

INTEGRATING DIGITAL INNOVATION AND SUSTAINABLE PRACTICES IN SMES: A DECADE OF INSIGHTS AND EMERGING DIRECTIONS

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ABSTRACT

This study aims to examine the bibliometric characteristics of previous literature concerning digital innovation and sustainability in small and medium enterprises (SMEs), which further aims to identify the most influential and productive contributors in terms of documents, authors, countries, sources, affiliations, etc. The bibliographic data of 332 documents is extracted from the Scopus database by applying a systematic search strategy with defined inclusion and exclusion criteria. R software and VOS viewer software were used to analyze and visualize the bibliographic data to gain insights into the leading authors, key sources, relevant affiliations, research clusters, and influential publications in this particular field.

For clustering, co-occurrence of keyword analysis was used, which further depicts three clusters and themes around which the research related to digital innovation and sustainability in small and medium enterprises. The findings of the study showed a growing trend of publication reflecting the evolving landscape of research in this particular domain. This study represents a novel attempt in the research landscape, as it bridges the gap between two critical areas- digital innovation and sustainability within the context of small and medium enterprises (SMEs). The study's findings could act as a spark for policymakers, industry leaders, and academics to gain a deeper understanding of the current landscape and emerging trends within this domain.

Keywords – Digital Innovation, Sustainability, Small and Medium Enterprises (SMEs), Bibliometric analysis

1. INTRODUCTION

Small and Medium-sized Enterprises (SMEs) constitute the backbone of global economies, driving innovation, creating jobs, and contributing to local communities. Sustainability is the practice of conducting business or activities in a way that meets the needs of the present without compromising the ability of future generations to meet their own needs. Digital innovation refers to the adoption of digital technologies and integrating them into various aspects of business operations. It empowers SMEs to streamline operations, access new markets, and improve resource management. It provides them with the tools and capabilities to optimize processes, enhance customer experiences, and make data-informed decisions.

In the era of rapid technological advancements, global connectivity, and escalating environmental challenges, the nexus/link between innovation and sustainability has become crucial for business success (Sagar, 2023). Through the adoption of digital technologies, SMEs can streamline their processes, automate their tasks, sustain their growth momentum, accelerate their business activities, and contribute to regional development (Dodd & Hynes, 2012; Chatterjee et al., 2022). These innovations enable SMEs to respond swiftly to market changes, personalize customer experiences, and access global markets with minimal infrastructure costs. Embracing sustainability, small and medium enterprises (SMEs) can gain a competitive advantage, attracting customers and investors, fostering innovation, reducing costs, and enhancing their reputation (Martínez-Peláez et al., 2023). Sustainability through digital transformation is essential for contemporary businesses (Nejati et al., 2014). This strategic combination of sustainability and technology adoption holds immense potential for driving positive environmental and social impact while ensuring the long-term viability of SMEs (Piccarozzi et al., 2022). In addition to environmental considerations, digital transformation enables micro, small, and medium enterprises to prioritize social sustainability (Goodland, 2002). Through digital platforms and e-commerce, these enterprises can reach broader markets, connect with socially conscious consumers, and communicate their sustainability initiatives effectively (Osmonbekov et al., 2002).

The synergy between digital innovation and sustainability is therefore not only essential for business continuity but also for contributing to broader global goals, such as the United Nations Sustainable Development Goals (SDGs). As such, understanding how SMEs can strategically leverage digital innovation for sustainable growth is crucial for policymakers, entrepreneurs, and researchers alike. This study aims to explore this intersection, highlighting its transformative impact on the operational, environmental, and strategic dimensions of SMEs.

There are limited study on analyzing the relationship between digital innovation and sustainability within the SME sector. The majority of existing studies in this domain primarily consist of case studies, which typically focus on developing conceptual models, thereby limiting their generalizability across the broader paradigm. The existing literature that integrates these two approaches (Digital innovation and sustainability) in context of SME sector, has not yet been systematically structured comprehensively. This presents an opportunity to organize existing body of knowledge (corpus of literature) systematically, thereby shedding light on current trends in this domain, which would help the researchers, academicians, practitioners and industrialists to discover gaps and opportunities for further research.

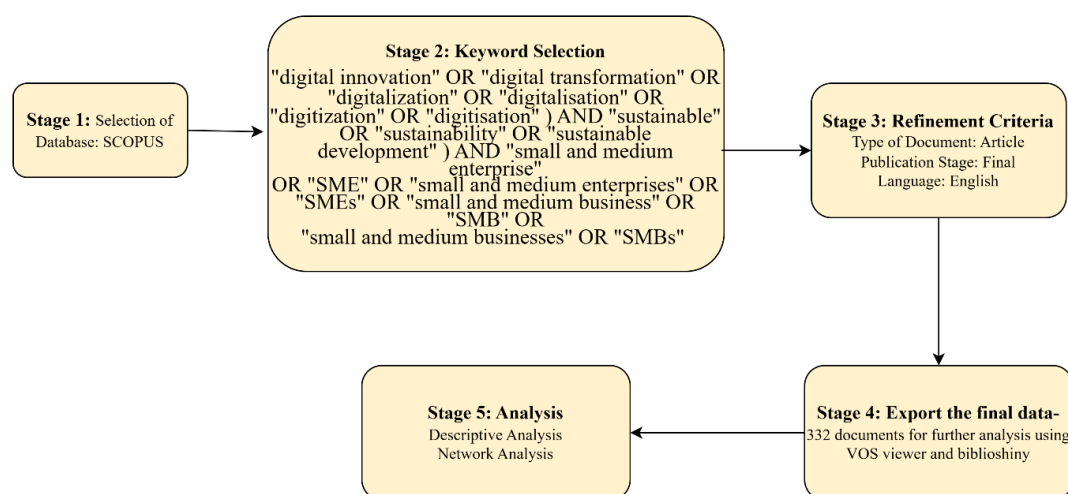
1.1 Research Objectives

1. To elicit the trends of publications on digital innovation and sustainability within the small and medium enterprises (SMEs).
2. To identify the key figures in terms of journals, authors, nations, and documents within this particular domain.
3. To identify the prominent themes and areas of focus on digital innovation and sustainability within the small and medium enterprises (SMEs).

The subsequent part of the paper is structured as follows. Section 2 delineates the research methodology employed in the present study. Section 3 displays descriptive analysis and findings of the study. A summary of the review is provided in section 4. Section 5 elucidates the implications that can be inferred from the study, and the final section outlines the conclusion, limitations, and potential avenues for future research.

2. MATERIALS AND METHODS

The present study has implemented a systematic review strategy incorporating different bibliometric analysis techniques to understand the integration of digital innovation and sustainability in the context of small and medium enterprises. Bibliometric analysis makes use of quantitative tools and techniques to analyse the bibliometric data (Broadus, 1987; Pritchard, 1969). Bibliometric analysis enables researchers to thoroughly examine a variable from various angles, which illuminates the pattern of that variable's evolution. (Fellnhöfer, 2019). This methodology proves to be extremely helpful in building an exhaustive panorama of prevailing patterns within a particular field of study (Hood & Wilson, 2001). Therefore, bibliometric analysis is best suited technique as it assists in exploring the most popular authors, journals, articles, and countries related to the topic under analysis. It encapsulates evaluating the significance and impact of research on a particular issue using various bibliometric indicators like citation counts, co-authorship networks, and keyword analysis (Donthu *et al.*, 2021).



(Figure 1: Methodology adopted for bibliometric analysis)

Figure 1 demonstrates that the initial stages of the data collection process is to select the source of data. The Scopus database was chosen as the primary source for retrieving relevant research publications for this bibliometric analysis. SCOPUS is recognized as the largest repository of research publications, abstracts, and peer-reviewed literature (Dunakhe & Panse, 2021), offering a comprehensive collection of academic literature (Zainuldin & Lui, 2022), had extensive coverage in the social sciences, surpassing that of the Web of Science (WoS) database (Kumar *et al.*, 2021; Mongeon & Paul-Haus, 2015). The data retrieval was performed on 10th of February 2024, in order to retrieve the maximum number of

publications and ensure the most up-to-date study possible. The most commonly used keywords were selected based on some review studies (Selçuk, 2023; Ragazou et al., 2022; Xu et al., 2018).

Table 1: Initial Extraction of Data

Database	Keyword used	Search Criteria	Documents extracted
Scopus	(TITLE-ABS-KEY ("digital innovation" OR "digital transformation" OR "digitalization" OR "digitalisation" OR "digitization" OR "digitisation") AND TITLE-ABS-KEY ("sustainable" OR "sustainability" OR "sustainable development") AND TITLE-ABS-KEY ("small and medium enterprise" OR "SME" OR "small and medium enterprises" OR "SMEs" OR "small and medium business" OR "SMB" OR "small and medium businesses" OR "SMBs")) Search Date: April 17, 2025	Article title, abstract or keyword	698

Refinement Criteria

Table 2: Screening of documents

Base	Inclusion	Exclusion
Document type	Article (384)	Conference Paper, Conference review, Book chapter, Review, Book, Editorial, Erratum, Data paper (314)
Publication stage	Final (342)	Article in press (42)
Language	English (332)	Italian, Russian, Serbian, Spanish (10)

Search Query -

(TITLE-ABS-KEY ("digital innovation" OR "digital transformation" OR "digitalization" OR "digitalisation" OR "digitization" OR "digitisation") AND TITLE-ABS-KEY ("sustainable" OR "sustainability" OR "sustainable development") AND TITLE-ABS-KEY ("small and medium enterprise" OR "SME" OR "small and medium enterprises" OR "SMEs" OR "small and medium business" OR "SMB" OR "small and medium businesses" OR "SMBs")) AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "cp")) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (LANGUAGE , "English"))

VOSviewer (Visualization of Similarities), a widely utilized free software for bibliometric analysis, and Biblioshiny which is a web interface of R studio were used for analysis. (Bashar and Singh, 2022; Singh and Bashar, 2021)

3. RESULTS & DISCUSSIONS

The descriptive analysis aims to show the trend of publications, total citations per year, top cited documents, most relevant authors considering their productivity, most relevant sources with their productivity, and most relevant affiliations. The dataset, which can be seen in

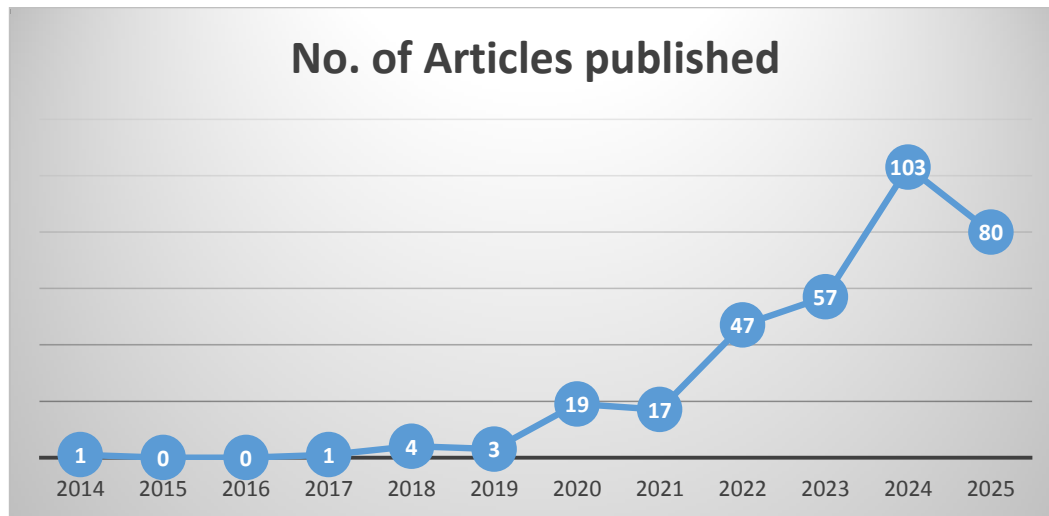
Table 3 given below, consists of 332 articles that were published by 202 sources over a period of 10 years.

Table 3: Main Information about Data

Timespan	2014:2025
Sources (Journals, Books, etc)	202
Documents	332
Annual Growth Rate %	48.94
Document Average Age	1.77
Average citations per doc	16.46
References	22556
DOCUMENT CONTENTS	
Keywords Plus (ID)	778
Author's Keywords (DE)	1118
AUTHORS	
Authors	1128
Authors of single-authored docs	21
AUTHORS COLLABORATION	
Single-authored docs	21
Co-Authors per Doc	3.61
International co-authorships %	30.42
DOCUMENT TYPES	
article	332

YEAR-WISE PUBLICATION

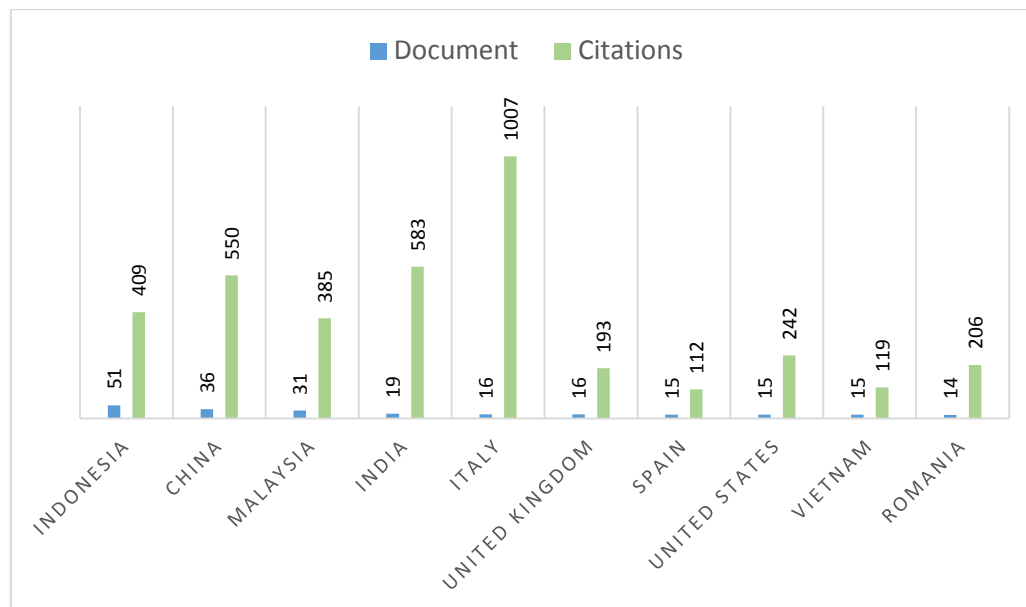
The year-wise publication diagram shows the evolving landscape of digital innovation and sustainability in Small and Medium Enterprises (SMEs). Due to its infancy, the topic received little attention between 2014 and 2017. A steady rise started in 2018, with a significant uptick in 2020 brought on by the COVID-19 pandemic, which hastened SMEs' digital transformation. Significant growth occurred between 2022 and 2024, reaching a peak of 103 articles in 2024, propelled by greater funding, global sustainability initiatives, and governmental assistance. Research on how digital tools might improve sustainability in SME operations became more widely accepted during this time. Notably, by April 2025 alone, 80 articles had already been published, indicating continued strong interest and sustained relevance of the topic. This trend underscores how digital innovation is now widely recognized as a key enabler of sustainable growth in SMEs.



(Figure 2: Year-wise documents)

COUNTRY-WISE PUBLICATION ALONG WITH CITATIONS

By considering the country as a unit of analysis, Total citations of documents reflect the level of interest in a particular area of study. Figure 3 demonstrates that Indonesia, with 51 publications having 409 citations, emerged as the leading country in terms of research output, and topped the list in terms of the number of publications in this domain, followed by China, Malaysia, and India with 36, 31, and 19 documents, respectively.



(Figure 3: Country-wise publication along with total citations)

MOST INFLUENTIAL DOCUMENTS

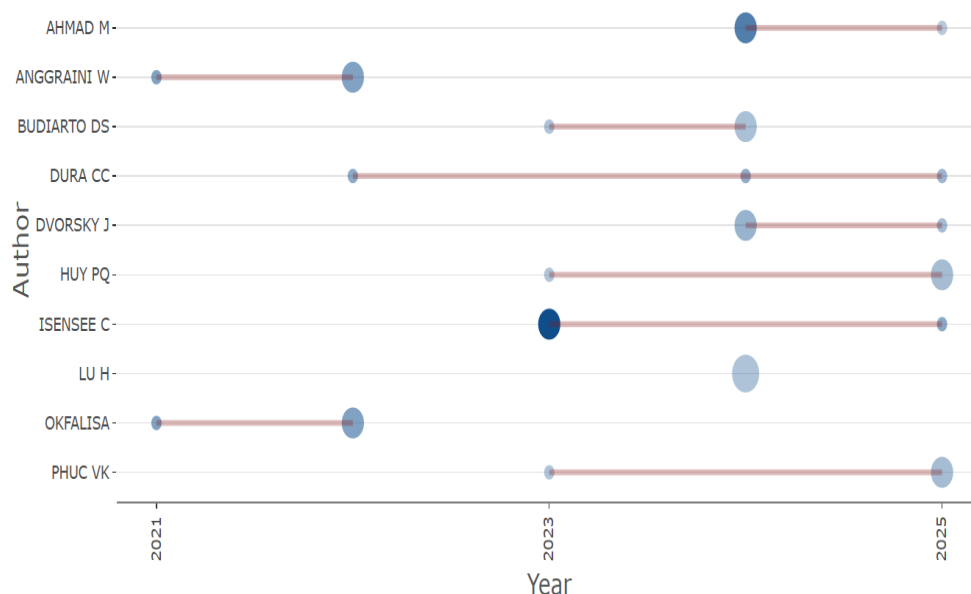
Table 4: Top 10 most cited documents

Sr. No.	Document	Title	Journal	Total Citations
1	Denicolai et al. (2021)	Internationalization, digitalization, and sustainability: Are SMEs ready? A survey on synergies and substituting effects among growth paths	<i>Technological Forecasting and Social Change</i>	328
2	Ardito et al. (2021)	The duality of digital and environmental orientations in the context of SMEs: Implications for innovation performance	<i>Journal of Business Research</i>	297
3	Dutta et al. (2020)	Digital transformation priorities of India's discrete manufacturing SMEs – a conceptual study in perspective of Industry 4.0	<i>Competitiveness Review: An International Business Journal</i>	195
4	Ukko et al. (2019)	Sustainability strategy as a moderator in the relationship between digital business strategy and financial performance	<i>Journal of Cleaner Production</i>	181
5	Ingaldi & Ulewicz (2020)	Problems with the Implementation of Industry 4.0 in Enterprises from the SME Sector	<i>Sustainability</i>	159
6	Brozzi et al. (2020)	The Advantages of Industry 4.0 Applications for Sustainability: Results from a Sample of Manufacturing Companies	<i>Sustainability</i>	149
7	El Hilali et al. (2020)	Reaching sustainability during a digital transformation: a PLS approach	<i>. International Journal of Innovation Science</i>	141
8	Teng et al. (2022)	Research on the Relationship between Digital Transformation and Performance of SMEs	<i>Sustainability</i>	118
9	Hein-Pensel et al. (2023)	Maturity assessment for Industry 5.0: A review of existing maturity models	<i>Journal of Manufacturing Systems</i>	116
10	Yousaf et al. (2021)	Towards Sustainable Digital Innovation of SMEs from the Developing Countries in the Context of the Digital Economy and Frugal Environment	<i>Sustainability</i>	112

Table 4 showcases the top 10 most frequently cited articles in the area of integration of digital innovation and sustainability concept in SMEs, along with the title of the document, publication source, and number of citations. The document Denicolai et al. (2021) entitled

“Internationalization, digitalization, and sustainability: Are SMEs ready? A survey on synergies and substituting effects among growth paths”, published in *Technological Forecasting and Social Change*, holds the top position in the list with 174 citations. They studied the relationship among internationalization, digitalization, and sustainability as key growth paths for Small and Medium Enterprises (SMEs). Ardito et al. (2021), having 132 citations, is the second most cited document, titled “The duality of digital and environmental orientations in the context of SMEs: Implications for innovation performance,” published in the *Journal of Business Research*. This study aims to examine the effect of digital orientation and environmental orientation on SMEs' likelihood of introducing product and process innovations. Dutta et al. (2020), having 119 citations, is the third most cited document, titled “Digital transformation priorities of India’s discrete manufacturing SMEs – a conceptual study in perspective of Industry 4.0,” published in *Competitiveness Review: An International Business Journal*. They conducted this study to explore how Industry 4.0 technologies can facilitate the transformation of India's small and medium discrete manufacturing establishments, aligning with the country's National Manufacturing Policy.

MOST INFLUENTIAL AUTHORS



(Figure 4: Most Relevant Authors)

The authors' output is shown graphically in figure throughout time, highlighting the academic contributions and publication trends of important scholars in the subject of digital innovation and sustainability in SMEs between 2021 and 2025. The darker and bigger nodes represent authors with high total citations (TC) annually, such as Isensee C, Dvorsky J, and Huy PQ. With constant contributions and a substantial impact on citations, Isensee C stands out as one of the most influential authors. Additionally, the graph demonstrates that Anggraini W, Okfalisa, and Dura CC have remained active over a number of years, albeit with differing degrees of article production and citation performance. Nearer 2025, Ahmad M and Budiarto DS show more activity, indicating new interest in the subject.

MOST RELEVANT SOURCES

Table 5: Top 10 most relevant authors

Source	TC	NP	PY_start
Sustainability (Switzerland)	1179	50	2020
Journal of Cleaner Production	404	8	2019
Corporate Social Responsibility and Environmental Management	64	6	2023
Cogent Business and Management	22	6	2023
Serbian Journal of Management	45	5	2022
Sustainability (Switzerland)	28	5	2024
International Journal of Innovative Research and Scientific Studies	3	5	2025
Resources Policy	41	4	2023
Administrative Sciences	2	4	2024
Problems And Perspectives in Management	14	4	2023

Table 5 presents an overview of the leading 10 sources in terms of the number of articles they have published within this specific subject area. The utmost number of documents, 50, with 1179 citations, has been disseminated through the publication titled "Sustainability," issued by MDPI. Subsequently, the second highest number of publications originated from "Journal of Cleaner Production" issued by Elsevier, which has made a contribution of 8 documents having 404 citations. Similarly, the journal named "Corporate Social Responsibility and Environmental Management," published by Wiley online library, has also contributed 6 documents to the realm of research encompassing the integration of digital innovation and sustainability within the small and medium enterprises..

NETWORK ANALYSIS

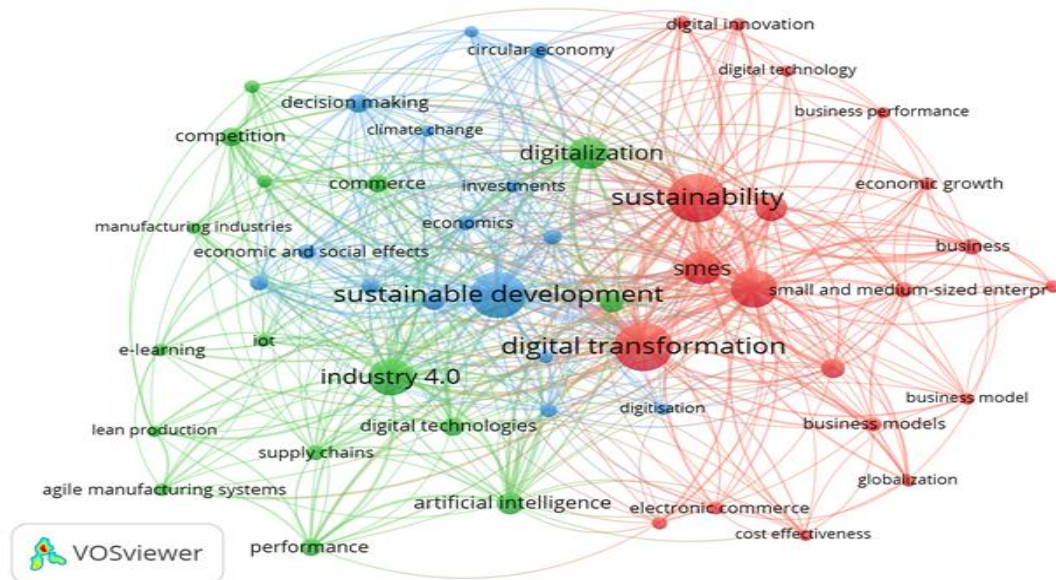
Co-Occurrence of Keyword Analysis

Co-occurrence of keywords analysis involves using the keywords provided by authors to explore the connections between the main topics within the analysed domain (Ji *et al.*, 2018; Corvo *et al.*, 2021). Table 8 presents the data revealing the interconnected fields in the domain of financial market dynamics. Only keywords appearing at least five times are considered, and variations such as singular/plural forms and synonyms were properly processed by manual. When the minimum number of occurrences of keywords was set at 5, out of 1615 keywords 62 keywords met the threshold.

Table 6: Top 15 Keyword Occurrence

Sr. No.	Keyword	Occurrence	Total link strength
1	Sustainability	107	413
2	Digital transformation	99	297
3	Small and medium-sized enterprises	62	328
4	Digitalization	58	196
5	Sustainable development	56	221
6	Innovation	38	157
7	Digitization	37	198

8	Industry 4.0	34	126
9	Digitalisation	18	61
10	Artificial Intelligence	12	40



(Figure 5: Co-occurrence of Keyword analysis)

Examining the distribution of authors' keywords is important for identifying prevalent research themes among academics and plays a substantial role in the progress of scientific knowledge (Li et al., 2009). After examining the connections of keywords in co-occurrence analysis of keywords, Figure 5 displays three main distinct clusters distinguished by different colors.

The red cluster includes the following keywords: Sustainability, digital transformation, small and medium enterprises, SMEs, digital innovation, digital technology, business performance, economic growth, cost effectiveness, business, business models, globalization, and electronic commerce. These keywords suggested that the primary focus of this cluster could be "Synergizing Sustainability and Digital innovation for SMEs in a Globalized economy."

The green cluster includes the following keywords: Industry 4.0, Digitalization, Digital technologies, Artificial intelligence, agile manufacturing system, competitive advantage, lean production, supply chains, industrial management and performance. These keywords indicated that the primary focus of this cluster could be "Integrating industry 4.0 technologies in SMEs to revolutionize their manufacturing processes."

The blue cluster includes the following keywords: Sustainable development, Circular economy, digitisation, Decision making, Economics, social and economic effects, energy efficiency, climate change, Small and medium enterprises. These keywords indicated that the primary focus of this cluster could be "Balancing Economic Growth and Environmental Preservation: Decision Making in SMEs for Sustainable Development."

Table 7: Thematic Cluster

Thematic Clusters	Authors	Title	Total Citations
“Synergizing Sustainability and Digital innovation for SMEs in a Globalized economy”	Denicolai et al. (2021)	“Internationalization, digitalization, and sustainability: Are SMEs ready? A survey on synergies and substituting effects among growth paths”	328
	Szabó et al. (2023)	“Environmental Sustainability, Digitalisation, and the Entrepreneurial Perception of Distances as Drivers of SMEs’ Internationalisation”	9
	Fayos et al. (2022)	“The contribution of digitalisation, channel integration and sustainability to the international performance of industrial SMEs”	9
“Integrating industry 4.0 technologies in SMEs to revolutionize their manufacturing processes”	Dutta et al. (2020)	“Digital transformation priorities of India’s discrete manufacturing SMEs – a conceptual study in perspective of Industry 4.0”	195
	Ingaldi & Ulewicz (2019)	“Problems with the Implementation of Industry 4.0 in Enterprises from the SME Sector”	159
	Brozzi et al. (2020)	“The Advantages of Industry 4.0 Applications for Sustainability: Results from a Sample of Manufacturing Companies”	149
“Balancing Economic Growth and Environmental Preservation: Decision Making in SMEs for Sustainable Development”	Mondal et al. (2023)	“Green entrepreneurship and digitalization enabling the circular economy through sustainable waste management - An exploratory study of emerging economy”	67
	Isensee et al. (2023)	“How can corporate culture contribute to emission reduction in the construction sector? An SME case study on beliefs, actions, and outcomes”	17
	Voza et al. (2022)	“Environmental sustainability in digitalized SMEs: comparative study from Poland and Serbia”	12

The two most popular articles are presented along with brief summaries of their respective works within these thematic clusters. Denicolai et al. (2021), having 174 citations under the theme “Synergizing Sustainability and Digital innovation for SMEs in a Globalized economy”, had studied the relationship among internationalization, digitalization, and sustainability as key growth paths for Small and Medium Enterprises (SMEs) and concluded that SMEs may face trade-offs between investing in digitalization and sustainability initiatives when expanding into international markets. Szabó et al. (2023) explored the interplay between sustainability, digitalization, and entrepreneurship on SMEs’

internationalization intentions and suggested that environmental communication, digital systems, and cultural perception play an important role in fostering internationalization opportunities for SMEs.

Dutta et al. (2020) having 119 total citations, under the theme “Integrating industry 4.0 technologies in SMEs to revolutionize their manufacturing processes” had explored how Industry 4.0 technologies can facilitate the transformation of India's small and medium discrete manufacturing establishments (SMMEs), aligning with the country's National Manufacturing Policy. Ingaldi & Ulewicz (2019) having 118 citations, examined the potential for small and medium-sized enterprises (SMEs) in Poland to adopt Industry 4.0 solutions, given their significant contribution to the country's GDP. Findings highlighted that financial constraints and a lack of specialized support as key challenges hindering transformation. The proposed solution involves developing a platform to facilitate collaboration among SMEs for sustainable development initiatives, aiming to address identified barriers and enhance the sector's adaptation to Industry 4.0. With 107 citations,

Mondal et al. (2023) under the theme “Balancing Economic Growth and Environmental Preservation: Decision Making in SMEs for Sustainable Development and Circular Economy Adoption” investigated the facilitators of Green Entrepreneurship (GE) and digitalization in Indian MSMEs within the Circular Economy (CE) and Waste Management (WM) framework. Using mixed methods, it identifies high-priority enablers such as top management involvement and organizational coordination, emphasizing the significance of technology-based initiatives for sustainable action. The research underscores the interconnectedness of GE and digitalization in advancing CE objectives, offering valuable insights into fostering sustainable development in Indian manufacturing MSMEs. Isensee et al. (2023) studied delves into the role of corporate culture in emission reduction within an SME in Germany's steel construction sector. Through various methods, including surveys and interviews, it demonstrates how a focus on vision development and leveraging information systems has enabled the SME to reduce emissions while boosting revenue, serving as a pioneering example of sustainable and digital development in the industry.

SUMMARY OF REVIEWS

The most significant contributors to this field were found using VOS viewer and biblioshiny based on many indicators, including authorship, country of origin, organisation affiliation, publishing source, and organisational engagement. Dossou P.-E has emerged as the leading author in this field, holding the top position and having the most citations, followed by Anggraini W and Okfalisa. Indonesia, China, Malaysia, India, and Italy stand out among the top research-producing nations in terms of the number of publications. The journal “Sustainability (Switzerland)” published by MDPI AG, has diffused the most articles, followed by “Procedia CIRP” issued by Elsevier and “Lecture Notes in Mechanical Engineering,” published by Springer, made a significant contribution to the realm of research encompassing. The co-occurrence analysis of keywords revealed clusters related to “Synergizing Sustainability and Digital innovation for SMEs in a Globalized economy,” “Integrating industry 4.0 technologies in SMEs to revolutionize their manufacturing processes,” and “Balancing Economic Growth and Environmental Preservation: Decision Making in SMEs for Sustainable Development.”

IMPLICATIONS

The present study provides the most frequently researched topics and themes on how SMEs are adopting digital innovation and sustainable practices. These insight helps the researchers and industry professionals to stay informed about emerging trends and areas of interest. It elucidates the prospects of a synergistic relationship between digital innovation and sustainability. The results of the study could act as a spark for the researcher to explore the unexplored areas of the body of existing research, thereby highlighting those areas that need additional in-depth examination. The current research has the potential to serve as an influential compass for policymakers and industry leaders to guide them in their decision-making regarding investments, strategic partnerships, and the adoption of innovative solutions that not only enhance business performance but also contribute to environmental sustainability.

CONCLUSION, LIMITATIONS AND FUTURE RESEARCH AVENUES

SMEs are undergoing significant transformations, especially due to the emergence of Industry 4.0 technologies, and requires detailed discussion on how effectively integration of these digital innovation technologies, along with sustainable practices affect their performance. The present study attempts to fill this gap in the existing body of literature. The study's findings underline the expanding significance of digital innovation and sustainable practices in SMEs. Prominent contributors to the established knowledge base, encompassing authors, institutions, and nations, have been recognised. Despite its numerous valuable contributions, it's essential to acknowledge the presence of certain limitations in this study. Since the data used for analysis came solely from the Scopus database, it may possible that some significant documents which are listed in other databases were missed. Another possible limitation is that this study considered only journal-published articles and conference paper written in English. Lastly, due to our limited scope of data mining in the analysis, which focused exclusively on examining the title, abstracts, and keywords instead of conducting a comprehensive analysis of the entire text, it's possible that certain crucial ideas and trends may differ when compared to data mining that involves analysing the whole text. In order to include a wider range of publications relevant to this particular domain, future research endeavours may investigate through alternative approaches and databases.

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