Understanding how digital transformation can enable SMEs to achieve sustainable development: A systematic literature review

Cómo la transformación digital puede permitir a las PYMEs alcanzar el desarrollo sostenible: Una revisión sistemática

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Abstract

Small and medium-sized enterprises (SMEs) are key drivers of economic growth and development. Innovation through digital transformation has the capacity to enable sustainability, competitiveness and customisation in products and services. However, adoption of digital technologies by SMEs to underpin sustainability outcomes is poorly understood. A systematic literature review identified an initial dataset of 1300 articles, which after screening and application of exclusion criteria resulted in a dataset of 64 articles for synthesis. Analysis was carried out according to three main areas, namely the technology aspects of digital transformation, sustainable development according to the triple bottom line (i.e. economic, environmental and social aspects), and the business characteristics of SMEs. In the latter case, business strategy and management, organizational structure, organizational culture, skills and qualifications, and leadership factors are identified from the literature. Furthermore, literature expressing the triple bottom line dimensions and the type of Industry 4.0 technology areas adopted are synthesized. Correlation of the data through bibliographic analysis is provided on the type of technology enabling SMEs towards a pathway for sustainable development as well as synthesis of future research directions arising from the study.

Keywords: small and medium-sized enterprise; SME; digital transformation; sustainability; sustainable development; systematic literature review; SLR

JEL Classification: L20; L25; L26; O32

Resumen

Las pequeñas y medianas empresas (PYMEs) son motores clave del crecimiento y desarrollo económico. La innovación a través de la transformación digital tiene la capacidad de permitir la sostenibilidad, la competitividad y la personalización de los productos y servicios. Sin embargo, la adopción de tecnologías digitales por parte de las PYMES para apuntalar los resultados de sostenibilidad es poco conocida. Una revisión bibliográfica sistemática identificó un conjunto de datos inicial de 1.300 artículos, que tras el cribado y la aplicación de criterios de exclusión dio como resultado un conjunto de 64 artículos para sintetizar. El análisis se llevó a cabo en tres áreas principales, a saber, los aspectos tecnológicos de la transformación digital, el desarrollo sostenible según la triple cuenta de resultados (es decir, los aspectos económicos, medioambientales y sociales) y las características empresariales de las PYMEs. En este último caso, se identifican a partir de la literatura la estrategia y la gestión empresarial, la estructura organizativa, la cultura organizativa, las competencias y las cualificaciones, y los factores de liderazgo. Además, se sintetiza la literatura que expresa las dimensiones de la triple cuenta de resultados y el tipo de áreas tecnológicas de la Industria 4.0 adoptadas. Se ofrece una correlación de los datos a través del análisis bibliográfico sobre el tipo de tecnología que permite a las PYMEs avanzar hacia una vía de desarrollo sostenible, así como una síntesis de las futuras direcciones de investigación que surgen del estudio.

Palabras clave: pequeña y mediana empresa; PYME; transformación digital; sostenibilidad; desarrollo sostenible; revisión sistemática; RS

Clasificación JEL: L20; L25; L26; O32

1. Introduction

Small and medium-sized enterprises (SMEs) are acknowledged as key drivers of economic growth and development, thereby creating employment opportunities and stimulating competition through innovation and new venture creation (Mago & Modiba, 2022). SMEs are vital in sustaining the economic health of both developed and developing countries (Gherghina et al., 2020). The OECD (2017) has reported that many countries are challenged by low economic growth, high unemployment rates as well as rising income inequality and poverty. Although SMEs are key contributors to economic development, they increasingly need to respond to the issues of sustainability according to economic, environmental and social dimensions (Johnson & Schaltegger, 2016). Indeed, the need to understand the sustainability performance of SMEs has been investigated by researchers from various different countries, such as Romania (Burlea-Schiopoiu & Mihai, 2019), New Zealand (Lawrence et al., 2006), South Africa (Masocha, 2018), Austria (Falle et al., 2016) and the Netherlands (Eikelenboom & de Jong, 2019). Businesses are also faced with the parallel challenge, and opportunity, to engage in digital transformation through digitalising existing business processes in order to remain competitive (Azevedo & Almeida, 2021). Businesses can be guided according to a blend of factors across market, learning and entrepreneurial orientations in order to leverage emerging digital technologies to generate business competitiveness as well as seizing opportunities for innovation-driven growth (Quinton et al., 2018). The need for innovative methods and digital production strategies to maintain the current competitive advantage in the long-term is becoming a pressing need for SMEs (Matt et al., 2020). Furthermore, the wider concept of Industry 4.0 involves adoption of a range of technologies associated with distributed data management as part of the cyber-physical system (CPS), and such technologies are being harnessed to enable changes in the performance of firm's technical and production development, thereby leading to improved business performance (Moica et al., 2018). Moreover, the process of digital transformation can be viewed as a driver as well as a predecessor of sustainability, where industrial companies need to develop supporting digital capabilities in order to achieve a balanced set of impacts across economic, environmental and social dimensions (Gomez-Trujillo & Gonzalez-Perez, 2021). Therefore, there is the opportunity for SMEs to leverage the capabilities of digital production methods to support a pathway towards sustainability (Denicolai et al., 2021; Šimberová et al., 2022; Telukdarie et al., 2022).

Sustainability is defined as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (UNESCO, 2015). From an industrial perspective, this means firms need to be responsible and take account of resource usage (Kleindorfer et al., 2009) and the subsequent environmental footprints that are created (due to activities such as production and transportation) as well as judiciously act to maintain employee health and safety and the quality of life of the external community (Gimenez et al., 2012). Digitalization helps in attaining sustainability of the business by inherently addressing the principles of circular economy and sustainable development. A review conducted by Williams and Lang (2019) discusses research related to awareness, preparedness, smart manufacturing and suitable technologies to be adopted by SMEs. Sustainability practices that relate to social impact created by business enterprises in the context in which they operate is a more recent development (Chege & Wang, 2020). Moreover, as the market is burdened by environmental challenges, firms are compelled to make allowance for environmental sustainability while innovating in terms of digital adoption (Feroz et al., 2021). In this regard, sustainable development can be conceived as a business strategy and as an instrument for tackling environmental problems through the sustainable growth for enterprises (George & Schillebeeckx, 2022). Thus, it is widely accepted by researchers that sustainable development implementation is an emergent business strategy for firms as well as offering potential for long-term growth and stability (Lu et al., 2020).

The article is structured in the following manner. After the introduction, the conceptual framework is provided along with review of the literature to highlight the present gap in the knowledge base and the reason for our study. This is followed description of the systematic literature review (SLR) approach adopted in the study as the research methodology. The results section provides extraction and analysis from 64 documents synthesised through the SLR method followed by discussion of the key findings and the future research agenda.

2. Conceptual framework and literature review

The volume of literature provides conceptual evidence through defining Industry 4.0 and its role in logistics and the need for impact analysis on Industry 4.0 interventions in different facets of business (Hofmann & Rüsch, 2017). Furthermore, there are a number of systematic literature reviews (SLRs) that focus on technologies adopted by manufacturing SMEs (Abdirad & Krishnan, 2021; Núñez-Merino et al., 2020; Saucedo-Martínez et al., 2018; Yang et al., 2018). SLRs provide a robust and repeatable method to explore an emerging research area through capturing the state-of-the-art from the extant literature and enable identification of the key factors to be addressed as well as future agenda. Birkel and Müller (2021) examined the concurrence of Industry 4.0, the triple bottom line (TBL) of sustainability, and the circular economy under the functions of supply chain management. Taking inspiration from the work of Müller (2019), the current study adopts a systematic literature review (SLR) to understand the impact of digital transformation on the sustainable

development of SMEs. Consequently, the research question of the exploratory study is: How can digital transformation enable SMEs to achieve sustainable development? This is based on exploring the research gap, which can be viewed as the overlap of the constructs of SMEs, digital transformation and sustainable development (as depicted in Figure 1). From this perspective, the object of the research study is the SME, where digital transformation is the enabler (i.e. input to a transformation process) and sustainable development is the outcome (i.e. output from a transformation process). In this context, it is useful to provide the supporting definitions of key terms and constructs, which are as follows:

- Small and medium-sized enterprises (SMEs) are regarded as *"enterprises which employ fewer than 250 persons and which have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million"*, where an enterprise is an *"entity engaged in an economic activity, irrespective of its legal form. This includes, in particular, self-employed persons and family businesses engaged in craft or other activities, and partnerships or associations regularly engaged in an economic activity"* (EU, 2003).
- Digital transformation can be viewed as *"an evolutionary process that leverages digital capabilities and technologies to enable business models, operational processes and customer experiences to create value"* (Morakanyane et al., 2017).
- Sustainable development is *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Emas, 2015).

Figure 1. Research gap at the intersection of SME, digital transformation and sustainable development
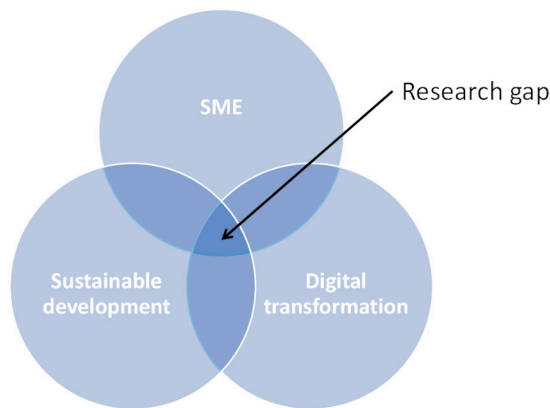
Source: Authors' own

We reviewed existing SLRs in the literature in related areas to assess the research space and assimilate existing knowledge. The SLR documented by Williams and Lang (2019) discusses the awareness, preparedness, smart manufacturing and suitable technologies to be adopted by SMEs. The study employs a robust SLR with a total of 33 strings covering pertinent search terms. The findings reveal that there is little to no research on smart manufacturing in relation to SMEs in low-income countries and particularly the African continent. The authors identify the barriers to smart manufacturing initiatives (including lack of expertise/skills, lack of finance and lack of human capital) along with a major concern of treating all SMEs alike without considering the heterogeneity created by different sectors.

The barriers that hinder digital adoption by SMEs are discussed at length by Chouki et al. (2020) as well as Chauhan et al. (2021). Both studies list the intrinsic and extrinsic factors affecting adoption. The latter evaluated how these barriers influence the linkage between digitalization and the firm's performance regarding its supply chain competency as well as operational performance. The findings are that digital adoption by firms is dependent on certain contingencies, such as resistance by other stakeholders, lack of standard architecture, lack of internet access, contractual and privacy and security issues and regulatory under-development. The identified barriers of resources, end users, senior management, organization and external issues are categorically analyzed by Chouki et al. (2020). Furthermore, the need for maturity models in SME digital ventures are captured in the work by Williams and Lang (2019). Whereas Anim-Yeboah et al. (2020) attempted to research the major trends, characteristics, and distribution of research work on digital entrepreneurship, underlying concepts/methods, constraints and the gap in the literature. Most studies target technology adoption from technology aspects and application perspectives rather than the capabilities and capacities of enterprises, as well as the strategies in implementing digital technologies and harnessing the opportunities of digitalization. The investigation delineates critical and fundamental issues about digital entrepreneurship that remain unresolved in the literature.

Other studies have focused on the intersection of Industry 4.0 and the triple bottom line (TBL) of sustainability (Beier et al., 2020; Rosa et al., 2020) as well as supply chain management and the TBL (Govindan & Hasanagic, 2018). It can be observed that there is currently a gap in the knowledge base in regard to

understanding how SMEs can adopt digital technologies to support sustainable development. Indeed, this knowledge gap was also identified by Müller and Voigt (2018) as this study examined the impact of the IIoT (Industrial Internet of Things) as a key enabler of SMEs through considering the dimensions of sustainability. Therefore, the primary focus of the study herein is to investigate the impact of digital transformation on the sustainable development of SMEs in a holistic manner without any selection criteria or bias.

3. Method

The investigation relies on the rigor of the SLR approach with the intent to acquire a reliable knowledge base, address management and research issues, and highlight the research gaps (Rousseau et al., 2008; Schanes et al., 2018). The reproducibility, quality and reliability are assured through adhering to the recognized PRISMA (Preferred Reporting Items for Systematic Reviews and Meta Analyses) approach (Moher, 2009). The sequence of operations are identification, screening, eligibility and inclusion (see Figure 2). The Scopus database was employed to identify the literature through selection of plausible keywords, which relate to the research agenda and the aforementioned gap in the extant literature. The search was carried out on the 25th July 2021.

Figure 2. PRISMA method employed in the SLR
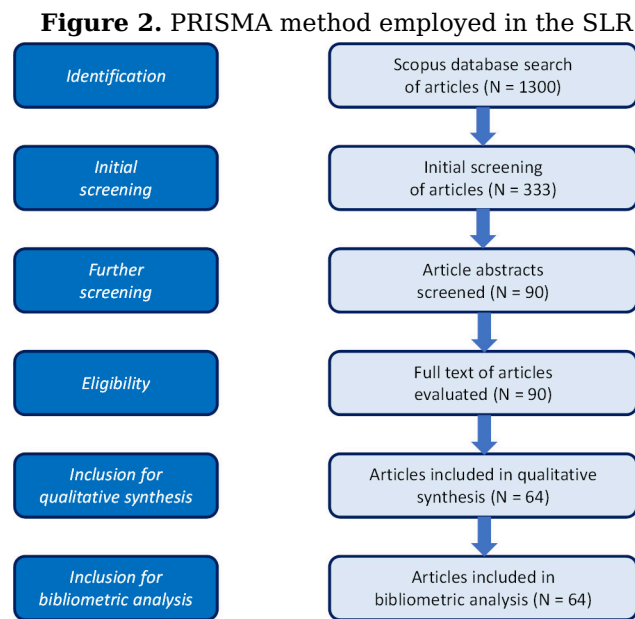
Source: Authors' own

Searched keywords

The keywords are implicit to three underpinning concepts, namely: SME, sustainability and terms representing digitalization (or digital transformation). The latter is expanded into "Industry 4.0", "Fourth Industrial Revolution", "Digitalization", "Digital Transformation", "Automation" and "Smart manufacturing" as used by Williams and Lang (2019). The approach of Padalkar and Gopinath, (2016) is adopted to limit the search to titles and abstracts of articles published in the sphere of SME sustainability and the enabling impact of digitalisation.

Screening

The Scopus search (see Table 1) with the selected keywords for the past 10 years resulted in 1,300 documents. Reduction in data was carried out with an additional filter of capturing data from published works in journal articles in English language only, yielding 514 documents. This was further refined to enable an up-to-date view through limiting the search to 2016-20, yielding 333 documents.

Table 1. Literature search data with screening and exclusions applied

No.	Data capture from Scopus	Screening and exclusions applied	Total number of documents
1	Original literature data	None	1,300
2	Data reduction	Journal articles in English; 2010-21	514
3	Data reduction	Journal articles in English; 2016-20	333
4	Abstract screening	Manual reading of abstracts based on relevance	90
5	Eligibility	Full text retraval and analysis	64

Source: Authors' own

Exclusion and inclusion criteria

The output of 333 documents were abstract screened to reflect the intent of our research objective (i.e. how can digital transformation enable SMEs to achieve sustainable development?) without any bias to generate a total of 90 documents. The final synthesis followed scrutiny of the full text of 90 articles to establish 64 documents, which constitutes the subject matter of our investigation. Analysis on the technology, method of research, sustainability and themes under SMEs were performed.

Bibliometric analysis

The SLR approach is supplemented by bibliometric analysis (Ranasinghe et al., 2020). The method gains strength by providing a co-occurrence map of keywords appearing in the literature in a structured manner, which further helps to interrelate the keywords and conceptualise the findings. This is the essence of science mapping (Van Eck & Waltman, 2018). A plethora of science mapping tools are available, such as VOSviewer, CiteSpace, Sci2, BibExcel, CoPalRed, VantagePoint, and Gephi (Hosseini et al., 2018). VOSviewer was selected for the present study owing to the network visualization of keywords from literature (Hosseini et al., 2018). The science mapping concept was utilised to a create co-occurrence map of keywords and analyse the trend and patterns to extract insightful information.

4. Results

4.1 Descriptive analysis

The profile in Figure 3 clearly indicates that the subject area of interest is quite new, relevant and offers scope for research. In fact, the area has undergone major growth since 2016 (N = 1) to 2020 (N = 41), which highlights the emerging nature of the research area.

Figure 3. Number of publications published
each year from 2016 to 2020
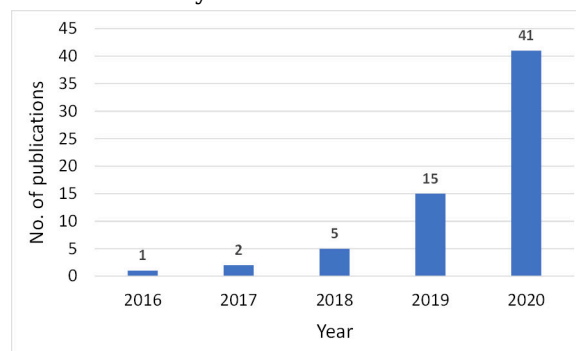
The research contribution from various countries is presented in Figure 4. The concept of collaborative work culture is evident from the magnitude of documents observed under the international category of authors (27%). The international category consists of documents co-authored by researchers from at least two different countries. After the international category, the next highest countries are Thailand (N = 8), Indonesia (N = 6), Spain (N = 5) and Taiwan (N = 5), followed by other countries having three or less publications. The analysis highlights that researchers from across the world are actively investigating the area of the research study.

Figure 4. Research contributions from countries of
publication authors (with countries having at least two
publications)
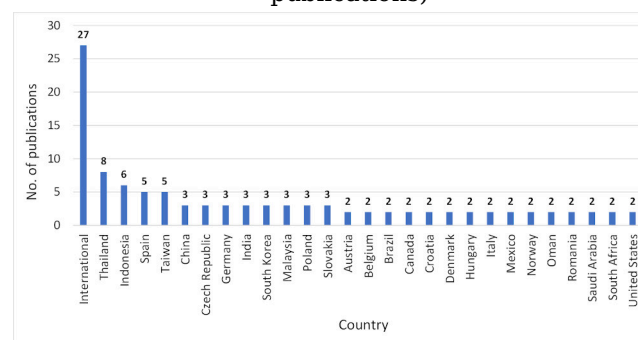
Literature comprises of articles from journals such as *Sustainability* (N = 13), which scores high, accounting for 20% of documents, followed by *Polish Journal of Management Studies* (N = 2), *Journal of Manufacturing Technology Management* (N = 2), *Journal of Enterprise Information Management* (N = 2), *Journal of Cleaner Production* (N = 2), *Journal of Business Research* (N = 2), *Journal of Asian Finance, Economics and Business* (N = 2), and *International Journal of Supply Chain Management* (N = 2), followed by publications from various other journals. This analysis highlights the highly multidisciplinary nature of the subject area since research is being conducted across a range of academic journals covering academic disciplinary areas associated with sustainability and clean technologies, technology and engineering management, IT systems, business management, social sciences, engineering and various other aspects. The research area is rich in contributions across different academic disciplines associated with the social sciences and engineering.

The method of research (see Figure 5) to gather data from the SMEs are typical of conventional practice with the survey instrument being utilized in many studies (41%). This is followed by questionnaires (17%), case study (16%) and interviews (15%). The remaining data set comprised of other methods (6%), such as bibliometric, literature and government database studies of SMEs, simulation modelling (4%) and Delphi study (1%). This highlights that although the survey instrument dominates as the main method, some studies have employed other methods to investigate the research area. Consequently, articles representing different methods and types of data are available in this area.

Figure 5. Percentage of publications according to research method adopted
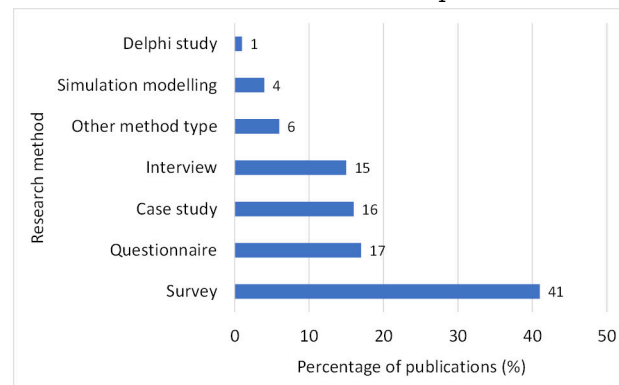
4.2 Content analysis

The focus of the SLR considers three primary areas, namely the technology aspects of digital transformation, sustainable development, and the business characteristics of SMEs. Attempts were made to focus the SLR synthesis and identify content or articles that best describe the defined areas and supporting theoretical concepts. An in-depth content analysis according to the technology aspects of digital transformation, sustainable development and the business characteristics of SMEs is detailed below. The extraction resulted in tabulation of themes and content falling under the corresponding areas and theoretical constructs.

4.2.1 Technology dimension – Industry 4.0 intervention on SME sustainability

The inspection of technology intervention under the paradigm of Industry 4.0 within the domains of our synthesis representing 64 documents and is presented in Figure 6. ICT/IT and other technologies (referred to as General ICT) account for 32%, smart technology (16%), cloud technology and IoT/IIoT each contributing 12% followed by internet enabled platforms 10%. General ICT appears to co-occur with the rest of the technology, while smart technology is usually described as a sophisticated adoption of automation through robotics. The role of Industry 4.0 technologies as an enabler impacting sustainability of SMEs are analyzed and elaborated (see Appendix 1).

  A. General ICT (Information and communications technology)

Digital transformation initiatives in a firm starts with a positive culture of adoption with a clear view of the processes in the firm. SMEs need to sense and seize digitally enabled growth opportunities and adopt project-based learning processes to transform the organization to remain competitive in turbulent environments (North et al., 2019). Indeed, Mukhtar et al. (2020) illustrate the impacts of IT (information technology) on the economic performance of SMEs in conducting sales activities. In other work, the application of a simple internet enabled platform, through an eco-sourcing tool grounded on Model View Control (MVC) architecture for SMEs, enables clients to select and order automobile products online (Anthony, 2019). Whereas Mekhum (2020) examined the relationship of supply chain cultural competence and adoption of supply chain technology

for the performance of Thai SMEs. The study found that both factors impact performance, with supply chain cultural capabilities playing a crucial role in the adoption of supply chain technology.

Figure 6. Percentage distribution of documents
according to technologies from the literature synthesis

- General ICT
- Smart technology
- Cloud computing
- IoT/IIoT
- Internet enabled platforms
- CPS
- Big data
- AI
- 3D-printing
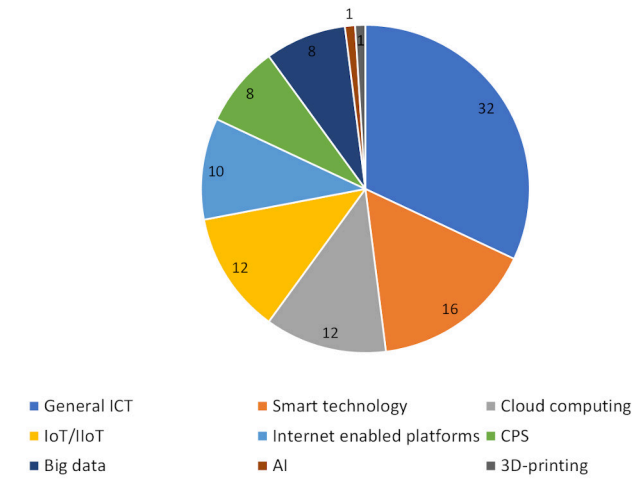
B. IoT and IIoT

The Internet of Things (IoT) and Industrial Internet of Things (IIoT) refers to systems where embedded sensors are integrated with physical objects along with the software and integration capabilities to support real-time monitoring and data exchange across distributed networks. Haseeb et al. (2019) investigated the role of Industry 4.0 to promote sustainable business performance in Thai SMEs. Big data, IoT and smart factory set-up are seen to play a positive role in promoting information technology (IT) implementation, thereby aiding sustainable business performance. The organizational structure and a regulated process adds strength to the relationship between Industry 4.0 application, IT implementation and subsequent business performance. The former (i.e. structure and process) are found to act as a moderating variable between the smart factory and IT implementation, where big data and IoT strengthen the IT base leading to sustainability.

The power of IoT to render IoT-as-a-service (IoTaaS) helps to realize smart value creation leading to business sustainability and is illustrated through textile SMEs in Taiwan (Chen, 2019). The focus areas are elements of, and approaches to IoTaaS-driven value chains, such as integrated manufacturing, logistics and marketing employed by textile SMEs. The key elements of a successful IoT business ecosystem have been found by Chen (2019) to be the role of smart technology, partnerships for value co-creation and customer orientation and offering new services. The findings reveal the performance of Industry 4.0 technology is governed by data (i.e. data analytics) from the perspective of capturing value chain information and identification of customer behavior to deliver value-added service. The technology aids in integrating all the entities in the global value chain (GVC) and also enables co-creation of value for foreign customers and draws customer participation through smart devices. Creation of new business models and services are seen as the opportunities in this regard.

As a development of the Smart SMEs 4.0 Framework (Chonsawat & Sopadang, 2019), Chonsawat and Sopadang (2020) attempted to develop readiness indicators to assess and support SMEs toward Industry 4.0 through employing bibliometric techniques. Industrial internet, cloud manufacturing, collaborative robot, business model and digital transformation are the keywords with prominent occurrences in the study. The clustering of keywords resulted in the evolution of five dimensions namely, organizational resilience, infrastructure system, manufacturing system, data transformation, and digital technology. The indicators were then tested on SMEs and revealed 23 indicators, which support SME 4.0 readiness as well as decision-making in the context of Industry 4.0. The Industry 4.0 technology enabled through cloud computing and IIoT can be attributed to smart technology in this context. In conjunction with cloud computing technology and CPS (cyber physical systems), smart Industry 4.0 has been found to be an enabler in technology strategies for cross-disciplinary value creation in clothing SMEs in Taiwan (Chen, 2020). Further, Dutta et al. (2020) observe that IoT, cloud computing and big data are key technologies for manufacturing SMEs to undergo digital transformation in India.

Analysis of IIoT implementation drivers, strategies, capabilities, HCI (human computer interface) and the derived benefits are extracted from 30 articles over the last 7 years and are documented in the literature (Jiwangkura et al., 2020). Lightweight flexibility, non-monotonous tasks of new HCI, top management's real-

time decision making and market opportunity are the four significant adoption items. The observations help SMEs to understand and learn from the analyzed IIoT implementation strategies to empower their business.

The role of blockchain smart contracting in facilitating the implementation of collaborative logistics structures and the means of integration of SMEs into sustainable maritime supply chains by reducing high entry barriers and weakening the domination of big players are recorded in the work of Philipp et al. (2019). The key to this concept is a smart port fully automated with IoT system. Reduction in time, with decreased transaction and enforcement costs due to blockchain smart contracting systems are the main advantages. Data sharing between charterers and ship-owners that is provided on the web-based marketplace platform are also featured.

C. Smart technology

The word 'smart' refers to self-monitoring, analysis, and reporting technology where the technology that uses artificial intelligence, machine learning, and big data analysis provide cognitive awareness to appropriate objects and actors in the system. Studies on the adaptation possibilities of automation/robotics in SMEs are documented by Ingaldi and Ulewicz (2019). The article identifies the maturity of adoption, interest of the firm in using modern communication channels based on the platform structure, optimization of product portfolio with investment strategy and selection of technology according to Industry 4.0 as key factors. The barriers to this effect are the costs of automation and robotization of production processes, narrow product portfolio of SMEs not justifying complete use of automated facilities, resistance of employees to adoption (i.e. fear of retrenchment), environmental uncertainty and the fragmentation of the technological and product portfolio in the sector.

A practical case study for SMEs to adopt a sustainable, intelligent smart manufacturing system based on robotic systems with sensors is illustrated by Ghafoorpoor Yazdi et al. (2018). Intelligent material handling system for material distribution utilizing an agent-based algorithm as control architecture is designed and a time study-based methodology, which has been implemented to evaluate the overall equipment effectiveness (OEE). Results of the OEE study helps in process optimisation assuring sustainable productivity. Reduction in expenditure of over time, deferment of investments of larger capital, reduction in downtime/idle time and improvement in the performance of the operator are the benefits of OEE for SMEs. Moreover, the need for smart manufacturing (SM) has been discussed by Mittal et al. (2020), which emphasizes the importance of identification of manufacturing data available within the SME, readiness assessment of the SME, data-hierarchy steps, SM awareness of SME leadership and employee, development of the vision for SME with SM and identification of SM tools and practices necessary to attain the firms vision.

D. Cloud computing technology

Cloud computing enables users to store and access data and programs over the internet instead of on a local storage unit such as a hard drive. The need for adopting appropriate digital technologies for the identified functional areas in the context of Indian manufacturing SMEs has been researched by Dutta et al. (2020). The research method employed was based on literature data with maturity assessment through a survey instrument. The study reveals the preference of Indian SMEs to prioritize industrialization, i.e., connecting machines and generating data analytics using IoT, Cloud and Big Data. The survey further emphasizes the need for capturing real time machine data and strategies to design and improve system capabilities based on the performance observation. Whereas, according to Trstenjak et al. (2020), company size of SMEs has a significant influence during the developmental stage with the use of digital technology, such as cloud computing supported by fundamental infrastructure when using complex process planning methods to elicit pronounced impact compared to traditional firms.

E. CPS (Cyber Physical Systems)

A cyber-physical system (CPS) or intelligent system is a computer system in which a mechanism is controlled or monitored by computer-based algorithms. Incorporation of value creation mechanisms, value offer and value capture mechanisms are defined in the investigation of Müller et al. (2018). The article discusses the benefits from Industry 4.0, where firms need to share production data with suppliers and customers to benefit stakeholders within the supply chain; although caution is needed in regard to IP (intellectual property) and cyber security considerations. Further, broad product spectrum through Industry 4.0 adoption (namely CPS and ICT) and value capture innovations via automated online platform for CRM (customer relation management) are the striking features of the system. A lack of skill, lack of government support and adoption hesitancy are identified as the barriers. The shortcomings in value creation arise due to a lack of data, lack of finance and lack of human resources with the former being countered by digitalisation of manufacturing data. The impact of Industry 4.0 adoption on SMEs has been identified by Müller (2019). Key resources, such as digital skill, value proposition, revenue, and cost), were also identified in the study.

F. Big Data

Big data deals with the ways and means to treat, analyse and extract data that is voluminous, characterised by greater variety and arriving with velocity. The mediating role of 'big data analytics' (BDA) played between 'project performance' and nine factors, including top management, project knowledge management focus on sustainability, green purchasing, environmental technologies, social responsibility, project operational capabilities, project complexity, collaboration and explorative learning, and project success, has been explored by Mangla et al. (2021). The results indicate that project knowledge management as well as green purchasing and project operational capabilities require the mediating support of BDA. Big data analytics adoption is observed to exert a positive influence on project performance in the manufacturing sector.

A unified model for the adoption of BDA among SMEs with the integration of the technology–organization–environment (TOE) model and resource-based view has been recorded in the literature (Maroufkhani et al., 2020). Factors examined in the study, such as relative advantage, compatibility, complexity, risk and insecurity, trialability, observability, top management support, organizational readiness, competitive pressure, external support and government regulation must be emphasized in manufacturing sector of SMEs to have a successful usage of BDA in their businesses. The need for coherent and unambiguous data-driven culture and infrastructure in the firm are a mandatory requirement to reap the necessary results from BDA implementation.

The direct effect of BDA capabilities, as well as the interaction term between BDA infrastructure and BDA capabilities are observed to be positive and significant from the literature (Bertello et al., 2021). The need for developing specific BDA capabilities and the existence of a positive interplay between governance of BDA infrastructure and BDA capabilities can generate new knowledge arising from BDA in SME international growth.

G. AI (Artificial Intelligence)

Artificial intelligence (AI) is the ability of a computer or a robot controlled by a computer to complete tasks that are usually done by humans. Basri (2020) examined the impact of artificial intelligence-assisted social media marketing (AISMM) on the performance of start-up businesses in Saudi Arabia. Creative thinking, improvements in workplace connectedness and reduced rates of employee turnover are the main advantages of AISMM. An overall increase in the number of customers and customer bases as well as subsequent profit generation are the benefits arising from adoption. AISMM was found to increase SME performance and effective business management.

H. Additive manufacturing or 3D-Printing

3D printing involves layering materials, like plastics, composites or bio-materials to create objects that range in shape, size, rigidity and colour. In related work, Coreynen et al. (2017) examined the research questions: how can digitization enable servitisation for manufacturers?; and how digitalisation can enable value-added service to customers?. The article considers three pathways of servitisation namely, industrial, commercial and value servitisation with the aid of ICT and 3D-printing (for industrial servitisation). Industrial and commercial servitisation (i.e. based on ICT for CRM, web app, and the digital 'marketplace') enables services that support customers completing tasks on their own, such as advice, training, consulting and online self-service management tools. Whereas value servitisation (i.e. digital products for scanners) enables companies to unburden customers from certain activities more quickly.

4.2.2 Sustainability dimension

The impact created by manufacturing firms on the environment has provided a new impetus and hence stringent regulations to decrease or possibly mitigate the hazards generated from industrial process and other business activities. This calls for circular economy practices under the premise of Industry 4.0 technologies adoption to meet both the market driven and environmental challenges. The other concerns for sustainable industrial development are job equity, job losses, gender equity, employee well-being with regulations in place to assure growth and quality of life for personnel. The contents under the sustainability dimension are elaborated in regard to the economic, social and environment dimensions that impact SMEs as well as more broadly sustainability as a generalized term (see Appendix 2).

A. Economic sustainability

The sustainability of small businesses depends on innovativeness as well as other factors. Innovation in the form of technology adoption, new product launch and securing new opportunities in the form of services offered leads to business sustainability and economic growth. In this regard, the positive relationship between technology innovation and firm performance in Kenya has been reported by Chege et al. (2020) through considering the impact of entrepreneurial innovativeness. The study provides recommendations to develop

innovative strategies to actualize firm performance with government support and improve ICT infrastructure; promoting technological externalities within the industry and establishing ICT resource centres to boost SME performance.

A business strategy needs to incorporate all the three dimensions of sustainability, with a view to achieve the triple bottom line (TBL) of sustainable development. The application of Carroll's pyramid model for SMEs as an effective business strategy for overall organizational performance improvement in the context of developing nations and in the stage of infancy towards Industry 4.0 adoption has been documented in the literature (Lu et al., 2020). Economic, ethical, legal and philanthropic dimensions reveal a positive and significant relationship with organizational performance under the modified Carroll's pyramids of CSR (corporate social responsibility). This outcome is vital for sustainability in the long run with a competitive edge.

Technology aids in creating new business models and services. The pathways to realise success through integrated manufacturing, logistics and marketing adopted by textile SMEs and the content with strategies of value-creation activities are documented by Chen (2019). The former is achieved through IoTaaS driven value chains. The service orientation is achieved by integrating players of global value chains (GVCs) to co-create value for foreign customers. Sustainability through value-creation by identifying customer behaviour through data capture and involving them to participate in the business is the core concept. Growth through servitisation in the manufacturing sector accomplished through digitalisation is discussed by Coreynen et al. (2017). The managerial implications of servitisation and growth are the development of digital assets and skills to integrate into customer aligned processes.

Deployment of an industry-specific web portal as an IT resource and its impact on e-business organizational performance has been discussed in the literature (Chen et al., 2016). The service-oriented portal function dimension, consisting of portal maintenance service, B2B function and cloud computing, significantly influences organizational performance. Moreover, the impact of digital platform capability and network capability on SMEs financial performance has been researched in the extant literature (Cenamor et al., 2019). The networking capacity gained through the digital platform capability has a positive indirect effect on performance. Additionally, sustainable growth is through profitably utilising the potential of the platform and aligning with the most appropriate business orientation.

Various parameters, such as material, energy, labour, and equipment and fixtures, have effect on the overall sustainability of a manufacturing firm. Assessment of sustainability factors for a United States based SME in the transition from shielded metal arc welding (SMAW) process to a robotic gas metal arc welding (GMAW) process are case studied in the literature (Epping & Zhang, 2018). The results indicate the SME benefits from associated economic costs through robotic implementation.

B. Environmental sustainability

Just like other companies, SMEs also contribute substantially to environmental issues as they add to the emissions of greenhouse gases and hence remedial actions on their activities are required. The current scenario demands the formulation of an eco-friendly business strategy and initiatives to go green through adopting the smart factory concept. The need for firms to not just concentrate on cost calculation and quantitative benefit analysis but also on CSR activities through creating a green corporate image by adding an environmental dimension has been coupled with the smart factory concept (Lu et al., 2020). Whereas Chen (2020) developed a strategic model for the innovative integration of textile manufacturing companies and cultural content industry into GVC elaborated through 'green manufacturing concepts'.

The process of sustainability assessment is set to indicate the vulnerable points of the firm and the best possible solution to achieve sustainable performance. The use of tools to estimate the impact of product or process on the environment are discussed in the literature (Epping & Zhang, 2018). The study identifies a range of tools that can be adopted in this regard, such as life cycle assessment tool (LCA) for identifying and quantifying the flows of materials and required energy and their emissions into the environment; public goods tool (PG) for a simple, measurable and accessible way of showing public goods reaching from different farming systems; ecological footprint-evaluation of processes according to environmental capacity using sustainable process index (SPI); carbon footprint calculators-carbon generated from agricultural business and fixed to soil and biomass on the land; comprehensive tools like multi-criteria tools, SAFA (sustainability assessment of food and agriculture systems); GRI (global reporting initiative) tools.

Cost effective, simple, efficient, automated, comprehensive and simplified systems for sustainability assessment are designed by Kassem and Trenz (2020). A simple automated information system WEBRIS (Web Information System for Corporate Performance Evaluation and Sustainability Reporting) is trial tested in the Czech breweries sector. The procedure relies on sustainability value added (SVA) as an effective method of sustainability assessment. The firm needs to identify economic, environmental, social and governance factors impacting overall sustainability. WEBRIS allows comparison with other firms to identify weak points arising from the calculated SAV (with all the 4 dimensions).

C. Social sustainability

The role of high-performance people management practices in realising productivity of the firm through innovation is presented in the literature by Llinas and Abad (2020) as illustrated through Spanish SMEs. The study observed people management practices to strongly correlate with productivity and innovation with Industry 4.0 technologies being the core enablers. The research study identifies that people management practices are a high priority for any firm adopting Industry 4.0. Incorporation of Carroll's pyramid model in SMEs as an effective business strategy for overall organizational performance underpinning all the dimensions of sustainability has been well articulated (Lu et al., 2020). The important factor for business success is providing social or rational advantages as well as transitional advantages to all the stakeholders while the firm is set to transform.

In an era marked by the dominance of technology, SMEs are faced with the challenges of adopting technology in an efficient and effective manner within the firm, and especially as automation can result in a likely reduction and replacement of blue-collar workers. Job decreases in the manufacturing sector associated with the automation of monotonous tasks are a consequence of technology adoption. Consequently, recommendations from the research of Müller and Voigt (2018) are to facilitate training and re-educate employees while the firm is in transformative stage. This assures confidence and well-being for the workforce. The work by Haseeb et al. (2019) identifies that IT is available in organizations; however, the implementation of IT is often missing, and with negative sustainable business performance.

Social life cycle assessment (SLCA) assesses the social and socioeconomic aspects of producing products and their positive and negative impacts; in the case of transforming through adoption of robotics, Epping and Zhang (2018) have employed such methods. Social life cycle inventory gathers both quantitative and qualitative data from processes to be analysed. Some of the social impacts from the manufacturing sector are related to wages and compensation, safety, personal and technical growth and social interaction. The study emphasises the need for fair salaries for employees along with health and safety considerations for employees while on duty.

The social component of sustainability is nurtured amongst networking SMEs and other stakeholders involved (such as academic institutions, competitors and consumers) through transition from a 'business-as-usual' strategy to a long-term strategy for digitalized management of common resources. Indeed, Zoppelletto et al. (2020) attempt to answer the question: How can a digital transformation strategy (DTS) strengthen the relationship between network organizations and the generation/regeneration of their business network commons (BNC). In this regard, digital resources are found to be the key driver to promote BNC regeneration with DTS supporting quality and social responsibility. The research adds to the literature on the positive externalities of digitalization in the social and economic environment.

4.2.3 SME dimension

Sustainability in an organization is marked by the ability of the firm to estimate the internal and external environment and swiftly respond to market fluctuations. The need to address and respond to these changes are governed by the aptitude within the firm instilled through good leadership and best management practices. The organization structure, in line with the framed strategy and resource base enable delivery of value outcomes to the customer. The content analysis of 64 documents evolved five SME related themes namely, business strategy and management; organizational structure; organizational culture; skills and qualifications; and leadership intrinsic to the firm (see Appendix 3).

A. Business strategy and management

The need to develop innovative strategies to achieve firm performance are the recommendations from the research work of Chege et al. (2020). The research findings corroborate that technology innovation influences firm performance positively. The advent of Industry 4.0 interventions has drastically reduced the lifecycles of business models with a focus shifting towards innovation. The need to develop a new business model or adjust the existing one according to market demands and the innovativeness associated with the change are necessary. Moreover, the level of technology activities in the enterprise are positively impacted by the innovativeness of enterprises and the business environment (Pucihar et al., 2019).

To appreciate the impact of Industry 4.0 technologies as key enablers, SMEs need to devise innovative strategies for technology adoption policy. Innovation strategies for SMEs exert a positive and significant effect on Industry 4.0 digital enablers, which are the findings from the work of Somohano-Rodríguez et al. (2020). However, knowledge of technology as well as selection and adoption of the optimal technology are often found to be lacking in SMEs. The need for a maturity level-based assessment tool therefore becomes a requirement. A maturity level-based assessment tool has been devised and tested on 17 companies by Rauch et al. (2020) with a repository of 42 Industry 4.0 concepts and a strategy based on the results of the assessment to support SMEs in introducing the most promising concepts. Furthermore, an illustration from the manufacturing sector

(Jiwangkura et al., 2020) reveals IIoT implementation strategies with new HCI for SMEs in multi-dimensional facets. The findings provide insights into firms to adopt IIoT in their capacity to empower. An enterprise which attempts to adopt IT, system integration of information systems (IS) and business process automation to extract data with quality deliverance and BPM (business process management) is set to handle competition efficiently (Pomffyová et al., 2017). Moreover, Prause (2019) highlights that the adoption of Industry 4.0 technologies and processes is primarily driven by external factors (market uncertainty) and less by internal drivers.

B. Organizational structure

Despite the challenges faced by technology adoption, Industry 4.0 technologies aid SMEs in sustainable performance. This notion is tested through studies from Thailand (Haseeb et al., 2019). It has been found that organization structure and process strengthen the positive relationship between Industry 4.0 and IT implementation. The readiness indicators towards Industry 4.0 are defined using bibliometric analysis evolving 5 clusters with organizational resilience being one of them. Under the dimension of organizational resilience, the factors of business model, business strategy, digital transformation, leadership, organizational structure and supply chain management can support SMEs' Industry 4.0 readiness indicators. Additionally, a culture of communication between the interdisciplinary departments and workers with able support from management and organization strategies support adoption of Industry 4.0 principles.

C. Organizational culture

SMEs with the attitude and capabilities to adapt to the environmental changes need to be engaged in the business culture. Indeed, Mekhum (2020) remarks that *"organizational culture must have strong liaison with the goals of organizations because it has direct association with organizational performance"*. Research indicates that adaptive capability has a positive influence on innovation and competitive advantages. Further, innovation has become the mediation variable between adaptive capability and competitive advantages (Dewi et al., 2020). It is noteworthy that without the role of entrepreneurial orientation (EO), the level of digitalization does not predict the firm performance directly. Moreover, to perform in global market innovativeness capability, risk-taking, and proactiveness are crucial. Also, Chen (2020) identified that an effective value creation strategy through reaching GVC from Industry 4.0 adoption can be enhanced through trust that is developed with business partners.

In other work, a survey conducted with 270 SMEs and large firms from Hungary aims to understand firms' perception on the relationship between change management, digitalization, business performance and green development (Irimiás & Mitev, 2020). Change management has a direct and positive effect on digital maturity and on business performance, while managers also perceive it is not profitable to go green. The need for managers to understand the merits of adoption, for instance, often confuse ERP adoption to realize a competitive edge and organizational performance as strategic benefits (Jayeola et al., 2020). This is set to counter the resistance to change within the firm. Further, SMEs need to bring in a resilient data-driven culture and infrastructure to reap the benefits of adoption such as BDA (Maroufkhani et al., 2020). A strong correlation between high-performance people management practices and success in Industry 4.0 leads to productivity improvements as discussed by Llinas and Abad (2020).

D. Skills and qualifications

Human resource management, qualifications and skills are vital for SME innovation, productivity and growth. Indeed, impact analysis of digital literacy, economic literacy, and entrepreneurial skills on the performance of SMEs in garment clusters in the tourism industry are documented by Sariwulan et al. (2020). The study finds that positive correlations are observed between the pairs, namely: Digital literacy and entrepreneurial skill; economic literacy and entrepreneurial skill; economic literacy and performance. Digital literacy aids in business development through marketing networks assuring performance. Moreover, Bertello et al. (2021) in their investigation on the relationship between BDA and internationalization deduce that BDA infrastructure and the degree of internationalization is not a significant factor for productivity but rather the overriding factor is the status of the BDA capabilities.

The performance, especially the financial outcomes, of SMEs utilizing digital platforms indirectly through network capabilities is addressed in the literature by Cenamor et al. (2019). The platform enhanced capabilities have a positive relation with innovativeness. Chinakidzwa and Phiri (2020) report that digital strategy development and execution capability are the main reasons for final market performance outcomes of sales growth, market share and profitability in SMEs. Furthermore, a model developed by Kulathunga et al. (2020) aims to analyse the effect of techno-finance literacy and enterprise risk management (ERM) practices (i.e. applications) on the performance of SMEs. In this case, technological literacy and financial literacy have a positive effect on SME performance and ERM practices with higher financial literacy of SMEs enabling their ERM practices.

E. Leadership

The role of leadership and the factors affecting digital transformation in Omani SMEs using the technological, organizational, and environmental (TOE) model are reported by Alraja et al. (2021). The study recommends that leaders must formulate strategies to provide organizational and technological facilities for smooth transformation to enable capabilities and enhance international competitiveness. The transformation is set to surface various parameters for engineers and managers to consider.

Frameworks like the customer-product-process-resource (CPPR 4.0) model have been conceived in the extant literature (Martínez-Olvera & Mora-Vargas, 2019), which describes the value proposition-creation-capture cycle of an Industry 4.0 environment in the context of a manufacturing organization's customer, product, process and resource perspectives. The system dynamics model proposed in the study could be replaced by a discrete-event simulation and used as a what-if scenario testing tool to strike a balance between cost structure and revenue stream. These frameworks are ready for decision-making and forecasting tools for leaders and managers.

4.3 Intersection of theoretical concepts

A primary focus of this research study is to understand the role played by digital transformation in enabling SMEs to achieve sustainable development. From the SLR, synthesis of the 64 documents focused on the core concepts of SMEs, digital transformation and sustainable development. Since we have considered sustainability according to the TBL of economic, environmental and social dimensions, it is useful to identify the breakdown of the 64 documents in regard to which aspect of the TBL they are focused on and furthermore to identify cases where more than one aspect is covered. In this regard, we identified 10 articles that had content related to more than one aspect of the TBL. This includes 6 articles that have content on the economic, environmental and social dimensions; 3 articles that have content on the economic and social dimensions; and 1 article on the economic and environmental dimensions. The breakdown of technologies adopted in the 10 articles that have content on more than one aspect of the TBL is depicted in Appendix 4 and Figure 7.

Figure 7. Percentage distribution of documents according to technologies from extracts in Figure 6
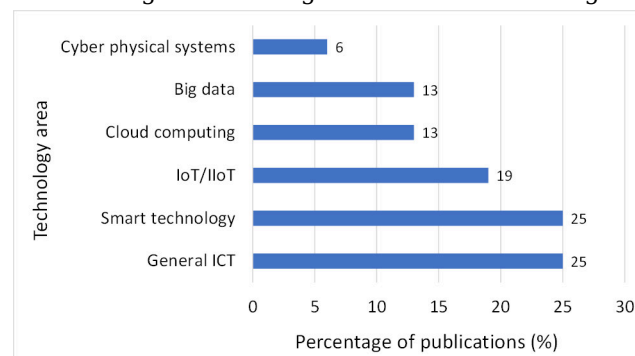
The six articles that have content across all three TBL dimensions of economic, environmental and social aspects identify that strategy, innovative integration, sustainability assessment, cost effective tools for sustainability assessment and government support are key areas that aid in realizing overall sustainability. People management practices, skills, digital resources, human resources, digital transformation strategy (DTS) and business networking are the key drivers towards economic and social sustainability (from the 3 articles with content on the economic and social dimensions). Whereas skills, organizational culture (data driven), green purchasing, environmental technologies are the factors favoring economic and environmental sustainability (from the 1 article on the economic and environmental dimensions).

Incorporation of environmental, ethical, legal, philanthropic and economic aspects in the modified Carroll's pyramid model of CSR is observed to establish a positive and significant relationship with organizational performance, thereby enabling long-term sustainable growth and competitive advantage coupled with smart factory concept adoption (Lu et al., 2020). This is conceived as an improved strategy to facilitate a green corporate image rather than concentrating only on economics (i.e. cost benefit analysis). Provision of social or rational advantages as well as transitional advantages for all stakeholders while enabling digital transformation assures social sustainability. Indeed, innovative integration strategies between SMEs from different sectors with the intent of value creation and participation in GVC employing 'green manufacturing concepts' are the observations leading to sustainable business as perceived by Chen (2020).

Firms with a keen eye for sensing technological opportunism, adoption of technology and exploitation of technology with effective government regulations are in a favourable position to attain environmental, social

and economic sustainability. Asim et al. (2019) reported that technological opportunism is an important antecedent of business sustainability. Government regulates environmental policies and imposes penalties on firms breaching environmental and social regulations and is found to moderate the factors technological opportunism and sustainability. Having the strategy and right technology, the firm needs to perform sustainability assessment to estimate the impact of product or process on the environment. Further, Epping and Zhang (2018) in their sustainability assessment for a welding firm in transition to robotic arc welding have deduced the impact of transition on the three dimensions of sustainability. The sustainability impact assessment is vital to recognise and address the issues concerning each dimension of sustainability. Designing a simple, cost effective, efficient, automated, comprehensive and simplified system for the sustainability assessment (WEBRIS) is the result of the study by Kassem and Trenz (2020).

IIoT enablement of SMEs from German and Chinese cases reveals ecological benefits, resource efficiency and energy efficiency as key findings. Moreover, it is imperative for good management practices with circular economy concepts or lean practices to help in achieving economic and environmental sustainability. The transformation is marked by upgrading of skills and education of the existing workforce to ensure social sustainability within the firm. The challenges of IIoT adoption in China are increasing competition, lack of financial resources and fear of retrenchment due to adoption.

4.4 Bibliometric analysis

The bibliometric analysis using VOSviewer with 64 documents yielded 42 keywords, which were checked for plurality, synonyms and redundant terms by creating a thesaurus file. Input of 64 documents (Excel csv files) and the thesaurus file resulted in a refined co-occurrence map of keywords with 27 keywords, which needed to be frequent at least once in the dataset (see Figure 8).

Figure 8. Co-occurrence map generated from the SLR synthesized documents
(N = 64)
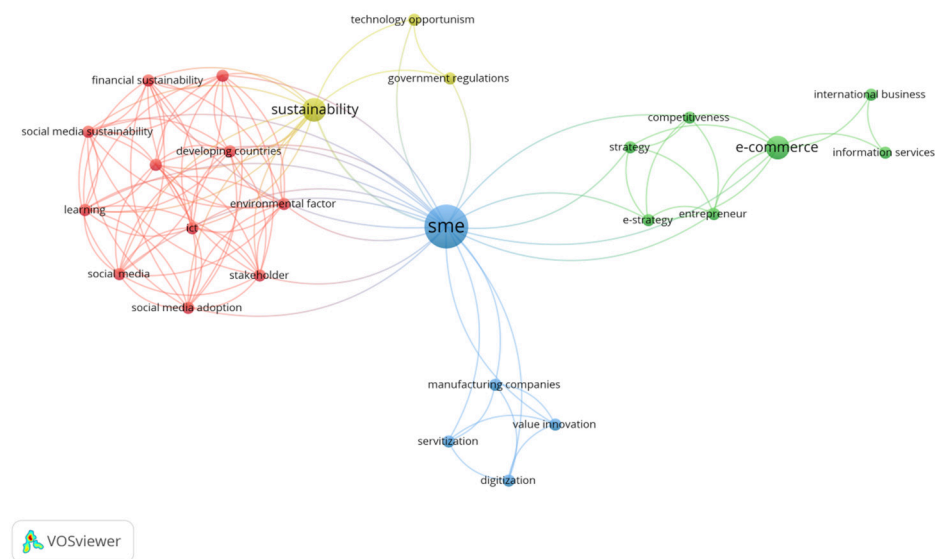
In the bibliometric analysis, four prominent clusters, namely green, blue, yellow and red are observed. The term/keywords sustainability and e-commerce are prominent spheres (size) indicating high occurrence frequency. Sustainability is directly associated with (linked or co-occur) with terms like social media (SM) and SM adoption, learning, stakeholder, government regulation, policy implementation, environmental factors, and financial sustainability with ICT (red cluster) as the enabler. Overall sustainability enabled by ICT, SM and aforementioned drivers are the findings from the map. SME is found co-occurring with e-commerce (green cluster) and blue cluster apart from sustainability links (yellow and red cluster). E-commerce is the strong driver co-occurring with e-strategy, competitiveness, international business and information services which emphasis the digital orientation of SMEs with the need for data driven culture to enable GVC. Digitization, value innovation and servitisation are the factors implicit to digital intervention. Whereas ICT, SM, e-commerce, technology adoption, technology opportunism and focus on data collection are the enablers for SME growth.

Further bibliometric analysis was conducted using the VOSviewer software package. Figure 9 provides the co-occurrence map identifying constructs associated with the term SME. Figure 10 provides the co-occurrence

map identifying relative contributions of countries where authors reside. Figure 11 provides the co-occurrence map identifying association between the authors of the articles.

Figure 9. Co-occurrence map identifying constructs associated with the term
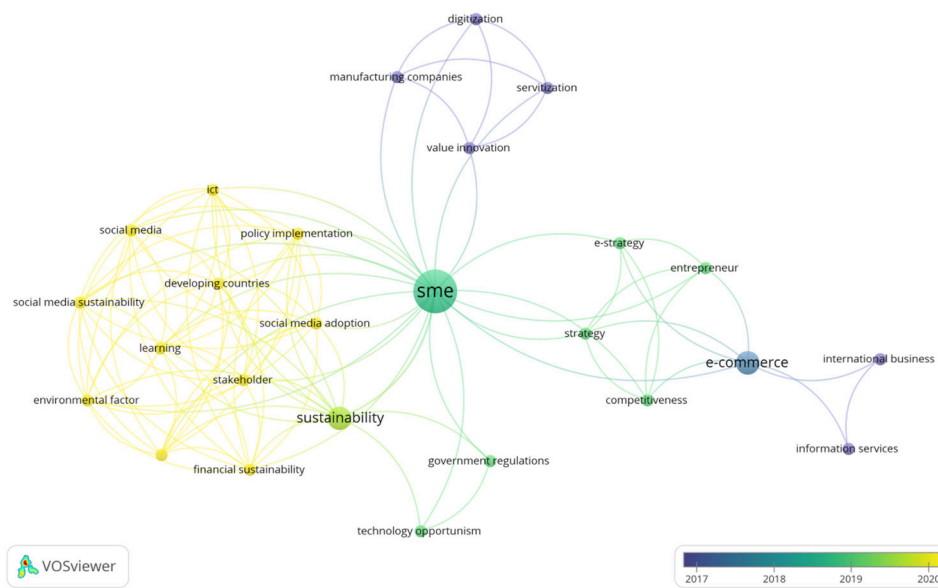SME

Figure 9 illustrates the SME associated keywords based on years published. The figure illustrates 10 keywords with a high presence in 2020 that are strongly linked to SME and sustainability. This appears to be a primary cluster and these keywords are highly interlinked in terms of presence. Figure 10 also provides other clusters with a lower presence in the 2017 to 2019 timeline. A strong presence of the term e-commerce with links to strategy, competitiveness, entrepreneur, international business and information services is also identified in the co-occurrence map.

Figure 10. Co-occurrence map identifying relative contributions of countries
where authors reside
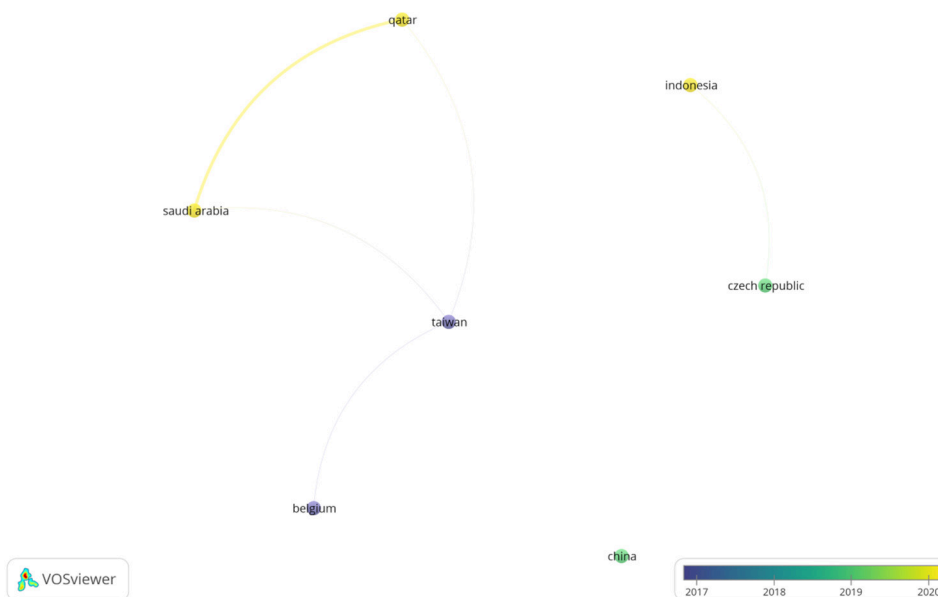
From Figure 10 it is apparent that the latest research contributions from 2017 to 2019 are from a range of counties from the Middle East, Far East and parts of Europe. This includes specifically Saudi Arabia, Qatar, Indonesia, Taiwan, China, Belgium and the Czech Republic. There are stronger links, in terms of the authors

from the Middle East, namely from Saudi Arabia and Qatar. Weaker links exist between Middle East and Taiwanese authors. The remaining countries and author links are weak to none existent.

Figure 11 identifies the links between author associations. There are 5 key clusters with three smaller author clusters with 3 to 4 authors and two larger clusters with between 5 and 7 authors. The authors are not interlinked between clusters indicating that the cluster of authors continue to work within their circle of influence.

Figure 11. Co-occurrence map identifying association between the authors of the articles
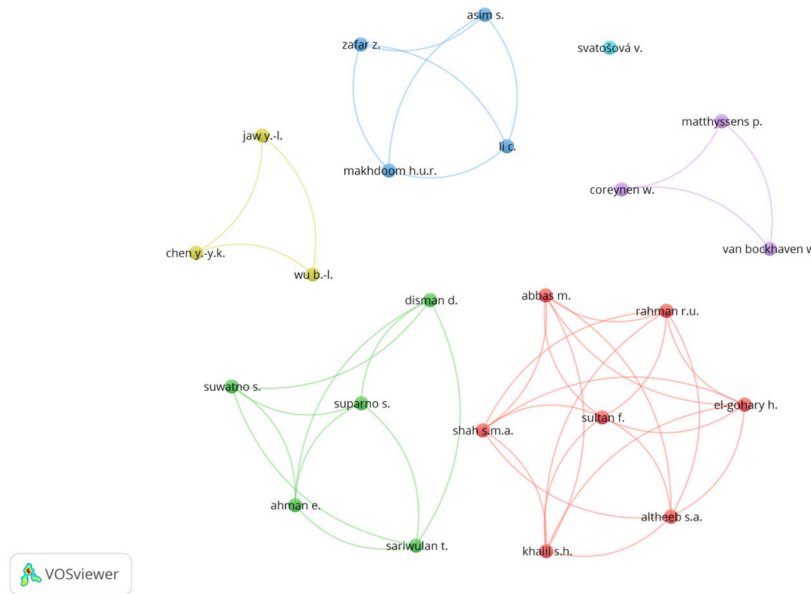
5. Discussion

5.1 Insights from the SLR

The literature review is based on gaining insight into three underpinning concepts namely, SME, digital transformation and sustainable development through employing appropriate search strings. Initial descriptive statistical analysis identifies the concept to be active since 2017 with active research collaborations worldwide (27% of documents under international category) and with 20% of articles being published in the *Sustainability* journal (Figures 4-6). The synthesis from the SLR (64 articles), involved the articles being segregated and analyzed based on the three broad concepts chosen. The data pertaining to SME aspects are further deconvoluted to categories under business strategy/management, organizational culture, organizational structure, skill/qualification, and leadership. The data is scrutinized to capture the economic, social and environmental dimensions of sustainability. The type of Industry 4.0 technology and other adoptions like ICT/IT, internet enabled platforms (social media network, e-commerce, web-based applications) and digital tools in use by SMEs to attain sustainability are noted. Further, sustainability discussed in the synthesized articles elaborating exclusively on TBL and articles with more than one dimension of sustainability being discussed are extracted to result in 10 documents (6 on TBL, 3 on economic and social dimension, 1 on economic and environmental dimension).

The technology adoption within these 10 documents indicates smart technology and general ICT as highly favoured and CPS being the least. This is followed by IoT/IIoT over cloud computing and big data with equal prominence. The technology associated to realise TBL (6 documents) are in the same order but, general ICT excels over smart manufacturing with the absence of big data intervention, while cloud computing shares equal adoption weightage with CPS. Digital strategies, innovative strategies, value creation strategies and strategic model are the drivers observed under the category of business strategy. Marketing execution capability, digital product display capabilities, BDA skills, IT skills, project operational capabilities and managerial capabilities with qualifications and training are found to exert positive influence in attaining economic sustainability (least) and overall sustainability (maximum) depending on management support.

Networking, e-market sensing ability, GVC, online marketing, social media marketing, industry-specific web portal as an IT resource as well as green purchasing activities and green manufacturing initiatives indicates the impact of technology (online presence and online business) to realise economic and environmental

sustainability. Additionally, investments in human and social capital aim to upgrade skills, data sharing with stakeholders with trust, cyber-physical integration and emotional marketing, digital assets and skills to integrate into customers' processes and digital transformation strategy with digital resources and networking are the findings to enable social sustainability of SMEs. Value creation strategies with stakeholder integration and other sector collaboration with digital intervention is observed as a mechanism to attain TBL. This mainly requires integrating all dimensions of sustainability in the business model with aptitude for adoption (change management, technology opportunism) with green manufacturing process as well as supporting government regulations and strict policy implementation. Skills, data access, digital resources and stakeholder integration are key. General ICT with 32% adoption, smart technology 16%, cloud technology and IoT/IIoT each contributing 12% followed by internet enabled platforms 10% are the key technology interventions observed in the SLR synthesis. The order is almost similar to that observed from the 10 articles extracted from the synthesis featuring TBL and more than one dimension of sustainability, except ICT and smart manufacturing appear with equal magnitude.

The VOSviewer analysis categorically highlights ICT, SM, e-commerce, technology adoption, technology opportunism and focuses on data collection as the factors to sustainability. The map identifies environmental factors and financial sustainability linked to sustainability apart from social media, government regulation, implementation and ICT. Further, ICT is the enabler, finding application in e-commerce business. International business, information service (data), digital strategy are factors enhancing competitiveness and sustainability. Value innovation, servitisation and digitalisation are the drivers co-occurring with SME term. The observation from VOSviewer runs parallel to the SLR approach except for the absence of terms describing social dimension and Industry 4.0 technologies.

5.2 Future research directions

The SLR based study has enabled synthesis of a number of specific future research directions, which have been generated in a similar way to the study by Lozano-Reina and Sánchez-Marín (2020). The future research directions identify areas that need to be pursued in order to build on the present study and gain an even greater understanding of how SMEs can adopt digital technologies in order to realise the goal of sustainability. The future research directions are summarized as follows.

Technology dimension:

- Digital transformation and the wider Industry 4.0 paradigm involve a range of different technologies, such as IoT, CPS, big data and AI/ML. Consequently, there is a need to investigate which technologies have the capacity to have the greatest impact on the performance of SMEs. This includes understanding which technologies impact on sustainability as well as the level of maturity of the technology and the corresponding viability of adopting the technology in certain timeframes (such as short-term, medium-term and long-term). Technology maturity can be assessed using the technology readiness level (TRL) framework.
- The readiness of SMEs to adopt technologies, such as smart manufacturing, IoT and internet-enabled platforms as part of digital tool intervention is described in detail in the SLR, however, there is a need for further investigation of the cost/benefit analysis associated with digital transformation by SMEs.
- There is need for a greater understanding of the benefits to be gained from digital transformation and how specific technologies can be linked to increased competitiveness as well as improved productivity. This knowledge can be used to inform digital transformation strategies adopted by SMEs, including consideration of which technologies to be adopted in the near-term, mid-term and long-term horizons.

Sustainable development dimension:

- Traditionally achieving economic sustainability is the main focus for SMEs but in order to fully realize sustainability, this needs to be accompanied by both environmental and social sustainability. However, there is the potential for trade-offs between these three orientations and there is a need to understand how such trade-offs can be mitigated so that SMEs realize sustainable development across all three dimensions of the TBL.
- The pursuit of 'green manufacturing concepts' and adoption of a 'go-green strategy' requires sustainability assessment according to a cost effective, efficient, automated, comprehensive and systemic approach. SMEs can be burdened while in pursuit of this goal, hence there is a need for support mechanisms to be in place. Consequently, further investigation is required of the type of support mechanisms made available to SMEs.
- In regard to sustainable development, there is a deep understanding of the economic sustainability of firms (including SMEs) as well as an emerging appreciation of environmental sustainability. However, there is a lack of recognition of studies on social sustainability, including understanding how social impact can be optimized by SMEs and especially in emerging economy situations. Further studies are required to investigate this important area.

Business characteristics dimension:

- There is a need to understand how SME business models are configured to accommodate technology maturity, organizational structure and process as well as other factors such as leadership competencies, digital skills and knowledge. New business model development is required so that SMEs can balance the costs of digital transformation against the benefits arising from sustainable development.
- Technology-driven innovation with value creation strategies support the process of SMEs engaging customers, suppliers and stakeholders thereby fostering market activity. This necessitates trust amongst stakeholders through data sharing with IP protection, although there is a need to understand how this can be supported by standard guidelines and regulations. Research studies are needed on the nature of these guidelines and regulations and how they can be optimally configured.
- SMEs need access to the necessary skills and knowledge to pursue a pathway towards sustainable development. Where appropriate, education and training mechanisms should be developed to support this requirement along with a focus on the leadership capabilities that are required. Further studies are needed on how such support mechanisms can be designed to enable SMEs to undergo digital transformation towards the goal of sustainable development.

6. Conclusions

The qualitative synthesis of documents through the SLR approach has revealed many insights, such as the pivotal role of organizational culture with an aptitude towards technology adoption and subsequent data management as the foundations for SMEs to undergo digital transformation. Sustainability initiatives through digital technology are enabled through innovative strategies. This calls for sustainability assessment to identify the requisite parameters and assist managers or leaders to transform SMEs in an efficient and effective manner. Organizational structure and processes need to be streamlined as this directly impacts implementation of digital technologies. Moreover, the selection of technology depends on the digital orientation adopted. Innovativeness and high-performance mean that management requirements become the priorities in transformation rather than the sophistication of the technology itself. It can be observed that advanced technologies, such as robotics appear to fare equally well compared to general ICT facilities, thereby implying innovation, skill and management are essential drivers alongside technology sophistication.

A set of future research directions have been synthesized from the SLR. Moreover, future work is recommended to build on this SLR through capturing empirical data (from surveys and interviews) on how SMEs can undergo the process of digital transformation towards sustainability. In particular, such studies should identify technology priorities (for near, medium and long-term perspectives) as well as develop suitable technology roadmaps to facilitate digital transformation according to the economic, environmental and social performance of SMEs.

Acknowledgements

Appendix

Appendix 1. Literature profile of Industry 4.0 technologies and tools employed by SMEs

Technology	Literature
General ICT (information and communications technology)	Ballestar et al., 2020; Cenamor et al., 2019; Chege et al., 2020; Chen et al., 2016; Coreynen et al., 2017; Mukhtar et al., 2020; Müller et al., 2018; North et al., 2019; Pisar & Mazo, 2020; Pomffyová et al., 2017; Prause, 2019; Pucihar et al., 2019; Somohano-Rodríguez et al., 2020; Ullah & Narain, 2021; Zoppelletto et al., 2020
Cloud computing	Chen, 2020; Chen et al., 2016; Chonsawat & Sopadang, 2020; Dutta et al., 2020; Jayeola et al., 2020; Mokhtar et al., 2020; Somohano-Rodríguez et al., 2020; Trstenjak et al., 2020; Zoppelletto et al., 2020
Cyber physical system (CPS)	Chen, 2020; Dutta et al., 2020; Korauš et al., 2020; Müller, 2019; Müller et al., 2018; Prause, 2019
IoT/IIoT	Benitez et al., 2020; Chen, 2019, 2020; Chonsawat & Sopadang, 2020; Dutta et al., 2020; Haseeb et al., 2019; Jiwangkura et al., 2020; Müller & Voigt, 2018; Philipp et al., 2019
Big data	Bertello et al., 2021; Dutta et al., 2020; Haseeb et al., 2019; Mangla et al., 2021; Maroufkhani et al., 2020; Somohano-Rodríguez et al., 2020
Artificial Intelligence (AI)	Basri, 2020
3D-Printing	Coreynen et al., 2017
Blockchain	Philipp et al., 2019
Robotics	Epping & Zhang, 2018; Ghafoorpoor Yazdi et al., 2018; Ingaldi & Ulewicz, 2019
Smart manufacturing	Lu et al., 2020; Mittal et al., 2020
Internet enable platforms	Anthony, 2019; Cenamor et al., 2019; Chinakidzwa & Phiri, 2020; Qalati et al., 2020; Sariwulan et al., 2020; Somjai et al., 2019; Svatošová, 2019; Ur Rahman et al., 2020
Technology/digital/Industry 4.0 and tools	Alraja et al., 2021; Cenamor et al., 2019; Chen, 2020; Dewi et al., 2020; Dumitriu et al., 2019; Gadi Djou et al., 2020; Irimiás & Mitev, 2020; Kassem & Trenz, 2020; Kelley et al., 2020; Kim et al., 2019; Kulathunga et al., 2020; Kumar et al., 2020; Llinas & Abad, 2020; Martínez-Olvera & Mora-Vargas, 2019; Mekhum, 2020; Navakitkanok et al., 2020; Rauch et al., 2020; Ullah & Narain, 2021; Urban et al., 2020; Yoo et al., 2018; Yu & Schweisfurth, 2020

Source: Authors' own

Appendix 2. Literature profile of sustainability dimensions from the SLR

Sustainability dimension	Literature
Sustainability as a generalized term in article.	Dumitriu et al., 2019; Epping & Zhang, 2018; Ghafoorpoor Yazdi et al., 2018; Haseeb et al., 2019; Irimiás & Mitev, 2020; Kassem & Trenz, 2020; Kim et al., 2019; Kumar et al., 2020; Lu et al., 2020; Mangla et al., 2021; Martínez-Olvera & Mora-Vargas, 2019; Müller, 2019; Müller et al., 2018; Navakitkanok et al., 2020; North et al., 2019; Philipp et al., 2019; Pomffyová et al., 2017; Svatošová, 2019; Urban et al., 2020; Yoo et al., 2018
Economic	Alraja et al., 2021; Asim et al., 2019; Ballestar et al., 2020; Basri, 2020; Cenamor et al., 2019; Chege et al., 2020; Chen, 2019, 2020; Chen et al., 2016; Chinakidzwa & Phiri, 2020; Coreynen et al., 2017; Epping & Zhang, 2018; Haseeb et al., 2019; Jayeola et al., 2020; Kassem & Trenz, 2020; Kulathunga et al., 2020; Lu et al., 2020; Mangla et al., 2021; Maroufkhani et al., 2020; Mokhtar et al., 2020; Mukhtar et al., 2020; Müller et al., 2018; Müller & Voigt, 2018; Navakitkanok et al., 2020; North et al., 2019; Pisar & Mazo, 2020; Pucihar et al., 2019; Qalati et al., 2020; Sariwulan et al., 2020; Somjai et al., 2019; Somohano-Rodríguez et al., 2020; Svatošová, 2019; Trstenjak et al., 2020; Ur Rahman et al., 2020; Yoo et al., 2018; Zoppelletto et al., 2020
Environmental	Asim et al., 2019; Chen, 2020; Epping & Zhang, 2018; Kassem & Trenz, 2020; Lu et al., 2020; Mangla et al., 2021
Social	Asim et al., 2019; Chen, 2020; Epping & Zhang, 2018; Haseeb et al., 2019; Kassem & Trenz, 2020; Llinas & Abad, 2020; Zoppelletto et al., 2020

Source: Authors' own

Appendix 3. Literature profile of key aspects of SMEs from the SLR

SME key dimensions	Literature
Business strategy and management	Basri, 2020; Chege et al., 2020; Chen, 2020; Chinakidzwa & Phiri, 2020; Chonsawat & Sopadang, 2020; Gadi Djou et al., 2020; Jiwangkura et al., 2020; Kassem & Trenz, 2020; Kelley et al., 2020; Lu et al., 2020; Müller, 2019; Pomffyová et al., 2017; Prause, 2019; Pucihar et al., 2019; Rauch et al., 2020; Sariwulan et al., 2020; Somohano-Rodríguez et al., 2020; Svatošová, 2019
Organizational structure	Chonsawat & Sopadang, 2020; Haseeb et al., 2019
Organizational culture	Chen, 2020; Coreynen et al., 2017; Irimiás & Mitev, 2020; Jayeola et al., 2020; Korauš et al., 2020; Llinas & Abad, 2020; Maroufkhani et al., 2020; Mekhum, 2020; Mittal et al., 2020; Navakitkanok et al., 2020; Pisar & Mazo, 2020; Yoo et al., 2018
Skills and qualifications	Ballestar et al., 2020; Bertello et al., 2021; Cenamor et al., 2019; Chinakidzwa & Phiri, 2020; Gadi Djou et al., 2020; Korauš et al., 2020; Kulathunga et al., 2020; Sariwulan et al., 2020; Zoppelletto et al., 2020
Leadership	Alraja et al., 2021; Benitez et al., 2020; Chinakidzwa & Phiri, 2020; Dutta et al., 2020; Epping & Zhang, 2018; Martínez-Olvera & Mora-Vargas, 2019; Trstenjak et al., 2020; Ullah & Narain, 2021; Ur Rahman et al., 2020

Source: Authors' own

Appendix 4. Intersection of three underpinning concepts (E = Economic sustainability; En = Environmental sustainability; S = Social sustainability)

Literature	(1)	(2)	(3)	(4)	(5)	(6)	(8)	Concepts discussed	SME dimension
Asim et al., 2019	E, En, S						X	Technological opportunism, business sustainability and governmental regulations.	Organizational culture
Chen, 2020	E, En, S		X	X	X	X		Global value chain, value creation strategies, digital product display capabilities, integrating cultural content design and online marketing, brand marketing with cyber-physical integration and emotional marketing.	Business strategy & organizational culture
Epping & Zhang, 2018)	E, En, S					X		Sustainability decision-making, digital transformation, cost, environmental impact, and social impact and robotics.	Leadership
Kassem & Trenz, 2020	E, En, S					X		Sustainability assessment, key performance indicators, economic, environmental, social and governance dimensions and automated information system.	Business strategy
Lu et al., 2020	E, En, S					X		Carroll's pyramid model, business strategy, corporate social responsibility, green manufacturing processes, green supply chain management, green products, organizational innovation and corporate or brand image.	Business strategy
Müller & Voigt, 2018	E, En, S				X			Triple bottom line, social challenges, capabilities data process and exchange and social benefits.	Skills/ qualification
Haseeb et al., 2019	E, S	X			X	X		Sustainable business performance, organization structure and process.	Organizational structure
Zoppelletto et al., 2020	E, S		X				X	Digital transformation strategy, network organizations, business network commons quality, social responsibility and digital transformation.	Skills/ qualification
Llinas & Abad, 2020	E, S						X	High-performance people management practices, digitization, productivity, innovation, business processes	Organizational culture
Mangla et al., 2021	E, En	X						Project performance, top management, project knowledge management focus on sustainability, green purchasing, environmental technologies, social responsibility, project operational capabilities, project complexity, collaboration and explorative learning, and project success and strategies.	Skills/qualification & strategy

Source: Authors' own

(1) Sustainability

(2) Big data

(3) Cloud

(4) CPS

(5) IoT

(6) Smart Manufacturing

(7) General ICT

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