

RE ARTICLE

A review of the digitalization of the small and medium enterprises (SMEs) toward sustainability

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Abstract

Small- and medium-sized enterprises (SMEs) are of paramount importance in the global economy. The advent of the COVID-19 pandemic has significantly impacted numerous economies, resulting in substantial transformations across various aspects and elements of SMEs. The acceleration of digital transformation has been observed as a notable response to the ongoing pandemic. The utilization of digital transformation as a means of fostering innovation has the potential to facilitate sustainability, enhance competitiveness, and enable customization in both products and services. Nevertheless, there is a lack of comprehensive understanding regarding the extent to which SMEs have embraced digital technology in order to support and promote sustainability objectives. Hence, the primary objective of this study is to present an in-depth review of the digitization of SMEs in relation to sustainability, employing the systematic literature review approach. The analysis conducted encompassed three primary domains: the technological facets of digitalization, sustainability in accordance with the triple bottom line (comprising economic, environmental, and social factors), and the business attributes specific to SMEs. This review analysis elucidated the specific technological advancements that facilitate SMEs in their pursuit of sustainable development. In addition, this study synthesizes material that discusses the sustainability aspects of the triple bottom line and the specific areas of Industry 4.0 technology that have been utilized. Furthermore, the literature identifies other aspects including corporate strategy and management, organizational structure, organizational culture, skills and qualifications, and leadership considerations. Additionally, it synthesized potential avenues for future research that have emerged from the study. This study makes a significant contribution to the achievement of sustainable development goals (SDGs) and offers vital insights for policymakers and SMEs seeking to transition their production practices towards sustainability and digitalization.

Keywords: SMEs; Digitalization; Industry 4.0; Sustainability; Technology; Innovation

Introduction

Small and medium-sized firms (SMEs) are widely recognized as significant catalysts for economic development (Raihan et al., 2023a). They play a crucial role in generating job opportunities and fostering competitiveness by promoting innovation and the establishment of new ventures (Mago & Modiba, 2022). SMEs account for around 90% of firms globally and contribute to over 50% of employment (World Bank, 2023). The advent of the COVID-19 epidemic has brought about significant transformations in various aspects and elements of SMEs.

The COVID-19 pandemic has expedited a particular shift known as digital transformation, which has had a profound impact on business procedures and organizational culture worldwide. This transformation has transcended traditional borders and posed challenges to the competitiveness of organizations (Melo et al., 2023). Nevertheless, enterprises are currently confronted with the simultaneous difficulty and prospect of undertaking digital transformation by digitizing their pre-existing business procedures in order to sustain competitiveness (Azevedo & Almeida, 2021). According to Quinton et al. (2018), businesses can strategically navigate the utilization of developing digital technologies to enhance their competitive advantage and capitalize on chances for innovation-driven growth. This can be achieved through a combination of market, learning, and entrepreneurial orientations. There is an increasing urgency for SMEs to adopt creative approaches and digital production methods to sustain their competitive edge over the long term. In addition, the broader notion of Industry 4.0 encompasses the utilization of various technologies related to decentralized data management within the cyber-physical system (CPS). These technologies are being employed to facilitate modifications in the technical and production advancements of companies, ultimately resulting in enhanced business performance.

Furthermore, it can be argued that the phenomenon of digital transformation serves as both a catalyst and a precursor to the pursuit of sustainability. In this context, it is imperative for industrial enterprises to cultivate the necessary digital competencies to effectively address the interrelated economic, environmental, and social aspects of sustainability (Gomez-Trujillo & Gonzalez-Perez, 2021). Hence, SMEs have the potential to utilize the functionalities of digital production techniques in order to facilitate a trajectory toward sustainability (Telukdarie et al., 2022). Digitalization plays a crucial role in achieving company sustainability by effectively addressing the fundamental principles of circular economy and sustainable development. Following the COVID-19 epidemic, there has been an increased significance placed on sustainability performance. SMEs experienced the greatest impact as a result of the pandemic, including heightened challenges stemming from disruptions to their business operations. According to Rodrigues et al. (2021), it is possible that this has resulted in enduring liquidity challenges and had an impact on employment sustainability. Furthermore, in light of the environmental issues faced by the market, companies are obligated to consider environmental sustainability while they engage in digital innovation (Feroz et al., 2021). From a conceptual standpoint, sustainable development may be perceived as a strategic approach employed by businesses to address environmental challenges by fostering sustainable growth inside organizations. According to Lu et al. (2020), there is a consensus among scholars that the adoption of sustainable development practices is increasingly recognized as a strategic approach for businesses, with the potential to contribute to long-term growth and stability.

Several studies in the extant literature have examined the performance of digitalization in SMEs (Abdirad & Krishnan, 2021; González-Varona et al., 2021; Pfister and Lehmann, 2021). In many instances, the attention was limited to a singular performance aspect, such as the economic or financial dimension, without considering the broader sustainability implications encompassing economic, social, and environmental factors. On the other hand, some studies have focused on the confluence between Industry 4.0 and sustainability (Rosa et al., 2020; Beier et al., 2020) along with supply chain management and sustainability (Birkel and Müller, 2021). Hence, there is a distinct void in the research on performance indicators for SMEs, which comprehensively incorporates digital, economic, social, and environmental dimensions. Therefore, to fill up the existing literature gap, this research aims to examine the influence of digital transformation on the sustainable development of SMEs by using the systematic literature review methodology.

This review analysis primarily examined three key areas: the technological aspects of digitalization, sustainability, and the business features of SMEs. This study provides valuable insights for academia, practitioners, and policymakers, aiming to assist SMEs in their efforts to adopt and implement sustainability-related practices. The study's findings would provide valuable insights for the effective implementation of policies aimed at fostering

digitalization in SMEs, thereby contributing to sustainability. Furthermore, this study makes a valuable contribution to the sustainable development goals (SDGs) outlined by the United Nations (UN), specifically SDG 1 (eradicating poverty), SDG 2 (eliminating hunger), SDG 3 (promoting good health and well-being), SDG 5 (achieving gender equality), SDG 8 (fostering decent work and economic growth), SDG 9 (advancing industry, innovation, and infrastructure), SDG 10 (reducing inequality), and SDG 12 (encouraging responsible consumption and production).

Methodology

The current investigation utilized the systematic literature review methodology as recommended by Raihan and Bijoy (2023). The systematic literature review methodology is widely regarded as a reliable and robust approach (Benita, 2021). Systematic literature reviews offer a rigorous and replicable approach to investigating a developing field of research. By comprehensively examining existing literature, these reviews provide an overview of the current knowledge and facilitate the identification of crucial issues that need to be addressed, as well as potential areas for future research. A preliminary literature review was undertaken to identify relevant articles, validate the proposed concept, prevent duplication of previously addressed topics, and ensure the availability of an adequate number of articles for conducting a thorough analysis of the digitalization in SMEs in relation to sustainability. The relevant publications were comprehensively searched through four well-regarded academic databases, specifically Google Scholar, Scopus, ScienceDirect, and Web of Science, encompassing the period from 2000 to 2023. The keywords encompass three fundamental principles, specifically: SMEs, sustainability, and digitalization. The latter concepts encompass the terms "Industry 4.0," "Digital Transformation," "Automation," and "Smart manufacturing." The present study exclusively utilized research publications that have completed a rigorous peer review process conducted by subject matter experts, hence ensuring the credibility and soundness of the results. The study encompassed an examination of both qualitative and quantitative secondary literature pertaining to the digitization and sustainability of SMEs. Following this, the review implemented the process of citation tracking, which involves systematically monitoring all scholarly works that mention each of the papers included in the collection. The preliminary search yielded about one thousand documents.

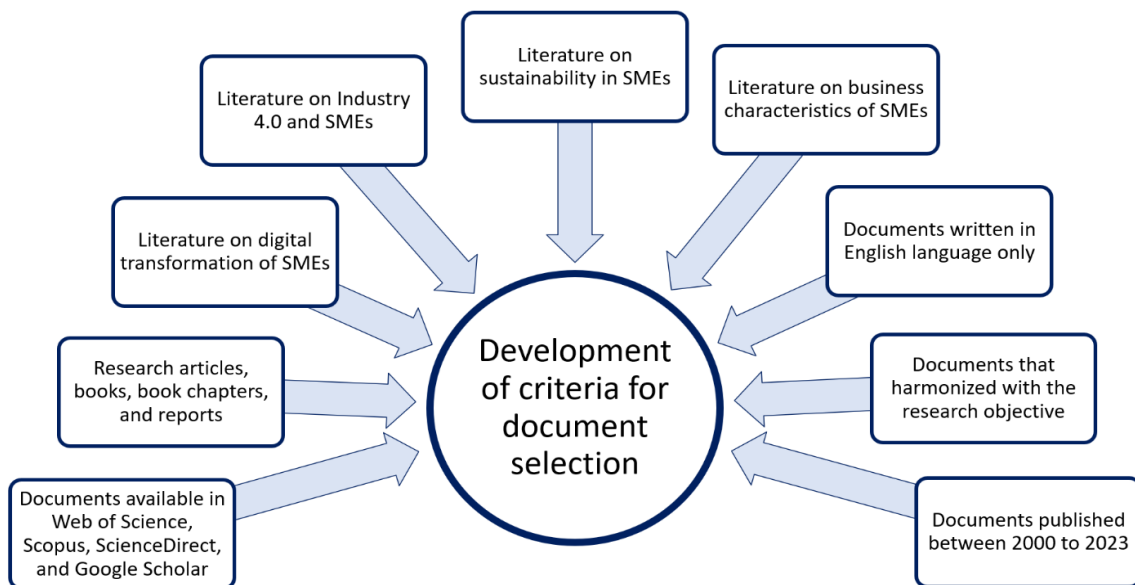


Figure 1. The development of criteria for the selection of documents.

The second search involved the inclusion of peer-reviewed papers, book chapters, and reports from government and international agencies. Subsequently, the examination involved an analysis of the titles, keywords, and abstracts of the retrieved search outcomes in order to ascertain their level of relevance. For example, any publications that did not discuss the digitalization or sustainability of SMEs were excluded. The main rationales for the deletion of articles are their lack of relevance, duplication, inadequate textual content, or limited inclusion of abstracts. The preset exclusion criteria were implemented in order to mitigate the risk of any biases that may impact the results. Figure 1 depicts the sequential evolution of the review criteria utilized in the process of selecting suitable documents.

The literature review conducted in this study comprised a total of 61 unique scholarly papers. It is important to highlight that out of the 61 papers included in the qualitative synthesis, only those publications that offered pertinent information were referenced in the manuscript's bibliography. It indicates that specific articles were omitted from the reference list. Figure 2 depicts the several stages of the systematic review technique employed in the present investigation. Once the research topic had been selected, this study progressed by conducting a comprehensive search for pertinent articles, followed by an analysis and synthesis of various literature sources. Subsequently, written materials were prepared for the purpose of article review. The synthesis phase involved gathering a diverse array of articles, which were then combined into conceptual analyses that were pertinent to the completed research.

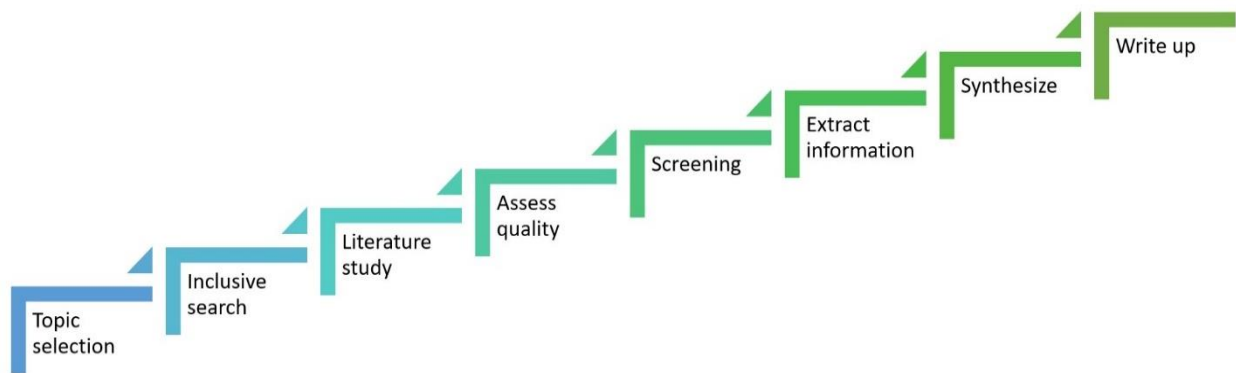


Figure 2. The procedure of systematic review conducted by the study.

Results and Discussion

Digitalization and technological innovations in SMEs

Digitalization and technological innovations within the framework of Industry 4.0 and sustainability in SMEs are presented in Figure 3. Firms start digital transformation initiatives with a favorable adoption culture and a clear perspective of procedures. SMEs must recognize and grasp digital growth opportunities and implement project-based learning to stay competitive in turbulent circumstances (North et al., 2019). Mukhtar et al. (2020) showed how IT affects SMEs' sales performance. Others use a basic internet-enabled platform and an eco-sourcing tool based on Model View Control (MVC) architecture for SMEs to allow customers to pick and order vehicle products online (Anthony, 2019). Mekhum (2020) explored how supply chain cultural competence and technology adoption affect Thai SMEs' performance. Both aspects affect performance, but supply chain cultural capabilities are vital to technological adoption, according to the study.

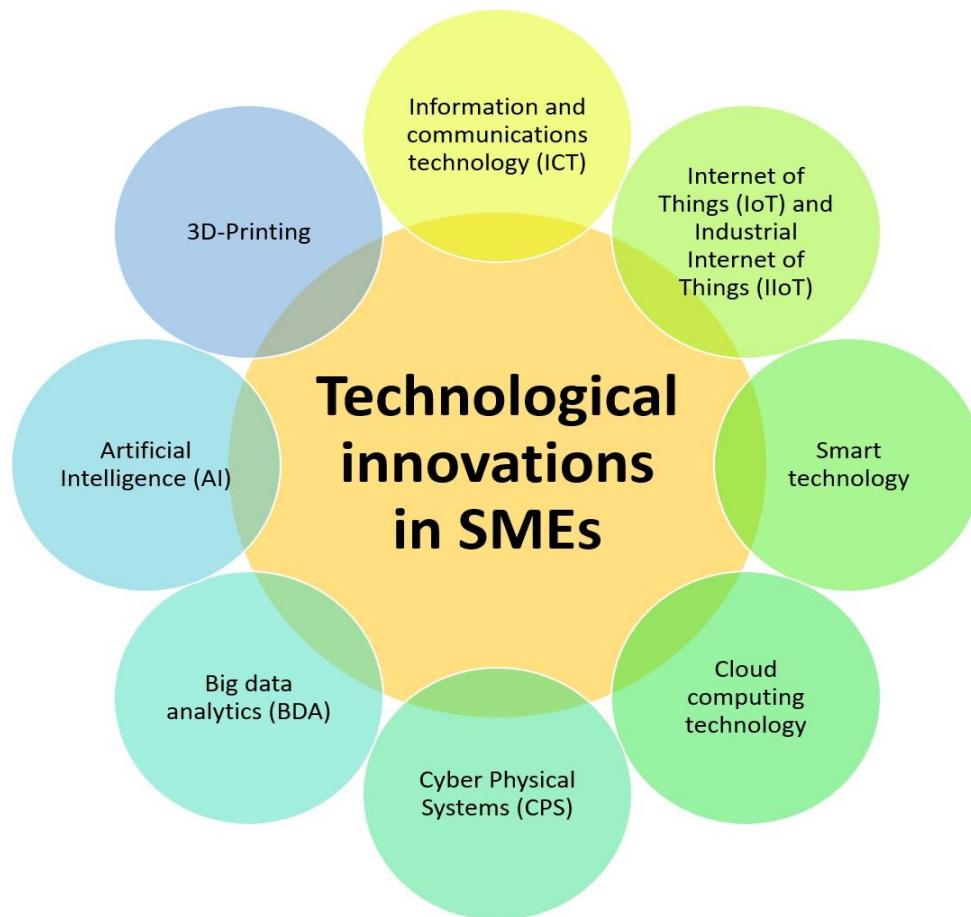


Figure 3. The use of technological innovations within the framework of Industry 4.0 in SMEs.

The IoT and IIoT use embedded sensors in physical items and software and integration to provide real-time monitoring and data exchange over distributed networks. Big data, IoT, and smart factory setups help Thai SMEs deploy IT and perform well (Haseeb et al., 2019). Taiwanese textile SMEs demonstrate how IoT-as-a-service (IoTaaS) creates smart value and sustains businesses (Chen, 2019). Cloud computing and IIoT enable Industry 4.0, which is smart technology (Chonsawat & Sopadang, 2020). Smart Industry 4.0, cloud computing, and CPS enable technology strategies for cross-disciplinary value creation in Taiwanese clothing SMEs (Chen, 2020). Dutta et al. (2020) also noted that IoT, cloud computing, and big data are essential for Indian manufacturing SMEs to digitize. Smart self-monitoring, analysis, and reporting technology uses artificial intelligence, machine learning, and big data analysis to offer appropriate objects and agents cognitive awareness. Automation/robotics adaption in SMEs is studied by Ingaldi and Ulewicz (2019). Yazdi et al. (2018) demonstrate how SMEs can adopt a sustainable, intelligent smart manufacturing system using robotic systems with sensors. An intelligent material handling system for material distribution uses an agent-based algorithm for control architecture and a time study-based technique to evaluate equipment efficacy. OEE research results optimize processes for sustainable productivity. Overall equipment effectiveness (OEE) helps SMEs reduce overtime, defer capital investments, reduce downtime/idle time, and increase operator performance. In addition, Mittal et al. (2020) emphasized the importance of identifying manufacturing data accessible within the SME, readiness assessment, data-hierarchy phases, smart manufacturing knowledge among SME leadership and employees, development of the SME's smart manufacturing vision, and recognition of smart manufacturing techniques and procedures needed to achieve the firm's vision.

Furthermore, cloud computing lets users store and access information and applications online instead of on a hard disk. Dutta et al. (2020) examined how Indian manufacturing SMEs should use digital technologies for their functional domains. The survey found that Indian SMEs prioritize industrialization—connecting machines and developing data analytics via IoT, Cloud, and Big Data. The survey stressed the need for real-time machine data and performance-based system design and improvement. As reported by Trstenjak et al. (2020), SMEs' company size has a significant impact during development when using digital technology like cloud computing aided by fundamental infrastructure and complex planning methods to outperform traditional firms.

A mechanism is regulated or controlled by computer algorithms in a CPS system. Müller et al. (2018) demonstrated how Industry 4.0 improves supply chain stakeholders by sharing manufacturing data with vendors and consumers. Broad product spectrum through Industry 4.0 adoption (CPS and ICT) and value capture innovations through automated online customer relationship management platforms are prominent elements of the system. Digitalization of manufacturing information addresses data, finance, and human resource shortages that hinder value development. Müller (2019) found that Industry 4.0 adoption affects SMEs.

Big data involves treating, analyzing, and extracting large, diverse, and fast-moving data. Big data analytics (BDA) mediated 'project performance' and nine aspects, which include top management, project information management focus on sustainability, buying green, green technology, social obligation, project operations, project difficulty, collaboration and exploratory learning, and achievement of goals (Mangla et al., 2021). In the literature, the technology–organization–environment (TOE) model and resource-based view are combined to model SMEs' BDA adoption (Maroufkhani et al., 2020). To use BDA successfully in manufacturing SMEs, relative benefit, reliability, quantity, risk and uncertainty, trialability, visibility, support from executives, company readiness, competition, external support, and governmental oversight must be considered.

AI allows computers or robots controlled by computers to perform human functions. Basri (2020) explored how AI-assisted social media marketing (AISMM) affects Saudi Arabian startups. Innovative thinking, workplace connection, and lower turnover are AISMM's key benefits. Adoption increases client numbers and profits. Effective business management and SME performance improved using AISMM.

3D printing layers of plastics, composites, or biomaterials to make objects of various shapes, sizes, rigidities, and colors. Coreynen et al. (2017) explored how digitization may promote manufacturer servitization and consumer value-added service. The study used ICT and 3D printing to examine industrial, commercial, and value servitization. Industrial and commercial servitization (based on ICT for customer relationships, web app, and digital 'marketplace') offers advising, training, consulting, and online self-service management tools to let clients complete tasks themselves. Value servitization (digital scanner items) helps organizations relieve customers faster.

Sustainability in the SMEs

The environmental impact of manufacturing enterprises has spurred stricter laws to reduce or eliminate manufacturing procedures and other business dangers (Raihan, 2023). Circular economy techniques under Industry 4.0 technologies are needed to address market-driven and environmental issues. For sustainable industrial development, job equity, gender equity, job losses, employee well-being, and growth and quality of life laws are also important. The sustainability dimension covers economic, social, and environmental issues that affect SMEs and sustainability in general. Figure 4 presents the pillars of sustainability.

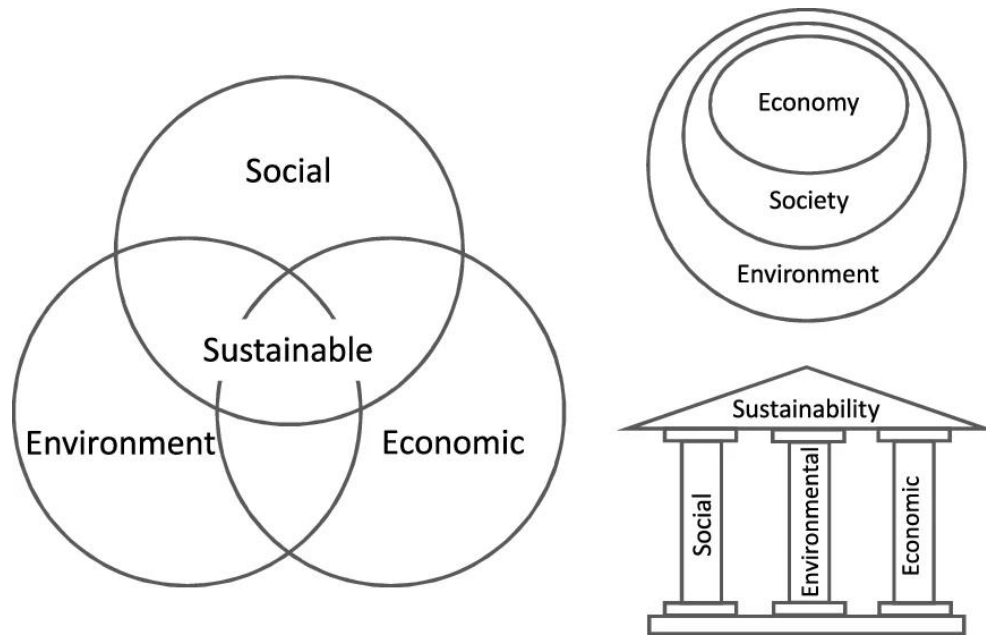


Figure 4. The three pillars of sustainability.

Economic sustainability

Small firms need innovation and other elements to survive. Technology adoption, product introduction, and service opportunity acquisition lead to corporate sustainability and economic expansion (Begum et al., 2020). Chege et al. (2020) found that entrepreneurial innovativeness positively affects technology innovation and company performance in Kenya. The study suggests new techniques to increase business performance with government support, promote technical externalities in the industry, and construct ICT resource centers to improve SME performance.

Technologies enable new business structures and services (Raihan et al. 2023b). Chen (2019) describes textile SMEs' integrated manufacturing, logistics, and marketing methods and value-creation techniques. IoTaaS value chains accomplish the former. Integrating global value chains (GVCs) to co-create value for overseas customers achieves service orientation. Sustainability via value-creation by capturing customer behavior and incorporating them into the business is key. Digitalization enables manufacturing servitization (Coreynen et al., 2017). Servitization and expansion require managers to build digital assets and capabilities for customer-aligned procedures.

Chen et al. (2016) examined how an industry-specific web portal affects e-business organizational performance. Service-oriented portal functions—portal maintenance, B2B, and cloud computing—significantly impact organizational performance. Literature also examined how digital platforms and network capability affect SMEs' financial performance (Cenamor et al., 2019). Digital platform networking capacity improves performance indirectly. Sustainable expansion requires profitably using the platform's capabilities and connecting with the right business orientation. Material, energy, labor, equipment, and fixtures affect a manufacturing firm's sustainability. Case studies in the literature assess sustainability issues for a US SME transitioning from shielded metal arc welding to robotic gas metal arc welding (Epping & Zhang, 2018). Results showed SME benefits from robotic implementation's economic expenses.

Environmental sustainability

SMEs increase greenhouse gas emissions like other enterprises; thus they must take corrective measures. A green company strategy and smart industrial efforts are needed in the current climate. The smart factory concept requires firms to focus on cost calculation, quantitative benefit analysis, and corporate social responsibility (CSR) activities to create a green corporate image and add an environmental dimension (Lu et al., 2020). Chen (2020) used “green manufacturing concepts” to create a strategic plan for integrating textile manufacturers and cultural content producers into GVC. The sustainability assessment process identifies the firm’s weaknesses and the best way toward sustainable growth. Tools to quantify product or process environmental effects were investigated by Epping and Zhang (2018). Life cycle assessment (LCA) to detect and quantify material flows, energy needs, and environmental emissions; public goods tool to display public goods from different farming arrangements in a straightforward, quantitative, and accessible way. Ecological footprint evaluation of methods based on ecological capacity via sustainable process index; carbon footprint calculators-carbon produced by agricultural companies and fixed to soil and biomass on land; multi-criteria instruments, sustainability assessment of food and agriculture systems; global reporting initiative tools. Kassem and Trenz (2020) propose cost-effective, easy, efficient, automated, comprehensive, and simplified sustainability assessment solutions. Czech brewers are testing WEBRIS (Web Information System for Corporate Performance Evaluation and Sustainability Reporting), a basic automated information system. Sustainability value added (SVA) is an effective sustainability evaluation method. Firms must identify economic, environmental, social, and governance elements affecting sustainability (Raihan & Tuspekova, 2022). WEBRIS compares firms’ computed SVA to discover weaknesses.

Social sustainability

Llinas and Abad (2020) used Spanish SMEs to demonstrate how high-performance people management techniques boost business efficiency through innovation. People management methods significantly correlated with productivity and innovation, with Industry 4.0 technology as a key facilitator. People management is a top priority for Industry 4.0 firms, according to the survey. Carroll's pyramid approach can improve SMEs' organizational performance and sustainability (Lu et al., 2020). Business success depends on giving stakeholders social, logical, and transitional benefits as the organization transforms. In an age of technology, SMEs must implement technology efficiently and effectively, especially since automation may reduce and replace blue-collar employment. Technology adoption reduces manufacturing jobs by automating boring tasks. Müller and Voigt (2018) advocate training and retraining staff during a company's transformation. This gives workers confidence and well-being. Haseeb et al. (2019) found that firms have IT but seldom implement it, which hurts business performance.

Epping and Zhang (2018) used social life cycle assessment (SLCA) to evaluate the social and socioeconomic implications of robotics adoption. Manufacturing affects earnings and remuneration, safety, personal and technical advancement, and social interaction. Fair wages and on-duty health and safety were emphasized by Epping and Zhang (2018). Through the transition from a ‘business-as-usual’ plan to a long-term approach for the digitalization of common resources, networking SMEs and other stakeholders (such as academic institutions, rivals, and customers) foster social sustainability. Zoppelletto et al. (2020) examined how a digital transformation strategy (DTS) might improve network organizations' business network commons generation/regeneration. Digital resources drove BNC revitalization, with DTS supporting quality and social responsibility. The study added to the literature on digitalization's social and economic benefits.

Business characteristics of SMEs

An organization's ability to evaluate its internal and external surroundings and respond quickly to market changes defines its sustainability. A firm's aptitude to adapt to these shifts is determined by excellent leadership and management. The organization structure, strategy, and resource base enable customer value delivery. This study addressed company strategy and management, organizational structure, culture, skills and qualifications, and firm-specific leadership as the key business characteristics of SMEs (Figure 5).

With an emphasis on innovation, Industry 4.0 interventions have substantially decreased business model lifecycles. Building a new business model or adapting an existing one to market demands requires innovation. Innovation in firms and the business environment boosts technology activities (Pucihar et al., 2019). To appreciate Industry 4.0 technologies as important facilitators, SMEs require new technology adoption policy measures. Somohano-Rodríguez et al. (2020) indicated that SMEs' innovation initiatives positively impact Industry 4.0 digital enablers. The selection and use of the best technology are typically inadequate in SMEs. Using a maturity-level-based assessment tool is necessary. Rauch et al. (2020) developed and tested a maturity level-based assessment tool on 17 enterprises as well as 42 Industry 4.0 concepts and a plan to help SMEs introduce the most promising ones. Additionally, Jiwangkura et al. (2020) showed multi-dimensional IIoT deployment methodologies with innovative HCI for SMEs in manufacturing. Results show corporations can empower using IIoT. An organization that uses IT, system integration, and automated business processes for gathering data with quality delivery and management would handle competition well (Pomffyová et al., 2017). According to Prause (2019), market uncertainty drives Industry 4.0 technology and process adoption more than internal forces.

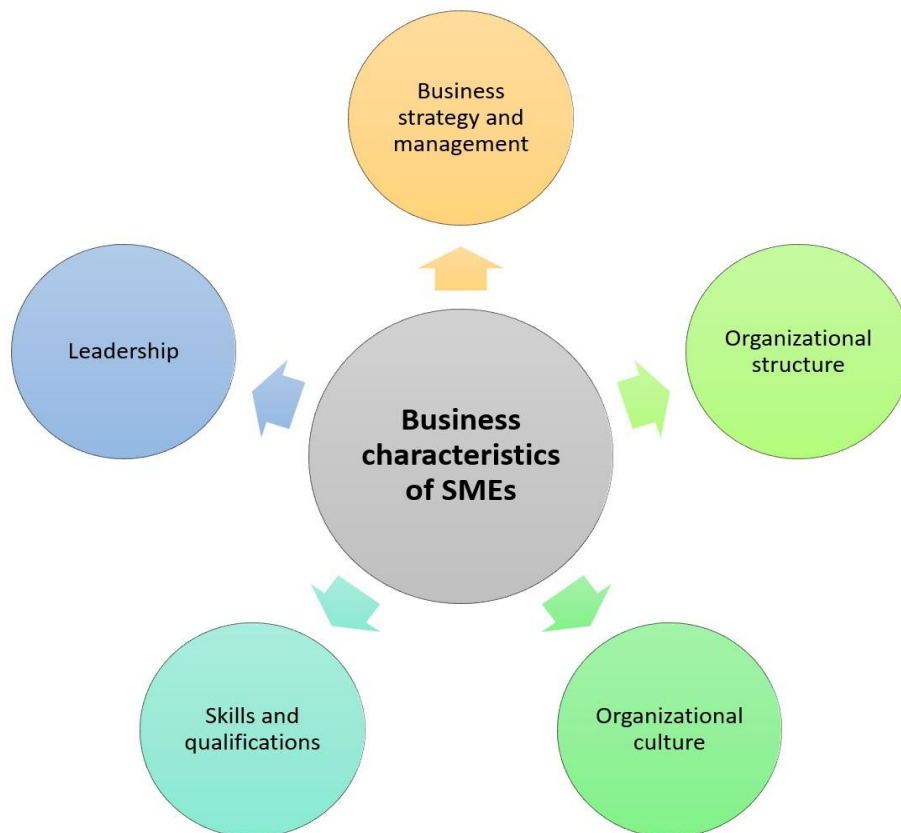


Figure 5. The key business characteristics of SMEs.

Industry 4.0 helps SMEs perform sustainably despite technology adoption obstacles. Haseeb et al., (2019) validated this idea by showing that organizational structure and procedure improve Industry 4.0 and IT implementation in Thailand. Business model, strategy, digitalization, leadership, organizational structure, and supply chain management assist SMEs' Industry 4.0 readiness indicators under organizational resilience. Industry 4.0 ideas are also supported by a culture of communication between interdisciplinary departments and workers, management, and organization techniques.

SMEs that can adjust to environmental changes must be part of the corporate culture. According to Mekhum (2020), "Organizational culture requires a significant connection with the objectives of an organization since it has a close connection with business performance". Dewi et al. (2020) showed that adaptable capability boosts creativity and competitiveness. Innovation now mediates adaptive capabilities and competitive benefits. Note that digitization does not directly predict corporate performance without a spirit of entrepreneurship. In the global market, innovation, risk-taking, and initiative are essential (Raihan et al., 2022). Chen (2020) found that business partner trust can improve a value creation approach for Industry 4.0 adoption to reach GVC. Irimiás and Mitev (2020) surveyed 270 SMEs and major enterprises in Hungary to determine how they view change management, digitization, business performance, and sustainability. Change management improves digital maturity and business performance, but managers think going green is unprofitable. Managers sometimes confuse business resource planning adoption for strategic benefits like competitive advantage and organizational performance (Jayeola et al., 2020). This will combat firm change resistance. To profit from BDA adoption, SMEs need a resilient data-driven culture and infrastructures (Maroufkhani et al., 2020). Llinas and Abad (2020) found that high-performance people management approaches to boost productivity in Industry 4.0.

SME innovation, productivity, and growth depend on HR management, credentials, and skills. Sariwulan et al. (2020) examined how digital literacy, economic literacy, and entrepreneurial abilities affect garment cluster SMEs in the tourism industry. The study demonstrated positive relationships between digital literacy, entrepreneurial skills, economic literacy, and performance. Digital literacy helps businesses grow through marketing networks providing performance. Bertello et al. (2021) found that BDA capabilities are more important than BDA infrastructure and internationalization for productivity. Cenamor et al. (2019) examined the financial performance of SMEs using digital platforms indirectly via network capabilities. The study reported that increased platform capabilities boost innovation. Chinakidzwa and Phiri (2020) found that digital strategy creation and execution competence drive SME sales growth, market share, and profitability. In addition, Kulathunga et al. (2020) examined how techno-finance literacy and enterprise risk management (ERM) apps affect SME performance. The study found that technological understanding and financial literacy improve business efficiency and ERM practices, with better financial literacy enabling ERM.

Using the technological, organizational, and environmental (TOE) paradigm, Alraja et al. (2021) examined leadership and digital transformation in Omani SMEs. According to the study, leaders must develop plans that offer organizational and technological support for an easy transformation to boost capacities and worldwide competitiveness. The change will reveal criteria for engineers and managers. The customer-product-process-resource (CPPR 4.0) model by Martínez-Olvera and Mora-Vargas (2019) outlines the value proposition-creation-capture cycle in an Industry 4.0 environment for manufacturing organizations, considering customer, product, process, and resource perspectives. The study's system dynamics model could be substituted with a discrete-event simulation for what-if scenario testing to balance cost structure and revenue stream. Leaders and managers can use these frameworks for decision-making and forecasting.

Conclusions

The objective of this study is to examine the effects of digital transformation on the sustainable development of SMEs. The systematic literature review approach has facilitated the qualitative synthesis of documents, leading to the discovery of various insights. One notable finding is the significant influence of organizational culture on the adoption of technology and subsequent data management, which serves as the fundamental basis for SMEs to undergo digital transformation. Sustainability projects facilitated by digital technology are made possible by the implementation of inventive solutions. The situation necessitates the implementation of a sustainability assessment in order to determine the necessary parameters and aid managers or leaders in efficiently and effectively transforming SMEs. The optimization of organizational procedures and structures is crucial as it has a direct influence on the successful application of digital technologies. Furthermore, the choice of technology is contingent upon the digital orientation that is embraced. The prioritization of management requirements over technological sophistication itself becomes crucial in the process of transformation, as it encompasses innovativeness and high performance. It is evident that advanced technologies, including robotics, provide comparable performance to ordinary ICT resources. This observation suggests that creativity, talent, and management play crucial roles alongside technological sophistication. A compilation of potential avenues for future research has been derived from the comprehensive review.

Recommendations and future research directions

This review ought to be expanded by collecting empirical data (from surveys and interviews) on how SMEs might digitally transition for sustainability. Such studies should define technology goals (immediate, medium, and long-term) and build technology roadmaps to better understand how SMEs may use digital technologies to achieve sustainability. Digital transformation and Industry 4.0 use IoT, CPS, big data, and AI/ML. Thus, it is necessary to determine which technologies can best influence SME performance. Further research is needed on SMEs' digital transformation cost-benefit analyses. Understanding the benefits of digitalization and how certain technologies might boost competitiveness and productivity is also needed. This knowledge can inform SMEs' digital transformation initiatives.

SMEs traditionally prioritize economic sustainability, but to achieve sustainability, they must also address environmental and social issues. To achieve sustainable development along all three dimensions, SMEs must understand how to offset trade-offs across these three orientations. Sustainability evaluation must be cost-effective, efficient, automated, comprehensive, and systemic to pursue green manufacturing concepts and a go-green strategy. SMEs can be pressured while pursuing this goal, hence support methods are needed. Thus, SME assistance mechanisms need additional study. SME economic and environmental sustainability are well understood in sustainable development. Social sustainability studies, including how SMEs might maximize social impact in emerging economies, are underrecognized. This crucial area needs more research.

Understanding how SME business models incorporate technology maturity, organizational framework and procedure, leadership capabilities, digital skills, and knowledge is crucial. SMEs must establish new business models that balance digital transformation costs and sustainable development rewards. Technology-driven innovation with value-creation methods helps SMEs engage customers, suppliers, and stakeholders, boosting market activity. This requires stakeholder confidence via data sharing with IP protection, but standard rules and legislation must be explored. These rules and regulations need more research on their nature and ideal configuration. Additionally, SMEs require the skills and knowledge to achieve sustainable development. Education and training

should support this requirement and focus on leadership skills. Further research is needed to establish support mechanisms to help SMEs digitally transform for sustainable development.

Limitations of the study

This study contains several limitations. First, the literature search strategies may exclude publications on specific aspects of corporate sustainability, such as corruption, tax behavior, or biodiversity, without explicitly linking them to sustainability. To improve the existing knowledge, more research could shed light on such subjects. Second, this review analysis only used four databases, potentially eliminating insights on SME sustainability from conference papers, books, book chapters, and journals indexed in other databases. Third, this review assessment included articles published in English-language. However, numerous French and Portuguese studies are pertinent to this study. Future studies may examine multilingual literature. Fourth, this study's sample consists of articles published between 2000 and 2023. Future research on digitization and sustainability in SMEs could replicate this study by using a wide range of sample sizes.

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Authors contribution: Asif Raihan contributed to conceptualization, visualization, methodology, reviewing literature, extracting information, synthesizing, and manuscript writing.

Data availability: The author confirms that the data supporting the findings of this study are available within the article.

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