredictability of the macro-environment, RM can be considered one of the most important approaches for companies to ensure business continuity (BC) and overcome uncertainties (Ferreira *et al.*, 2019). Successful RM enables companies to improve their ability to achieve objectives and ensure sustainability (Hopkin and Thompson, 2022, pp. xxiii, 1). Importantly, as a company's network grows more complex, the influence of factors at the external macro level becomes increasingly significant (Birnleitner, 2013).

Lark (2015, p. 8) highlight SMEs' vulnerability to risks compared to larger companies. Considering SMEs' vital role in national and global welfare (Statista, 2023a, b), the significance of RM cannot be emphasised enough in terms of enabling SMEs to deal with disruptions and their potential impacts. Small and medium enterprises constitute over 99% of businesses within the European Union (EU), serving as the backbone of the European economy. In manufacturing, they contribute nearly one-fifth of overall employment and value-added in the EU (EC, 2023, pp. 1, 12).

In the context of RM, the concept of resilience often arises (Hussen Saad *et al.*, 2021; Wooderson, 2022). Alongside RM and resilience, the significance of business continuity management (BCM) has been emphasised in responding efficiently to disruptions in the business environment (Bell, 2020, p. 30; Crask, 2021, p. 8). These aspects can also be seen as key elements that contribute towards organisational resiliency. Together with strategic agility and organisational resilience (OR), RM forms the fundamental cornerstones of sustainable and successful business operations (Crask, 2021, pp. 22–23; Holbeche, 2018, p. 22). Given the rapid development of new digital technologies and the data they provide, it would be beneficial to learn how these could be used for RM purposes (e.g. Araz *et al.*, 2020; Engemann, 2019; Stahl, 2021).

This review article summarises the key risks and challenges facing SMEs in their operating environment, both in general and specifically in the manufacturing industry, in countries that can be characterised as highly digitalised, such as many countries in the EU (Billon *et al.*, 2010). Within our review, we aim to answer the following research questions (RQs):

RQ1. What risk factors have been identified as affecting the BC of SMEs from the perspectives of business macro- and micro-environments?

RQ2. What benefits can SMEs operating in the manufacturing industry obtain by applying digital technologies or AI as part of their RM?

2. Background

2.1 RM and BCM

Risk can be defined as the impact of uncertainty on objectives, encompassing deviations from expected outcomes, whether these are positive, negative or both. When managing risks, organisations must confront internal and external factors that influence their operations and can make it uncertain whether they will achieve their objectives (ISO 31000, 2018, pp. v, 1). By anticipating potential risks and taking proactive steps to minimise their impact, RM enables organisations of all sizes to maintain their performance and capitalise on opportunities (COSO, 2017, pp. 3–4). The pursuit of business profits typically involves risks, and it rewards those with the best understanding of systems and the ability to select the most effective approach to managing risks (Olson and Wu, 2017). Risk management should be implemented

in strategic planning and throughout the organisation (Shad *et al.*, 2018). It can be seen as a continuous activity aimed at improving operations' resource allocation, ensuring compliance with established standards, achieving performance objectives, strengthening financial stability and safeguarding the company from potential harm (Chakabva and Tengeh, 2023).

While the RM framework is intended to assist the organisation in integrating risk management into significant activities and functions, BCM is intended to create plans as part of the BC process, setting out procedures for management to follow in order to recover after the disruption (Crask, 2021, p. 5; ISO 31000, 2018, p. 1). This transition from value creation to value protection, and then back to value creation, is a fundamental principle of BC (Crask, 2021, p. 6). Business continuity management refers to a management process that identifies potential threats to an organisation and provides a framework for building resilience and the capacity for an effective response. Combined with RM, it establishes key elements that contribute to organisational resiliency (Bell, 2020, p. 21; Crask, 2021, p. 4). Combined with strategic agility, RM and resilience form the "fundamental cornerstones" of sustainable business operations (Crask, 2021; Holbeche, 2018).

Regarding SMEs, Williams *et al.* (2022, p. 53) emphasise that disruptions can have fatal consequences for smaller companies in a worst-case scenario. Due to their limited financial and human resources, as well as their inability to systematically explore threats, smaller companies are particularly vulnerable. Because of their vulnerability issues, SMEs can be considered risky organisations (Ali *et al.*, 2023), and the significance of RM cannot be overstated. By incorporating RM strategies into their daily operations, SMEs can utilise their resources more effectively (Chakabva and Tengeh, 2023). On the other hand, Williams *et al.* (2022, p. 54) highlighted SMEs' ability to respond more quickly and agilely than large companies. Concerning responsiveness, Ruíz *et al.* (2016) point out that when a business's management team faces change, its members should also recognise the value of new information and risk-taking. Thus, when assessing risk factors, RM is not simply a question of anticipating or mitigating potential risks, but also of developing capabilities to turn uncertainties into opportunities (Plenty and Morrissey, 2020).

2.2 RM in connection to digital technologies and AI

In recent years, the adoption of advanced technologies has profoundly impacted nearly all industries, creating entirely new opportunities for businesses. These opportunities include benefits from technologies such as AI, algorithm-based decision-making and numerous other innovations (Johnston *et al.*, 2021, p. 468). These technologies enable the analysis of remote workers' productivity, supply-chain RM and modelling of changes in demand, among other capabilities. Digital tools and AI assist company management in gaining a better understanding of how things have changed and how disruptions have affected a company's operations (Baryannis *et al.*, 2018; Kane *et al.*, 2021, p. 119).

Digital technologies and AI also offer possibilities for RM, which can be supported by advanced software and data-mining methods. This involves creating understandable and useful information using the available data (Reddin and Miles, 2022; Runkler, 2020). These methods can be applied, for example, to reduce production-related risks (Collier and Evans, 2021) or in financial data collection and analysis (Naim, 2022).

3. Methods and materials

This study was based on a systematic literature review, conducted in seven phases (Fink, 2020, pp. 6–7) as described in Table 1. Prior to the actual database search, a pilot search was conducted to validate the functionality of the search terms and operators (see Appendix 1).

The review process began with 824 publications, which were exported to Covidence software for analysis. The number of studies was reduced to 798 after removing 26 duplicates

1	Selecting research questions	• RQ1 and • RQ2
2	Selecting bibliographic or article databases	• Scopus and • Ebsco (Academic Search Ultimate, Business Source Ultimate and AconLit with Full Text databases)
3	Choosing search terms	• Keywords • search terms • Boolean- and proximity operators (in Scopus PRE/5 and in Ebsco, N5 was used to permit a maximum word distance of five between the search terms to ensure that there were no overly close keywords)
4	Setting practical screening criteria	• English language • study setting and relevance • timeframe (2012–2023) • general applicability in highly digitalised countries, manufacturing and SMEs • abstract and full-text availability
5	Setting methodological screening criteria	• Study design: qualitative, quantitative and mixed methods
6	Conducting the review	• Database search • screening and title- and abstract-level review • full-text review and eligibility assessment based on the inclusion criteria
7	Synthesising the results	• Synthesis and analysis of the results • summary of the findings

Table 1. Phases of the literature review

Source(s): Created by the authors; Fink (2020, pp. 6–7)

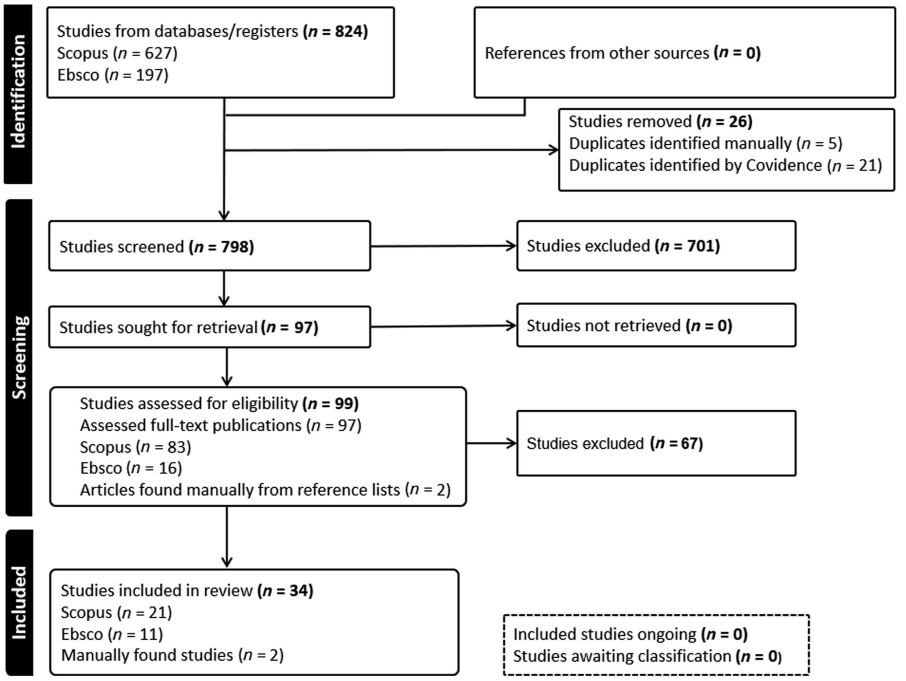
(see Figure 1). During the title and abstract screening, 701 publications were excluded due to misalignment with the screening criteria. Exclusions included studies conducted in irrelevant countries, industries, or research fields, and those focused on issues specific to underdeveloped countries and non-SME or manufacturing contexts. The screening left 99 full-text publications for further eligibility assessment after two articles were found manually. After thorough review, 34 publications met the inclusion criteria. In the final phase, the results were synthesised, and the findings were analysed and summarised.

3.1 Content and bibliometric co-word analyses

The final set of 34 publications was subjected to content analysis and bibliometric co-word analysis (Patton, 2002, pp. 452–453; Krippendorff, 2019, p. 93). The key information derived from the selected publications were presented descriptively in terms of a content analysis approach (Fink, 2020, p. 7; Patton, 2002, p. 452–453). A bibliometric co-word analysis was performed using VOSviewer (Version 1.6.18). The assumption that words in the same publication or context are related and reflect similar topics or concepts (Zupic *et al.*, 2015) forms the foundation of co-word analysis, which aims to uncover the underlying structure and thematic connections within the collected publications. The map represents the co-occurrence of terms based on the textual data, as illustrated in Figure 2. The density of each term is influenced by both the number of keywords and their respective weights.

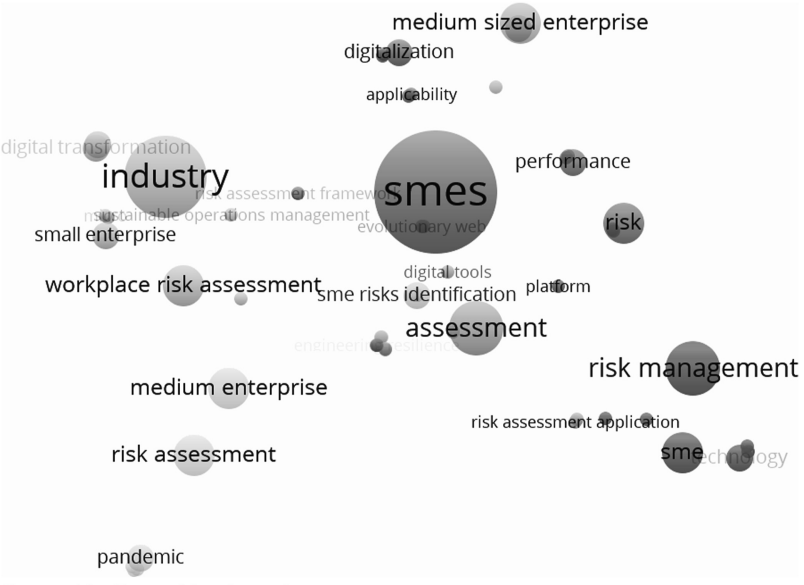
4. Results

Research has consistently highlighted the key obstacles for SMEs in maintaining BC. These include limited business development, disorganised structures, management errors, and vulnerability to external disruptions due to constrained organisational and financial



Source(s): Created by the authors

Figure 1.
Phases of the data selection process



Source(s): Created by the authors

Figure 2.
Co-word analysis of the included literature using VOSviewer

resources (De Matteis *et al.*, 2023; Shamsi and Aris, 2021; Zhu *et al.*, 2023). Unlike larger organisations, SMEs often struggle with investments in BC due to limited financial resources and weaknesses in technological, managerial, and human capacities (De Matteis *et al.*, 2023).

Additionally, OR is crucial for BC, where adaptive capacities, planning capacities, and foresight capacities play essential roles. A system is considered resilient when the likelihood of failing to reach the anticipated functionality or goal is sufficiently minimised (De Matteis *et al.*, 2023; Haraguchi *et al.*, 2016). Effective RM requires identifying and evaluating new risks, leveraging both internal and external information to assess them (Dvorsky *et al.*, 2021). However, limited resources hinder SMEs from effectively dedicating themselves to the RM process (Ponsard *et al.*, 2016), and the substantial data available for risk assessment further challenges their ability to perform manual analysis, impacting their BC (De Matteis *et al.*, 2023; Parikh *et al.*, 2024).

Proactive RM is emphasised for SMEs, particularly in the industry sector, to control changes and disruptions. In a dynamic business environment, today's decisions might not suit tomorrow's situations, making it essential to react proactively to uncertainty and change (Anguelov and Angelova, 2017).

Risks for manufacturing SMEs arise from various factors (see Appendixes 2 and 3). These risks manifest both externally and internally, and the impacts of both dimensions on company operations are recognised as crucial (Merich *et al.*, 2019; Vojtko *et al.*, 2019).

4.1 Defining risk factors in the macro-environment

Within the macro-environment (see Appendix 2), SMEs may encounter external risks arising from market, economic, political and pandemic-related uncertainties (Cheng *et al.*, 2021), with the COVID-19 pandemic being highlighted as the most recent example. Such external factors pose significant challenges and highlight the need for proactive RM (Grondys *et al.*, 2021). The pandemic showed the systemic nature of risk, extending beyond health to severe economic impacts and system disruptions. Post-pandemic, SMEs prioritised brand reputation risk alongside BC, market, and regulatory risks (Arnaudova *et al.*, 2023). Additionally, the shift to remote work introduced new risks on information systems, often with insufficient planning, design, or testing, leading to cybersecurity vulnerabilities (Jayarao *et al.*, 2024). Market environment risks affect new product or service production, customer retention and acquisition (Dvorsky *et al.*, 2021). Market environment risk factors included strong competitors, customer loss, market stagnation, and supplier unreliability (Grondys *et al.*, 2021). Market instability and uncertainty can cause financial issues (Georgios, 2019). Recognising the strategic importance of procurement and identifying risk factors in supplier relationships are also crucial (Urbaniak *et al.*, 2022).

Finding alternative suppliers is a significant challenge (Drydakis, 2022). During the financial crisis in 2008, SMEs struggled with financing due to tightened working capital and extended payment terms by buyers (Kong *et al.*, 2024). Economic risk factors include tax changes, limited financial resources, fluctuating interest or exchange rates, and increased energy costs (Cheng *et al.*, 2021; Grondys *et al.*, 2021). SMEs often rely on capital investments from owners or management, making them vulnerable to financial instability (Dvorsky *et al.*, 2021). The pandemic significantly influenced customer purchasing behaviour and supply chains, affecting performance. However, some SMEs thrived by quickly adapting to new opportunities, such as mask production (Chen and Wu, 2022).

4.2 Macro-environmental research trends

Research trends reflect concerns about market instability and uncertainty impacting business operations (Georgios, 2019). Recent studies emphasise various economic and political risk factors, including tax, interest, or exchange rate changes, and the complexity

faced by financial institutions in granting loans (Cheng *et al.*, 2021; Grondys *et al.*, 2021). There is also a growing awareness of the dynamic nature of global markets, with new competitors and unforeseen events posing significant risks (Dvorsky *et al.*, 2021). Recent publications have focused on the pandemic's impact on purchasing behaviours and market risks indicates a shift in consumer patterns and increased societal intolerance due to policymaking (Drydakis, 2022). Supply chain vulnerabilities and a lack of collaboration among suppliers remain concerns (Urbaniak *et al.*, 2022). Recent discussions have focused on how external crises and changing regulations affect business operations and investment decisions, with a continued emphasis on financial adaptability in response to new market conditions (Araudova *et al.*, 2023; Urbano *et al.*, 2023; Kong *et al.*, 2024).

4.3 Defining risk factors in the micro-environment

Operational risks for SMEs within the micro-environment stem from internal process deficiencies, including financial issues such as loss of profitability, insufficient capital, and payment difficulties (see Appendix 3). Risks may arise from limited utilisation of production capacity, outdated equipment, customer complaints, lack of innovation, and logistical deficiencies. SMEs face unique RM challenges due to limited resources compared to larger enterprises, necessitating continuous risk identification and evaluation (Grondys *et al.*, 2021). Effective RM in SMEs involves integrating internal and external management aspects. Key internal elements include motivation, employee engagement, dispersed responsibility, education and training (Arnaudova *et al.*, 2023).

Within the micro-environment, Cheng *et al.* (2021) highlighted environmental risk factors addressing waste, emissions, raw material usage, energy consumption, product responsibility, and regulatory compliance (Cheng *et al.*, 2021). Karthee *et al.* (2018) emphasise a range of risk factors affecting performance such as technical, economic, marketing, human resources, and management factors. Maintaining a company's economic stability requires addressing critical financial risk factors such as credit risks leading to insolvency (Georgios, 2019; Gošnik and Stubelj, 2022).

Furthermore, SMEs often lack consistent BCM strategies (Păunescu and Argatu, 2020) and face challenges in order-level risk evaluations due to insufficient data capital (Kong *et al.*, 2024). SMEs also contend with risks in five areas: physical, social, employee-related, equipment-related, and work-process-related (Dumitrescu and Deselnicu, 2018). Social risk factors include occupational safety, human rights, anti-corruption activities, labour practices, and product or service responsibilities (Cheng *et al.*, 2021). SMEs are also more vulnerable to occupational safety risks compared to larger companies, recognising inappropriate employee behaviour as a leading cause of workplace accidents in Polish manufacturing (Niciejewska and Idzikowski, 2022).

Additionally, in the post-COVID-19 era, new occupational health risks emerged, particularly psychosocial risks from increasing digitalisation, which blurs the boundaries between work and leisure (Palumbo *et al.*, 2022). While digital technologies improve task performance and productivity, they have subtle drawbacks that negatively impact workers' well-being, such as weakened face-to-face communication, increased dependence on technology, and changes to organisational culture (Beck and Lenhart, 2019). Risk factors related to organisational culture are linked to practices that may lead to bankruptcies, scandals, accidents and strikes and may risk the stability and future of a company (Readers and Gillespie, 2023). The organisational culture should align the RM infrastructure, allowing the team's shared vision, values, and goals to shape and reinforce the RM approach (Arnaudova *et al.*, 2023). Manufacturing SMEs also face obstacles regarding market access, lack of economies of scale, and higher transaction costs compared to larger enterprises

(Shamsi and Aris, 2021). Network risks related to trust, information sharing, and performance are also significant (Mahmood *et al.*, 2018).

4.4 Micro-environmental research trends

Research trends initially highlighted challenges due to limited organisational resources and the inability to execute RM strategies effectively (Ponsard *et al.*, 2016). In 2018, studies focused on technological, human resource, and RM gaps highlighting difficulties in adapting to technological development (Wiesner *et al.*, 2018; Karthee *et al.*, 2018; Dumitrescu and Deselnicu, 2018). In 2019, increasing pressures on operational and social environments were noted, with risks such as occupational safety (Merich *et al.*, 2019; Beck and Lenhart, 2019). More recent publications have emphasised the lack of consistent BCM strategies and the struggle with operational resilience (Păunescu and Argatu, 2020), highlighting outdated production facilities and impacting operational effectiveness (Cheng *et al.*, 2021; Grondys *et al.*, 2021). Limited technological and financial resources, particularly in SMEs, have been noted to affect competitive edge and market access (Shamsi and Aris, 2021).

Additionally, behavioural and psychosocial risks from digitalisation, alongside challenges related to operative processes and product quality, have been the focus areas of recent publications (Niciejewska and Idzikowski, 2022; Palumbo *et al.*, 2022; Urbaniak *et al.*, 2022). Notably, in the past two years the discussion has still been focused on internal challenges, such as limited financial resources, managerial weaknesses, and deficiencies in effective RM practices, emphasising the growing complexity of managing internal capacities to align with external demands (Mitra *et al.*, 2023; De Matteis *et al.*, 2023; Araudova *et al.*, 2023; Urbano *et al.*, 2023; Readers and Gillespie, 2023; Zhu *et al.*, 2023). Also an increased awareness of the need for robust data management systems for effective risk evaluation was recognised (Kong *et al.*, 2024).

4.5 Exploring benefits of digital technologies and AI in RM

The integration of digital technologies, particularly AI, has the potential to enhance SMEs' RM capabilities, contributing to their competitive advantage, performance, and productivity (see Figure 3). AI protects data and enhances cybersecurity (Drydakis, 2022), and provides real-time data for both humans and machines, improving production flexibility and efficiency. Technologies driving this digital revolution include the Internet of Things (IoT), Augmented Reality (AR), Virtual Reality (VR), Mixed Reality (MR), and Virtual Assistants (VAs), chatbots, and robots (Pereira *et al.*, 2023). However, it is crucial for SMEs to first assess their readiness and maturity level to ensure the effective adoption and utilisation of advanced technologies (Wiesner *et al.*, 2018).

Machine learning (ML) methods facilitate risk assessment by analysing various data types such as textual, image, categorical, and numerical data, improving financial risk prediction and order-level supply chain data analysis (Parikh *et al.*, 2024; Kong *et al.*, 2024). AI monitors consumer behaviour, user habits, and purchasing decisions, directly impacting sales and providing more reliable digital data for risk assessment. A data-driven approach to risk identification is increasingly recognised as a crucial tool compared with traditional, time-consuming manual analysis (Drydakis, 2022; Chavez *et al.*, 2020; Parikh *et al.*, 2024). Additionally, AI-driven applications in manufacturing optimise cash flow, manage financial risks, and enhance overall productivity and efficiency, particularly in labour-intensive tasks (Drydakis, 2022).

Digital tools automate RM tasks, saving time and reducing errors providing SMEs with reliable data for decision-making (Chavez *et al.*, 2020; Drydakis, 2022). Wiesner *et al.* (2018) propose a maturity model that can help SMEs assess their readiness to adopt new technologies. Stuja *et al.* (2018) highlight the fact that more advanced solutions offer better

Benefits of digital technologies and AI in Risk Management

SMEs

SMEs maturity and readiness to adopt new technologies (Wiesner *et al.* 2018).

Technological Advancements in Risk Assessment

AI	VA, Chatbots	VA and AI, Language Models	Machine Learning, Text Mining	Other Digital Technologies
✓ Protects data, customers` privacy and strengthens cybersecurity (Drydakis, 2022). ✓ Enhances dynamic capabilities and improves overall productivity and efficiency, particularly in labour-intensive tasks (Drydakis, 2022). ✓ Production flexibility and efficiency by providing real-time data to both humans and machines (Pereira *et al.* 2023). ✓ Monitoring sales, analysing consumer behaviour, user habits and purchasing decisions (Drydakis, 2022).	✓ Data accuracy, timely information to production workers (Pereira *et al.* 2023). ✓ Enhances customer communication (Drydakis, 2022). ✓ Improves financial RM and price prediction (Drydakis, 2022).	✓ Enhances information retrieval (Pereira *et al.* 2023). ✓ Can accommodate multiple data types for processing (Parikh *et al.* 2024). ✓ Better control of connected devices (Pereira *et al.* 2023). ✓ Enhances a company's capabilities (Pereira *et al.* 2023).	✓ Facilitates risk assessment by tailoring specific data types (Parikh *et al.* 2024). ✓ Makes data processing and analysis more effective (Mitra *et al.* 2023). ✓ Facilitates financial risk assessment (Kong *et al.* 2024; Mitra *et al.* 2023). ✓ Enhances the evaluation of financial risks within the supply chain (Kong *et al.* 2024). ✓ Enhances the accuracy of credit risk assessment (Mitra *et al.* 2023). ✓ Allow effective data processing and analysis, and creation of complex models (Mitra *et al.* 2023).	✓ Digital tools save time and provide more reliable digital data (Chavez *et al.* 2020). ✓ Enable more effective analysis compared to traditional, time-consuming manual analysis (Parikh *et al.* 2024). ✓ Allows the creation of more advanced solutions that offer better competitiveness in the market and support decision-making (Stuja *et al.* 2018).

Source(s): Created by the authors

Figure 3.
Key digital technologies for RM in SMEs

competitiveness in the market, especially for small and medium-sized manufacturers. They also assist SMEs in risk assessment and management, thus supporting decision-making. Furthermore, AI and ML applications, such as natural language processing (NLP), enable effective data processing and analysis. These technologies facilitate complex models for credit risk assessment (Mitra *et al.*, 2023), exemplifying how technologies powered by AI and ML contribute to financial risk assessment.

4.6 Conceptual synthesis of digital technologies and AI in RM

Integrating digital technologies and AI into SMEs' risk assessment represents a shift towards data-driven decision-making. Figure 3 highlights various technological advancements and their benefits in RM. These technologies not only improve the accuracy and efficiency of risk evaluations but also enhance OR and help maintain a competitive edge in a rapidly evolving business environment.

New digital technologies empower SMEs to enhance their dynamic capabilities and improve productivity, particularly in labour-intensive tasks (Drydakis, 2022). These technologies enable SMEs to process larger amounts of data with higher accuracy and efficiency (Pereira *et al.*, 2023). Machine learning algorithms tailor data analysis to specific risk factors, improving financial predictions and supply chain risk evaluations (Mitra *et al.*, 2023; Kong *et al.*, 2024). Technologies such as text mining and language models facilitate the analysis of unstructured data such as customer feedback and market trends, supporting more informed decision-making processes (Pereira *et al.*, 2023; Parikh *et al.*, 2024). Automation of RM tasks, such as monitoring sales and assessing credit risks, saves time and reduces errors, providing SMEs with more reliable data for decision-making (Chavez *et al.*, 2020; Drydakis, 2022).

4.7 Research trends of key digital technologies in RM

The starting point of the reviewed literature is the early adoption of AI and digital technologies, highlighting their potential to transform traditional risk management processes through enhanced data processing and analysis (Wiesner *et al.*, 2018). As technology advanced, studies have emphasised the mainstream adoption of digital tools, noting their role in improving reliability and efficiency in managing timely resources (Chavez *et al.*, 2020). In 2022, the focus shifted towards strengthening cybersecurity measures and enhancing operational efficiency and dynamic capabilities (Drydakis, 2022). Recent literature highlights the implementation of real-time data delivery and enhanced analytical capabilities, indicating a trend towards dynamic and responsive RM solutions (Pereira *et al.*, 2023). Looking ahead, the most recent research focuses on highly tailored and advanced risk assessments using AI, moving towards specialised, AI-driven solutions designed to tackle complex and specific risk environments (Parikh *et al.*, 2024; Kong *et al.*, 2024). This progression showcases the sophisticated future direction of digital technology applications in RM.

4.8 Theoretical synthesis of key factors influencing RM and BC

This chapter synthesises findings from the literature review, integrating the theoretical frameworks of RM and BC. Figure 4 illustrates the connections between these frameworks and the application of digital technologies and AI. SMEs can leverage these technologies to enhance RM practices, understanding their multifaceted benefits and the necessity of a proactive approach in assessing risk factors. SMEs face unique challenges owing to their limited resources, which hinder effective RM activities (De Matteis *et al.*, 2023; Shamsi and Aris, 2021; Zhu *et al.*, 2023). Digital technologies and AI provide tools for overcoming these challenges by facilitating real-time data analysis and enabling continuous risk identification

Source(s): Created by the authors

Figure 4.
The role of digital technologies and AI enhancing SMEs RM and BC

and evaluation (Grondys *et al.*, 2021; Dvorsky *et al.*, 2021). Effective RM and BC rely on a holistic view of the risk landscape, integrating data from internal operations and external conditions for a comprehensive understanding of potential threats and opportunities (Chen and Wu, 2022; Dvorsky *et al.*, 2021).

The synthesis of research insight underscores the need for a comprehensive, technology-driven RM approach. This strategy enhances SMEs' ability to manage risks effectively and ensures sustained BC in an uncertain, global, and digitalised environment. Embracing digital solutions and fostering a proactive RM culture helps SMEs navigate micro and macro-environmental challenges adeptly, positioning them for long-term success and resilience. A proactive RM approach leverages digital technologies to assess vulnerability, improve data accuracy and efficiency, automate compliance checks, and streamline resource allocation, making RM processes more efficient and sustainable (Dvorsky *et al.*, 2021; Pereira *et al.*, 2023; Mitra *et al.*, 2023; Kong *et al.*, 2024). To capitalise on the benefits of digital technologies and AI, SMEs must address knowledge gaps in AI integration and ensure regular updates, training, and education for staff. Integrating these technologies within their digital transformation strategies can significantly enhance dynamic capabilities by improving sensing, seizing, and transforming capabilities to mitigate risk (Drydakis, 2022; De Matteis *et al.*, 2023; Wiesner *et al.*, 2018).

This comprehensive technology-driven RM approach helps SMEs navigate micro and macro-environmental challenges, positioning them for long-term success. Additionally, these measures enhance adaptive capacity and move towards OR (Grondys *et al.*, 2021; De Matteis *et al.*, 2023; Dvorsky *et al.*, 2021). By embracing digital solutions and fostering a proactive RM culture, SMEs can strategically plan and execute decisions to boost performance and ensure sustained BC.

5. Discussion and future research directions

This review explored a range of risk factors affecting SME continuity, underscoring the need for multidimensional and cross-functional research (Fred and Forest, 2023; Glew *et al.*, 2023). Consistent with Ashby (2022) and Rasheed *et al.* (2015), the findings highlight the need for a multidimensional impact assessment in RM practices, complementing Hussen Saad *et al.*'s (2021) view on SME resilience in adapting to new, risky environments. The theoretical synthesis of key risk factors also highlights the need for a comprehensive approach to RM and BC across both macro and micro dimensions (Crask, 2021). The variety of risk factors underlines the necessity of a proactive approach, vulnerability assessment, and implementation of digital technologies and AI (Engemann, 2019; Ali *et al.*, 2023). Considering the rapid development of new technologies, it is crucial for SMEs to understand how to utilise these innovations for RM purposes to fully capitalise on their benefits (Araz *et al.*, 2020; Engemann, 2019; Stahl, 2021).

Due to SMEs' vulnerability to risks and recognised resource constraints (Lark, 2015; Williams *et al.*, 2022), the rapid adoption of digital technologies and AI in 2023–2024 offers a transformative opportunity for proactive RM. Technological advancements provide SMEs with tools for continuous risk identification and evaluation, essential for effective RM and BC (Grondys *et al.*, 2021; Araz *et al.*, 2020; Engemann, 2019; Stahl, 2021). Strategic integration of technological advancements significantly enhances SMEs' operational capabilities, allowing them to better handle uncertainties. AI adoption particularly improves SMEs' dynamic capabilities, enabling more effective RM (Drydakis, 2022; Pereira *et al.*, 2023). Regular updates and staff training further enhance adaptability and OR (De Matteis *et al.*, 2023), positioning SMEs to mitigate risks effectively. Technological development has evolved digital technologies in RM from initial adoption to essential, advanced tools that provide strategic advantages in assessing and mitigating risks. This shift highlights their growing integration

into core business functions (Rasheed *et al.*, 2015). SME managers should assess risks within internal and external dimensions, proactively identifying unforeseen risk factors and their impact on operations. Given the unpredictability of the macro-environment (Ferreira *et al.*, 2019), we emphasise the importance of continuous vulnerability assessments across both dimensions, especially as networks grow more complex (Ali *et al.*, 2023; Birnleitner, 2013). Economic and financial risk factors are fundamental to BC and RM and are essential for mitigating potential losses and capitalising on opportunities (Bajo *et al.*, 2012; Whittington *et al.*, 2020).

5.1 From reactive measures to proactive strategies

Gaps and challenges in the adaptation of technological development seem to be a pertinent issue (Wiesner *et al.*, 2018; Arnaudova *et al.*, 2023). The recognised RM benefits of applying new digital technologies or AI within manufacturing SMEs seem to be generally applicable outside the manufacturing sector as well (Stahl, 2021). Our review underscores the need for continuous exploration and a proactive approach to better understand the causality between risk factors and their impact on business operations. SMEs can foster a risk-aware culture and BCM processes through regular risk assessments, leveraging various digital technologies and AI. These tools support navigation in complex business environments and enable the assessment of factors from both opportunity and downside perspectives.

Acknowledging SMEs' resource constraints, external expertise may add value to effective RM and BCM. Integrating digital technologies and AI enhances SMEs' competitiveness and decision-making capabilities, and by breaking down barriers through more effective and proactive utilisation of internal and external information, as noted by Dvorsky *et al.* (2021), SMEs can leverage it as an asset to address acknowledged vulnerabilities. We consider this a key factor in enhancing a company's adaptability to new, risky environments (Hussen Saad *et al.*, 2021). In addition to RM's primary objective (Bajo *et al.*, 2012), the more effective and proactive utilisation of internal and external information, SMEs should recognise the value of RM in taking risks (Ruíz *et al.*, 2016).

5.2 Future research opportunities

Future research should prioritise evaluating the influence of SME resource constraints on OR. This involves understanding SME vulnerabilities from different resource perspectives, and identifying solutions to bridge these gaps. Research should focus on how SMEs can target their resources in RM processes to mitigate high-impact risks. Providing practical examples of integrating dynamic capabilities and adaptive capacities into digital transformation strategies may help strengthen SMEs' OR and BC. Future RM research should also further address the latest digital technologies, such as IoT, AR/VR/MR, virtual assistants, chatbots, and machine learning (Pereira *et al.*, 2023). The foundational components that enable these technologies to function effectively should be studied, aiming to find sustainable solutions for integrating these elements into SMEs' RM infrastructure. Additionally, research could explore Schein's (2004) theory of organisational culture within the context of SMEs and RM, examining how cultural factors affect risk tolerance and awareness across countries, which is crucial for RM and BCM in a global context (Graham and Kaye, 2006).

5.3 Limitations

This study has several limitations. First, it focuses specifically on SMEs and the manufacturing sector, limiting the generalisability of the results. Secondly, the reproducibility and transferability of the review are limited, as search results from databases may change over time, and different databases, search terms, or timeframes could yield different results. Thirdly,

the review excludes larger organisations that could be relevant to the SME context. Including larger organisations might have altered the database results. Therefore, there may be publications with different risk factors that were not considered in this study. Despite efforts to be thorough and objective, the researchers acknowledge the potential subjectivity in the paper-screening process.

6. Conclusions

6.1 Contribution to theory and practice

This paper provides a comprehensive literature review identifying the risk factors and challenges impacting SMEs' BC. It highlights the evolution of research from recognising general market instabilities to focussing on nuanced aspects such as regulatory changes, financial unpredictability, and global crises. Recent studies emphasise proactive RM and adaptation, reflecting a deeper understanding of global interconnections in economies, politics, and social systems. This reflects a shift from identifying basic operational and resource challenges to a more sophisticated analysis of technological advancements in RM. This underscores the crucial role of effective RM in sustaining SMEs in a complex and volatile landscape, emphasising the need to adopt digital technologies and AI to assess threats and opportunities.

The shift towards digital transformation in SMEs, particularly through AI adoption, enhances their dynamic capabilities. The strategic use of digital technologies reshapes traditional RM paradigms and operational efficiency, highlighting a shift towards more agile, foresighted, and resilient business practices. As SMEs continue to navigate the complexities of the digital era, the adoption of digital technologies and AI can provide them with tools to thrive in competitive and dynamic environments. The ongoing evaluation of AI's impact on business performance is crucial for refining these strategies and ensuring that SMEs can fully realise the benefits of digital transformation. To fully capitalise on these benefits, SMEs must address existing knowledge gaps in technology integration and adopt a holistic approach to digital transformation. This ensures sustained improvement in their RM practices, better preparation for future challenges, and a robust foundation for continued growth and competitiveness in an increasingly uncertain and digitalised era.

6.2 Implications for risk management

This review highlights the importance of a multidimensional approach to ensuring effective RM and capitalisation on opportunities, thereby enhancing BC and sustainable success. Our review underscores the difficulties in influencing macro-level risk factors, which are significant from a proactive perspective on a company's operations and success. In contrast, regarding the risk factors within the micro-environment, companies have a more immediate influence and can address them within a shorter response time.

While leveraging technological transformation in general, SMEs should also incorporate new digital technologies and AI to strengthen their RM capabilities, as well as to contribute to OR. In the current globalised, volatile and digitalised era, SMEs' vulnerabilities are evident, highlighting the need for comprehensive RM and consistent BCM strategies. Looking ahead, the integration of modern digital tools into RM processes will play a pivotal role in promoting SMEs' sustainable success.

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Table A1.
Search terms and number of hits from both databases

Time frame	Article title, abstract, keywords	Article title, abstract, keywords	Article title, abstract, keywords	Article title, abstract, keywords	Article title, abstract, keywords	Hits
Scopus						
2012–2024	(risk assessment OR continuity management) OR (risk* resilien* continuity PRE/5 management)	AND (organisational AND resilience) OR (manufactur* OR industr* OR factory OR plant OR production)	AND (sme OR smes OR smb OR smbs OR msme OR msmes) OR (small* OR medium PRE/5 business* OR compan* OR enterpris* OR firm* OR corporation* OR manufactur* OR industr* OR factory OR plant OR production)	AND (manufactur* OR industr* OR factory OR plant OR production)	OR (artificial AND intelligence* OR ai* OR machine AND learning* OR industry AND 4.0*)	627
Ebsco						
2012–2024	(risk assessment OR continuity management) OR (risk* resilien* continuity N5 management)	AND (organisational AND resilience) OR (manufactur* OR industr* OR factory OR plant OR production)	AND (sme OR smes OR smb OR smbs OR msme OR msmes) OR ((small* OR medium) N5 (business* OR compan* OR enterpris* OR firm* OR corporation* OR manufactur* OR industr* OR factory OR plant OR production))	AND (manufactur* OR industr* OR factory OR plant OR production)	OR (artificial AND intelligence* OR ai* OR machine AND learning* OR industry AND 4.0*)	197

Source(s): Created by the authors

Author(s)/ Year	Market and customer	Economic and financial	Political	IT	Performance	Environmental
Jayarao *et al.* (2024)				✔ New type of risks arising from a pandemic situation ✔ Cybersecurity vulnerabilities ✔ Security risks to information systems		
Kong *et al.* (2024)		✔ Changes or extensions of buyer payment terms				
Araudova *et al.* (2023)	✔ New type of business risks arising from a pandemic situation		✔ Changes in regulations that affect business operations			
Urbano *et al.* (2023)		✔ Trends that affect investment decisions				
Chen and Wu (2022)					✔ Supply-chain disruptions ✔ Lack of a proactive RM approach hindering business performance ✔ Decreased customer consumption	

(*continued*)

Table A2. Classification of macro-environmental risk factors

Table A2.

Author(s)/ Year	Market and customer	Economic and financial	Political	IT	Performance	Environmental
Urbaniak *et al.* (2022)	✔ Lack of collaboration of suppliers	✔ Suppliers weak financial situation			✔ Supply-chain disruptions ✔ Weak supplier relationships	✔ Situations such as floods, tsunamis, earthquakes or fire
Drydakis (2022)	✔ Changes in the purchasing behaviour of customers ✔ Markets are located in medium or high-risk countries	✔ Pandemic situation impacting on economic activity	✔ Policy making and governance exacerbating societal intolerance	✔ Cyber threats or complex cyber-attacks	✔ Pandemic situation impacting company performance	
Cheng *et al.* (2021)		✔ Changing tax, interest or exchange rates ✔ Financial institutions´ complexity in granting loans ✔ Supplier financial instability ✔ Indirect economic impacts	✔ Political decisions affecting company's performance			✔ Climate change ✔ Natural catastrophes

(*continued*)

Table A2.

Author(s)/ Year	Market and customer	Economic and financial	Political	IT	Performance	Environmental
Grondys *et al.* (2021)	✔ Strong competitors in the sector ✔ Market-environment change or disruption ✔ Volatility of market prices or drop in market demand ✔ Loss of customers ✔ Unreliable suppliers ✔ New type of business risks arising from a pandemic situation	✔ Increased energy costs ✔ Increased interest or exchange rates and inflation ✔ Poor availability or financial resources (grants, loans) ✔ Economic uncertainty or unpredictability of economic phenomena (stagnation, recession) ✔ Unknown threats arising from an economic downturn	✔ Increased compulsory contribution related to law or regulation ✔ Tax tightening ✔ Uncertainty or volatility in the country's political environment		✔ Supplier unreliability ✔ Loss of key partners	
Dvorsky *et al.* (2021)	✔ Threat of new, strong competitors ✔ Risks associated with unforeseen events or unanticipated risk factors					
Georgios (2019)	✔ Market instability or uncertainty					
Javaid and Iqbal (2017)				✔ Cybersecurity and IT risks		
Frequency of elements	13	13	6	5	8	3

Source(s): Created by the authors

Table A3. Classification of micro-environmental risk factors

Author(s)/ Year	Technological	Financial	Market	Operational	Employees and social environment	Environmental
Kong *et al.* (2024)	✔ Limited technological resources ✔ Insufficient data capital ✔ Lack of data to conduct order-level risk evaluations					
Mitra *et al.* (2023)		✔ Low collateral level	✔ Vulnerability to market conditions			
De Matteis *et al.* (2023)	✔ Weaknesses in technological, managerial, and human capacities	✔ Limited financial resources	✔ Limited operating market	✔ Limited organisational resources	✔ Weaknesses in managerial, and human capacities	
Araudova *et al.* (2023)	✔ Challenges to adapt to technological development			✔ Deficiencies in effective RM practices	✔ Lack of risk management culture ✔ Lack of shared vision, values, and goals to shape the RM approach	
Readers and Gillespie (2023)					✔ Risks in the social environment (organisational culture)	
Zhu *et al.* (2023)				✔ Lack of resources and reliable mechanisms to support RM activities		

(*continued*)

Author(s)/ Year	Technological	Financial	Market	Operational	Employees and social environment	Environmental
Urbano *et al.* (2023)		✓ Lack of long-term planning on investments				
Gošnik and Stubelj (2022)		✓ Weak financial performance and overall profitability				
Niciejewska and Idzikowski (2022)					✓ Inappropriate employee behaviour as a source of business risk	
Palumbo *et al.* (2022)					✓ Psychosocial risks associated with increasing digitalisation at work	
Urbaniak *et al.* (2022)				✓ Long order processing time		
				✓ Quality defects of products		
Drydakis (2022)				✓ Lack of knowledge on how to integrate AI into digital transformation strategies to enhance dynamic capabilities		

(*continued*)

Table A3.

Table A3.

Author(s)/ Year	Technological	Financial	Market	Operational	Employees and social environment	Environmental
Shamsi and Aris (2021)	✔ Limited technological resources	✔ Lack of financial resources ✔ Lack of economies of scale ✔ SMEs' potentially higher transaction costs as compared to larger companies	✔ Challenges related to market access ✔ Geographical isolation			
Cheng *et al.* (2021)	✔ Technological practicability ✔ Technological suitability				✔ Gaps in anti-corruption activities ✔ Human-rights deficiencies	✔ Gaps in product and service responsibility ✔ Gaps in regulation compliance ✔ Gaps in waste and emission management
Grondys *et al.* (2021)	✔ Innovation gaps as a source of business risk	✔ Poor availability of financial resources (grants, loans) ✔ Lack economies of scale	✔ Risks associated with customer complaints	✔ Outdated production facilities ✔ Limited utilisation of production capacity		
Dvorsky *et al.* (2021)		✔ Difficulties in business financing or lack of funds	✔ Lack of competitive advantage			

(*continued*)

Table A3.

Author(s)/ Year	Technological	Financial	Market	Operational	Employees and social environment	Environmental
Păunescu and Argatu (2020)				✔ Lack of consistent BCM strategies		
Beck and Lenhardt (2019)					✔ Increased pressure on working time ✔ Weakened face-to-face communication	
Georgios (2019)		✔ Credit risks or inability to fulfil financial obligations ✔ Payment difficulties leading to insolvency				
Merich *et al.* (2019)					✔ Occupational safety risks	
Dumitresku and Deselnicu (2018)			✔ Lack of domestic and international networks	✔ Hazardous or outdated equipment ✔ Risks associated with product quality		
Karthee *et al.* (2018)				✔ Technical, human resource and management factors that affects performance		

(*continued*)

Table A3.

Author(s)/ Year	Technological	Financial	Market	Operational	Employees and social environment	Environmental
Mahmood *et al.* (2018)	✓ Network risks associated with gaps in trust and information sharing				✓ Network risks associated with gaps in trust and information sharing	
Weisner *et al.* (2018)	✓ Challenges to adapt to technological development					
Ponsard *et al.* (2016)				✓ Limited organisational resources ✓ Inability to execute RM strategies		
Frequency of elements	11	12	7	14	12	3

Source(s): Created by the authors