

# Digital transformation in small and medium enterprises: a scientometric analysis

Digital  
transformation  
in SMEs

Diana Teresa Parra-Sánchez

*Department of Scientific Direction,*

*Centro de Innovación y Productividad InnovaCTIon, Río De Oro, Colombia, and*

Leonardo Hernán Talero-Sarmiento

*Facultad de Ingeniería, Universidad Autónoma de Bucaramanga,  
Bucaramanga, Colombia*

Received 25 June 2023  
Revised 13 September 2023  
27 October 2023  
Accepted 7 November 2023

## Abstract

**Purpose** – This paper aims to explore the research field of digital transformation in small and medium enterprises (SMEs), considering the importance of SMEs in the economic development of countries.

**Design/methodology/approach** – Considering the contributions of researchers and the challenges of SMEs to transform their business models, in this paper, the authors conducted a scientometric analysis using CiteSpace that included 448 documents indexed in Scopus.

**Findings** – The authors appreciated the growth in the number of publications that have studied the digital transformation process in SMEs, showing a niche of researchers interested in the flourishing research topic. Likewise, the authors identified the intention of SMEs to adopt digital technologies such as artificial intelligence, big data, cloud computing, data analytics, electronic commerce and the Internet of Things.

**Practical implications** – This paper is a valuable resource for academics and researchers in information systems, decision-makers in digital transformation in SMEs and governmental organisations concerned with digital technologies adoption in SMEs to achieve digital transformation and increase competitiveness and productivity.

**Originality/value** – This study used CiteSpace to conduct a scientometric analysis to explore how researchers have focused on frameworks and maturity models for measuring SME readiness, the impact of Industry 4.0 on SMEs, guides for helping managers evaluate their Industry 4.0 positioning, the development and implementation of digital business strategies for SMEs, the presentation of cases of SMEs that have driven digital transformation and future research opportunities.

**Keywords** Digital transformation, Digital transformation strategy, Digital technologies adoption, Scientometric analysis, Small and medium enterprises

**Paper type** Literature review

## 1. Introduction

Digital transformation is a concept that is becoming increasingly important in public and private organisations (International Telecommunication Union, 2019). It is a process in which

---

© Diana Teresa Parra-Sánchez and Leonardo Hernán Talero-Sarmiento. Published in *Digital Transformation and Society*. Published by Emerald Publishing Limited. This article is published under the Creative Commons Attribution (CC BY 4.0) licence. Anyone may reproduce, distribute, translate and create derivative works of this article (for both commercial and non-commercial purposes), subject to full attribution to the original publication and authors. The full terms of this licence may be seen at <http://creativecommons.org/licenses/by/4.0/legalcode>

This article, focused on digital transformation in SMEs, is a direct continuation of Diana Teresa Parra-Sánchez's Doctoral Thesis. The author Diana Teresa Parra-Sánchez is deeply grateful to her mentors and colleagues for their invaluable support and guidance in this expansion of my research, the contribution of whom has been fundamental to the development and enrichment of her ideas. The author also expresses her gratitude to the *Journal of Digital Transformation and Society* for considering the publication of this work, which marks a significant milestone in her academic career.



Digital Transformation and  
Society  
Emerald Publishing Limited  
e-ISSN: 2755-077X  
p-ISSN: 2755-0761  
DOI 10.1108/DTS-06-2023-0048

---

digital technologies transform the experience of citizens by improving their quality of life and how business is carried out, thus impacting competitiveness, aiming at compliance with the Sustainable Development Goals (SDGs) (Organisation for Economic Co-operation and Development, 2019). According to Gartner (2021), “Digital transformation can refer to anything from IT modernisation (for example, cloud computing), to digital optimisation, to the invention of new digital business models.” In this definition, modernisation refers to initiatives to adopt digital technologies capable of transforming traditional business models.

The Fourth Industrial Revolution, led by the Internet of Things, Cloud Computing, Big Data and Artificial Intelligence, has created unique opportunities for organisations to boost their productivity and competitiveness by transforming their business models (International Telecommunication Union, 2018). However, the digital transformation of small and medium enterprises tends to be slower than the processes developed by large companies due to their economic limitations, human resources and technology readiness (Organisation for Economic Co-operation and Development, 2021). In this sense, to perform a digital transformation process, SMEs require a chief information officer (CIO) to lead the digital transformation strategy (Parra Sánchez, Talero-Sarmiento, Ortiz Cuadros, & Guerrero, 2022; Parra-Sánchez, 2022).

Recent research has allowed us to appreciate how digital transformation has gained importance in SMEs, attracting researchers’ attention to how SMEs have begun to adopt technologies from the fourth industrial revolution to improve competitiveness in the digital world. Tarutė, Duobienė, Klovienė, Vitkauskaitė, and Varaniūtė (2018) identified the factors that determine the digital transformation of SMEs, reflecting on the concept and usage of digital transformation in companies of different types and sizes. Parra-Sánchez, Talero-Sarmiento, and Guerrero (2021) assessed information and communication technologies policies for digital transformation in Colombian SMEs in the trading sector. Silva, Saraiva, and Mamede (2022) proposed a model to assess organisational readiness for digital transformation in SMEs. Omrani, Rejeb, Maalaoui, Dabic, and Kraus (2022) identified and analysed the factors determining digital technologies adoption in SMEs based on the Technology-Organisation-Environment Model (TOE).

Particularly in developing literature reviews on digital transformation in SMEs, we identified three recent studies focused on identifying factors influencing SMEs’ digital transformation. Bin, Hui, Qifeng, and Ke (2021) conducted a systematic review using the PRISMA approach to identify the factors influencing SMEs’ digital transformation using the TOE Model. The authors searched Scopus and Web of Science, including a total of 25 documents in the review. Philbin, Viswanathan, and Telukdarie (2022) conducted a systematic literature review to understand how digital transformation can enable SMEs to achieve sustainable development. The authors carried out a bibliometric analysis with 64 documents indexed in Scopus, which allowed the identification of three future lines of research: the technology dimension, the sustainable development dimension and the business characteristics dimension. Costa Melo *et al.* (2023) analysed the state-of-the-art for evaluating digital transformation in SMEs, primarily focussing on performance measurement. The authors conducted a systematic literature review by analysing 74 papers in peer-reviewed journals until December 2021. They extracted papers from the Scopus and Web of Science (WoS) databases. The analysis reveals that this is a new research topic with increasing interest in recent years.

Considering the growing relevance of digital transformation in SMEs, the contributions of researchers and the challenges of SMEs to transform their business models (Organisation for Economic Co-operation and Development, 2021), this research seeks to understand how small and medium enterprises, through the adoption of digital technologies, can adapt to technological change and prosper in the fourth industrial revolution, providing an answer to the following research question: How has the digital transformation process been in small and

medium enterprises? For this purpose, we conducted a scientometric analysis using CiteSpace v. 6.2.R1 64-bit advanced, considering 448 documents indexed in Scopus about digital transformation in SMEs. Our study reveals an increase in the number of publications on digital transformation in small and medium enterprises, showing a niche of researchers interested in the flourishing research topic. In addition, we identified some earlier experiences of small and medium enterprises adopting digital technologies, such as Cloud Computing, the Internet of Things and Artificial Intelligence. [Section 2](#) presents the materials and methods to collect and analyse the data. [Section 3](#) presents the results, considering the overview of the field of digital transformation in SMEs and the scientometric analysis. [Section 4](#) presents the discussion. Finally, [Section 5](#) presents our conclusions.

## 2. Materials and methods

The scientometric analysis was selected to objectively map the scientific knowledge published about digital transformation in SMEs. The analysis was performed using CiteSpace “*a visual analytic tool for visualizing landmarks, critical paths, and emerging trends in the research field based on relevant scholarly publications*” ([Chen, 2022](#)). The scientometric analysis was used to study the production, distribution, and impact that scientific and academic research has had in the field of digital transformation in small and medium enterprises. The results of the scientometric analysis can be useful to inform SMEs, researchers and public policymakers about the key areas in which progress is being made and the challenges that still need to be addressed in the field of study.

### 2.1 Data collection

The Scopus database was selected as the data source. We chose Scopus because it is a source-neutral abstract and citation database that indexes many journals, proceedings and other sources that cover multiple disciplines and fields of knowledge, allowing the analysis of an interdisciplinary topic such as digital transformation in SMEs ([Scopus, 2023](#)). We used the search string (“Digital transformation” and “SMEs”) after conducting several tests. We decided to leave only the acronym SMEs, widely recognised in the scientific literature and industry, to refer to small and medium enterprises because it speeds up the search process. Likewise, using longer terms such as “small and medium enterprises” OR “small and medium-sized enterprises” could generate more irrelevant results, adding more difficulty in filtering results and selecting the relevant documents for the literature review.

The data extraction was set from 2016 to June 3rd, 2023. When the preliminary searches were carried out, we found that the first documents dealing with SMEs’ digital transformation were published in 2016. In this sense, 2016, as the start date of the document search, was not manually configured but was the result of what was identified in the literature. In addition, this research considers only articles and conference proceedings published in English without additional inclusion or exclusion criteria. This search yielded a total of 448 publications, which when searching the descriptors in the article title, abstract and keywords (data retrieval time: 20:31, 3rd June 2023).

### 2.2 Data analysis

We performed a descriptive analysis of the results obtained in Scopus, considering the number of documents published by year, author, source, affiliation, country or region and keyword occurrence, likewise revising the number of citations obtained by the documents. CiteSpace, v. 6.2.R1 64-bit advanced ([Chen, 2023](#)), was used to extract co-citation analyses for co-cited references and conduct burstness analyses. The co-citation analysis helps to identify the most influential publications or authors in the field of digital transformation in small and

medium enterprises. At the same time, the burstness analysis helps to determine the most rapidly growing areas of research in the field of digital transformation in small and medium enterprises, as well as areas that have received less attention over time.

### 3. Results and analyses

#### 3.1 Overview of the field of digital transformation in SMEs

**3.1.1 Publication trend.** Analysis of the recovered documents indicates a noteworthy increase in publications on digital transformation in SMEs from 2016 to 2023. It is remarkable that even if only three documents appeared in 2016 and 2017, in 2018, the number of publications increased to 16 (growth rate 433,33%); in 2019, it further increased to 30 (growth rate 87,5%). In 2020, there was a significant jump in the number of publications to 73 (growth rate 143,3%), followed by another increase in 2021 to 107 documents (growth rate 46,57%). The trend appears to continue in 2022, with 152 documents published (growth rate 42,05%). However, it is important to note that the data only covers June 2023, with 64 documents published on digital transformation in SMEs this year. Regarding citations, 299 of 448 documents have citations, totalling 5,167 citations. The results highlight that the ten most cited documents add up to 1,658 citations, equivalent to 32%. [Table 1](#) presents the top 10 most cited documents.

The most cited documents have laid the foundations for exploring the digital transformation process in SMEs and correspond to original articles. No literature reviews were identified in the top 10. The papers focused on studying how small and medium enterprises drove digital transformation, the environmental changes due to the COVID-19 pandemic and the adoption of digital technologies to transform the business model, the drivers and barriers for Industry 4.0 readiness and the factors affecting the digital transformation process in small and medium enterprises.

**3.1.2 Top 10 most productive countries.** [Table 2](#) presents the countries that have made the most significant contribution regarding the number of documents published on digital transformation in SMEs. The total number of documents published by the top 10 most productive countries is 283 (63,17% of the total documents), which adds up to 4,789 citations, equivalent to 92,68% of the total citations. The results indicate that Italy, Germany and China are leading the study area, while countries such as Spain, the United Kingdom and France show potential for high impact. Specifically, Italy is in first place with 61 documents published and an average citation rate per document of 22.23. With 56 documents published, Germany is in second place, with an average citation rate per document of 9.63. In third place is China, with 28 documents published and an average citation rate per document of 19.64. These three countries show leadership in the research topic regarding the number of documents published. However, countries such as Finland (18 documents, 465 citations and an average citation rate per document of 25.83) and the United States (17 documents, 676 citations and an average citation rate per document of 39.76), despite having fewer publications, have a high impact in the field of study. In contrast, countries such as Spain (23 documents, 165 citations and an average citation rate per document of 7.17) and Portugal (18 documents, 152 citations and an average citation rate per document of 8.44) have a lower citation rate per document, suggesting that their research output may not be as influential or widely recognised in the field of digital transformation in SMEs.

**3.1.3 Top 10 sources publishing about digital transformation in SMEs.** [Table 3](#) presents the most productive sources that have published documents about digital transformation in SMEs. The total number of documents published by the top 10 sources is 113 (25,22% of the total documents), which adds up to 1,313 citations, equivalent to 25,41% of the total citations. The results indicate that Sustainability Switzerland, Procedia CIRP and the Journal of Business Research are leading in the number of publications, with 32, 15 and 12 papers

Citation	Title	Source title	Article type	Cited by
Li <i>et al.</i> (2018)	Digital transformation by SME entrepreneurs: A capability perspective	<i>Information Systems Journal</i>	Research article	403
Matarazzo <i>et al.</i> (2021)	Digital transformation and customer value creation in Made in Italy SMEs: A dynamic capabilities perspective	<i>Journal of Business Research</i>	Research article	221
Priyono, Moin, and Putri (2020)	Identifying digital transformation paths in the business model of SMEs during the Covid-19 pandemic	<i>Journal of Open Innovation: Technology, Market, and Complexity</i>	Research article	180
Bouwman <i>et al.</i> , 2019)	Digitalisation, business models, and SMEs: How do business model innovation practices improve performance of digitalising SMEs?	<i>Telecommunications Policy</i>	Research article	172
Nasiri, Saunila, Ukko, Rantala, and Rantanen (2020)	Managing the digital supply chain: The role of smart technologies	<i>Technovation</i>	Research article	137
Müller, Buliga, and Voigt (2021)	The role of absorptive capacity and innovation strategy in the design of industry 4.0 business Models – A comparison between SMEs and large enterprises	<i>European Management Journal</i>	Research article	127
Stentoft, Aadsbøll Wickstrøm, Philipsen, and Haug (2021)	Drivers and barriers for Industry 4.0 readiness and practice: empirical evidence from small and medium-sized manufacturers	<i>Production Planning and Control</i>	Research article	117
Ulas (2019)	Digital Transformation Process and SMEs	<i>Procedia Computer Science</i>	Research article	110
Denicolai <i>et al.</i> (2021)	Internationalisation, digitalisation, and sustainability: Are SMEs ready? A survey on synergies and substituting effects among growth paths	<i>Technological Forecasting and Social Change</i>	Research article	97
Zangiacomi, Pessot, Fornasiero, Bertetti, and Sacco (2020)	Moving towards digitalisation: a multiple case study in manufacturing	<i>Production Planning and Control</i>	Research article	94

Source(s): Table by authors

**Table 1.**  
Top 10 most cited documents

Country	Documents	Citations	Cites/paper
Italy	61	1356	22.23
Germany	56	539	9.63
China	28	550	19.64
Spain	23	165	7.17
United Kingdom	23	249	10.83
France	21	450	21.43
Finland	18	465	25.83
India	18	187	10.39
Portugal	18	152	8.44
United States	17	676	39.76

Source(s): Table by authors

**Table 2.**  
Top 10 most productive countries

Source	Documents	Citations	Cites/paper
Sustainability Switzerland	32	234	7.31
Procedia CIRP	15	159	10.60
Journal of Business Research	12	387	32.25
Procedia Computer Science	11	145	13.18
ACM International Conference Proceeding Series	9	18	2.00
Ceur Workshop Proceedings	8	1	0.13
Lecture Notes in Information Systems and Organisation	8	22	2.75
IEEE Transactions on Engineering Management	7	15	2.14
Technological Forecasting and Social Change	6	235	39.17
Applied Sciences Switzerland	5	97	19.40

**Source(s):** Table by authors

**Table 3.**  
Top 10 sources that published about digital transformation in SMEs

published, respectively. Regarding the impact of the published sources in terms of citations received, the journal Technological Forecasting and Social Change (ninth in the ranking) reports six published documents, which have received 235 citations and an average citation rate per document of 39.17. In comparison, the Journal of Business Research (third in the ranking) reports 12 published documents, which have received 387 citations and an average citation rate per document of 32.25. The high average citation rate per document in these journals indicates the sources' significant impact on the digital transformation field in SMEs.

*3.1.4 Top 10 authors in digital transformation in SMEs.* Table 4 presents the authors that have published the largest number of documents in the field of digital transformation in SMEs. The total number of documents published by the top 10 authors is 42 (9.38% of the total documents), which adds up to 508 citations, equivalent to 9.83% of the total citations. Note that none of the authors or co-authors of the most cited documents listed in Table 1 appear among the top 10 authors presented in Table 4. Regarding the impact of the authors in terms of citations received, Del Giudice, M. (tenth in the ranking) reports three published documents, which have received a total of 139 citations and an average citation rate per document of 46.33. Scuotto V. (third in the ranking) reports five published documents, which have received 183 citations and an average citation rate per document of 36.60. Pelletier, C. (eighth in the ranking) reports four published documents, which have received 57 citations and an average citation rate per document of 14.25. The high average citation rate per document shows the authors' impact in the digital transformation field in SMEs.

Author	Documents	Citations	Cites/paper
Mamede, H.S.	5	3	0.60
Sassanelli, C	5	30	6.00
Scuotto, V	5	183	36.60
Terzi, S	5	30	6.00
Gamache, S	4	33	8.25
Guerrero, C.D.	4	15	3.75
Lehmann, C	4	11	2.75
Pelletier, C	4	57	14.25
Alves Junior, P.N.	3	7	2.33
Del Giudice, M	3	139	46.33

**Source(s):** Table by authors

**Table 4.**  
Top 10 authors in digital transformation in SMEs

3.1.5 *Top 10 most productive affiliations.* Table 5 presents the affiliations that have made the most significant contribution regarding the number of documents published on digital transformation in SMEs. The total number of documents published by the top 10 most productive affiliations is 63 (14,06% of the total documents), which adds up to 858 citations, equivalent to 16.60% of the total citations. The results indicate that the Université du Québec à Trois-Rivières, Politecnico di Milano and Università degli Studi di Torino are leading the study area. Regarding the impact of the affiliations in terms of citations received, Friedrich-Alexander-Universität Erlangen-Nürnberg (tenth in the ranking) reports four published documents, which have received a total of 129 citations and an average citation rate per document of 32.25. Link Campus University (ninth in the ranking) reports five published documents, which have received 149 citations and an average citation rate per document of 29.80. Università degli Studi di Torino (third in the ranking) reports eight published documents, which have received 234 citations and an average citation rate per document of 29.25. The high average citation rate per document shows the impact of the affiliations on the research topic.

3.1.6 *Top 10 keywords.* This work identifies 105 keywords with at least five occurrences extracted from the 448 documents. As shown in Table 6, the subject terms of this study are digital transformation and small and medium enterprises, ranking in the first and second places of the top 10 keywords, respectively. The other most frequent keywords related to our study are Industry 4.0 Digitalisation, Digital Technology, Innovation, Manufacture,

Affiliation	Documents	Citations	Cites/ paper
Université du Québec à Trois-Rivières	9	94	10.44
Politecnico di Milano	9	99	11.00
Università degli Studi di Torino	8	234	29.25
Free University of Bozen-Bolzano	7	17	2.43
Institute for Systems and Computer Engineering, Technology and Science	6	16	2.67
Universiti Sains Malaysia	5	38	7.60
HSE University	5	79	15.80
Universidade Aberta	5	3	0.60
Link Campus University	5	149	29.80
Friedrich-Alexander-Universität Erlangen-Nürnberg	4	129	32.25

Source(s): Table by authors

Table 5.  
Top 10 most productive affiliations

Keywords	Occurrences
Digital transformation	294
Small and medium enterprises	282
Industry 4.0	90
Digitalisation	70
Digital technology	39
Innovation	35
Manufacture	28
Digitisation	24
COVID-19	20
Sustainable development	20

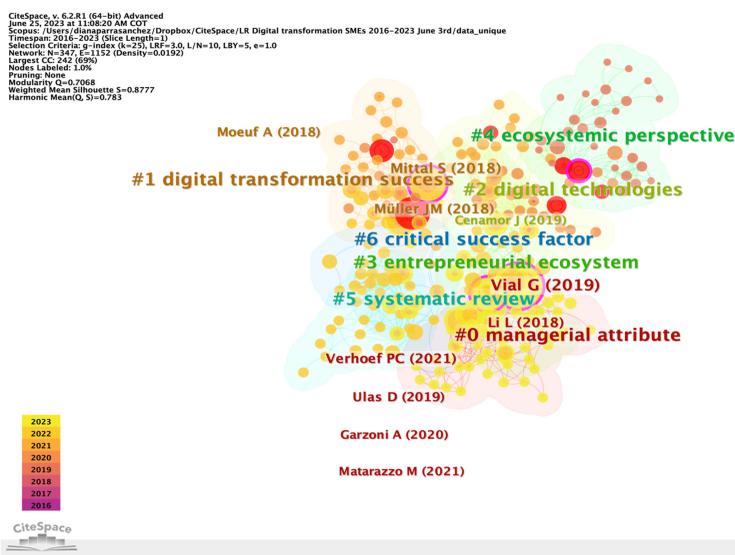
Source(s): Table by authors

Table 6.  
Top 10 keywords

Digitisation, COVID-19 and Sustainable Development. A possible interpretation of the occurrences of the identified keywords in the literature is that Digital Transformation has been a priority and recurrent topic. In addition, there was a growing interest among small and medium enterprises (SMEs) in digital transformation to guide SMEs to adopt digital technologies. Industry 4.0 has also been researched, albeit less than digital transformation, which allowed us to identify among the keywords some technological trends, such as Artificial Intelligence, Big Data, Cloud Computing, Data Analytics, Electronic Commerce and the Internet of Things. Digitalisation is another important topic, although less relevant than digital transformation. The adoption of digital technologies is also an emerging topic. Innovation, manufacturing, digitisation, COVID-19 and sustainable development have also been mentioned in business literature, but to a lesser extent than digital transformation. Finally, it is interesting to note that the impact of the COVID-19 pandemic on encouraging firms to adopt digital technology is mentioned in the literature.

### 3.2 Scientometric analysis

**3.2.1 The co-cited reference network.** The dataset analysed in this study consisted of 448 documents containing 21676 references. The co-cited reference network analysis reveals the evolution of research trends, clusters and hotspots in the literature on digital transformation in small and medium enterprises. The network comprises 347 nodes and 1152 links with an overall density of 0.0192, indicating the clarity and influence of the network (see Figure 1). A density of 1.00 represents a highly centralised and connected network. The network's weighted mean silhouette score is 0.8777, and its modularity is 0.7068, indicating that the clustering result of the network map is highly reliable. The network is divided into seven clusters, each with a size greater than or equal to 16, as shown in Table 7. The cluster size indicates the total number of citing articles, while the mean year reflects the recentness of the cluster. The log-likelihood ratios (LLR) labels of the clusters reflect the research frontiers in this knowledge domain. Overall, the co-cited reference network analysis suggests that digital



**Figure 1.**  
References co-occurrence network

**Source(s):** Figure generated by CiteSpace

Cluster-ID	Size	Silhouette	Mean (Year)	LLR
0	50	0.889	2020	Managerial attribute
1	44	0.889	2018	Digital transformation success
2	37	0.901	2017	Digital technologies
3	35	0.773	2018	Entrepreneurial ecosystem
4	33	0.956	2016	Ecosystemic perspective
5	27	0.873	2020	Systematic review
6	16	0.831	2019	Critical success factor

Source(s): Table by authors

**Table 7.**  
Clusters information

transformation is a central and evolving topic in the literature on small and medium enterprises, with clusters highlighting different aspects of digital transformation, such as digital literacy, strategic guideline, digital-related capabilities, sustainable digital transformation, technology adoption and transformation roadmap.

The largest cluster (#0), labelled “Managerial attribute”, has 50 members and a silhouette value of 0.889. The mean year of this cluster is 2020. This cluster includes top research topics: managerial attributes, digital literacy, transforming SMEs, technology interaction and organisational roles. The main cited article of the cluster is [Zahoor, Zopiatis, Adomako, and Lamprimakos \(2023\)](#), which studied the effect of managers’ digital literacy (MDL) on digital transformation in SMEs. The authors tested a moderated mediation model using survey data from 158 SMEs operating in the United Arab Emirates. The findings suggest that MDL impacts digital transformation through digital technologies. The most cited members in this cluster are: [Vial \(2019\)](#) reviewed a comprehensive body of information systems literature on digital transformation, [Li, Su, Zhang, and Mao \(2018\)](#), who studied how small and medium enterprises with inadequate capabilities and limited resources drove digital transformation and [Verhoef et al. \(2021\)](#) identified three stages of digital transformation: digitisation, digitalisation and digital transformation.

The second largest cluster (#1), labelled “Digital transformation success”, has 44 members and a silhouette value of 0.889. The mean year of this cluster is 2018. This cluster includes top research topics: digital transformation success, strategic guidelines, empirical evidence, medium-sized manufacturer and company size. The main cited article of the cluster is [Ghobakhloo and Iranmanesh \(2021\)](#), which offered a guideline for digital transformation success in small and medium-sized manufacturing enterprises under Industry 4.0. The study identified eleven success determinants crucial to SMEs’ digital transformation efforts, emphasising that obtaining external support for digitalisation is the first step in ensuring digital transformation success among SMEs. The most cited members in this cluster are: [Mittal, Khan, Romero, and Wuest \(2018\)](#) reviewed Smart Manufacturing (SM) and Industry 4.0 maturity models and analysed their fit for SMEs, [Müller, Buliga, and Voigt \(2018\)](#) studied how Industry 4.0 impacts manufacturing SMEs’ business models, and [Moeuf, Pellerin, Lamouri, Tamayo-Giraldo, and Barbaray \(2018\)](#) conducted a literature review of Industry 4.0 issues concerning SMEs.

The third largest cluster (#2), labelled “Digital technologies”, has 37 members and a silhouette value of 0.901. The mean year of this cluster is 2017. This cluster includes the top research topics: digital technologies, digital-related capabilities, shaping digital innovation, export management and small-sized firms’ practice. The main cited article of the cluster is by [Nasiri et al. \(2020\)](#), which explored the conditions under which digital innovation opportunities emerge in small and medium enterprises. The authors followed a quantitative research method, collecting data through survey questionnaires distributed

---

among 280 manufacturing SMEs in Finland. The results revealed that human, technical and innovation capabilities contribute to market offerings, while human, collaboration and technical capabilities contribute to the business process. The most cited members in this cluster are: [Cenamor, Parida, and Wincent \(2019\)](#) studied how entrepreneurial SMEs can enhance their performance through digital platforms, [Bouwman, Nikou, and de Reuver \(2019\)](#) studied how SMEs experiment with business model innovation, and [Yeow, Soh, and Hansen \(2018\)](#), conducted a longitudinal analysis of a business-to-business (B2B) company's journey to enact its business-to-consumer (B2C) digital strategy through a dynamic capabilities approach.

The fourth largest cluster (#3), labelled "Entrepreneurial ecosystem", has 35 members and a silhouette value of 0.773. The mean year of this cluster is 2018. This cluster includes the following top research topics: entrepreneurial ecosystem, digital transformation era, sustainable digital transformation, volatility, uncertainty, complexity and ambiguity (VUCA) environment and dynamic capability. The main cited article of the cluster is by [Khurana, Dutta, and Singh Ghura \(2022\)](#), which focused on adopting digital technologies by small and medium enterprises to build their resilience during a crisis. The study highlights how SMEs shift their focus from the core to the periphery of their organisational boundaries to develop resilience and dynamically transform their businesses. This cluster underscores the importance of the first-order dynamic capabilities of sensing, seizing and transforming in enhancing SMEs' resilience during a crisis. The most cited members in this cluster are: [Warner and Wäger \(2019\)](#) explored how incumbent firms in traditional industries built dynamic capabilities for digital transformation, [Coreynen, Matthyssens, and Van Bockhaven \(2017\)](#) explained how digitisation can enable servitisation for manufacturing SMEs, and [Eller, Alford, Kallmünzer, and Peters \(2020\)](#) studied how digitalisation can impact SME performance considering information technology, employee skills and digital strategy.

The fifth largest cluster (#4), labelled "Ecosystemic perspective", has 33 members and a silhouette value of 0.956. The mean year of this cluster is 2016. This cluster includes the following top research topics: Ecosystemic perspective, conceptualising digital transformation, funded support unit, procedure model and supporting digital transformation. The main cited article of the cluster is by [Pelletier and Cloutier \(2019\)](#), which examined the IT issues perception within an ecosystem that includes entrepreneurs, IT professionals and socioeconomic support professionals. The study underscores the need for a shared understanding of IT challenges among stakeholders and highlights the potential of conceptual representations to support policymaking and strengthen IT-related support for small and medium enterprises. The most cited members in this cluster are: [Matt, Hess, and Benlian \(2015\)](#) established a relationship between digital transformation strategy and other corporate strategies, [Goerzig and Bauernhansl \(2018\)](#) presented the foundation for the development of a method for holistic planning of the digital transformation in mechanical engineering SMEs, and [Scuotto, Del Giudice, Bresciani, and Meissner \(2017\)](#) investigated three key factors that are likely to determine the preference for informal inbound open innovation (OI) modes in small and medium enterprises in the United Kingdom.

The sixth largest cluster (#5), labelled "Systematic review", has 27 members and a silhouette value of 0.873. The mean year of this cluster is 2020. This cluster includes top research topics: Systematic review, technology adoption, transformation roadmap, precipitative effect and open innovation. The main cited article of the cluster is by [Ghobakhloo, Iranmanesh, Vilkas, Grybauskas, and Amran \(2022\)](#), which conducted a systematic literature review to identify technological, organisational and environmental determinants of Industry 4.0 technology adoption in small and medium enterprises. The authors developed a digitalisation roadmap that describes the necessary conditions for facilitating SMEs' digitalisation under Industry 4.0. The most cited members in this cluster are: [Horváth and Szabó \(2019\)](#) explored how top executives interpret the concept of Industry

4.0, the driving forces for introducing new technologies and the main barriers to Industry 4.0 in small and medium enterprises, [Denicolai, Zucchella, and Magnani \(2021\)](#) studied the impact of Artificial Intelligence readiness on the international performance of SMEs, and [Troise \(2022\)](#) studied how organisational agility has a positive impact on SMEs' performance.

The seventh largest cluster (#6), labelled "Critical success factor", has 16 members and a silhouette value of 0.831. The mean year of this cluster is 2019. This cluster includes the following top research topics: critical success factors, SME wineries, technology adoption strategies, grape harvesting and sensing technologies' role. The main cited article of the cluster is by [Teng, Wu, and Yang \(2022\)](#), which studied the impact of digital technology, employee digital skills and digital transformation strategy in small and medium enterprises. The authors used a structural equation model to analyse 335 questionnaires and identify the key factors that affect SME performance in the Chinese context. The most cited members in this cluster are: [Büyüközkan and Göçer \(2018\)](#) reviewed the state-of-the-art of existing digital supply chain (DSC) to identify key limitations and prospects in DSC, [Chanias, Myers, and Hess \(2019\)](#) studied how a European financial services provider has formulated and implemented a digital transformation strategy, and [Soto-Acosta \(2020\)](#) explored the impact of the COVID-19 pandemic on digital transformation in organisations.

We switched to a timeline view of the co-occurrence network to appreciate the years in more detail (see [Figure 2](#)). Cluster 0 runs from 2018 to 2022 (5-year period), Cluster 1 runs from 2015 to 2021 (7-year period), Cluster 2 runs from 2015 to 2020 (6-year period), Cluster 3 runs from 2016 to 2022 (7-year period), Cluster 4 runs from 2014 to 2018 (5-year period), Cluster 5 runs from 2017 to 2022 (6-year period) and Cluster 6 runs from 2018 to 2022 (5-year period). Based on duration, the two longest-lasting clusters are Cluster 1 and Cluster 3. The active clusters up to and including 2022 are Cluster 0, cluster 3, cluster 5 and Cluster 6.

Regarding the research question, there is a growth in the number of publications that have studied the digital transformation process in small and medium enterprises, showing a niche of researchers interested in the flourishing research topic. Likewise, SMEs intend to adopt

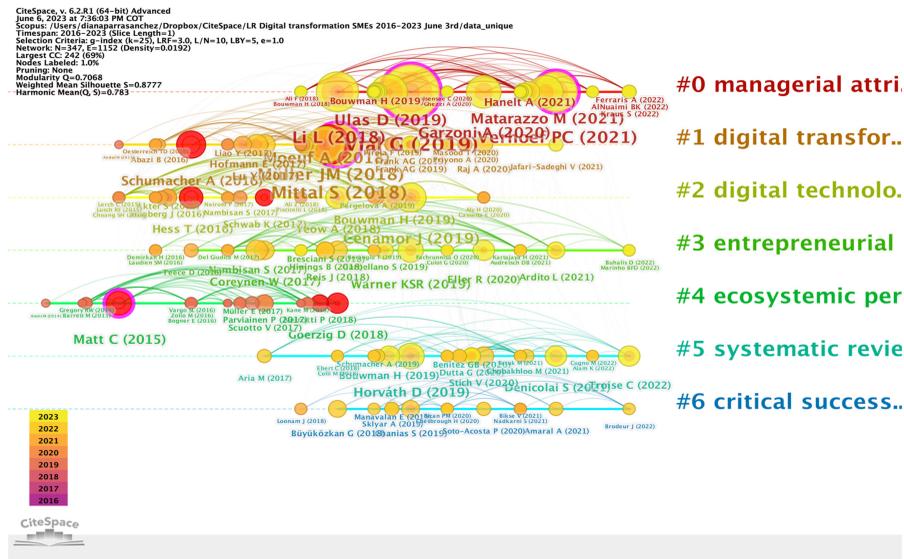


Figure 2. Timeline view

digital technologies to be competitive and increase their productivity (Ghobakhloo & Iranmanesh, 2021). The researchers have used technology adoption frameworks and statistical models based on adopter perceptions to study the factors affecting digital transformation in SMEs, developed guides to guide companies and proposed frameworks or maturity models to assess the technological readiness of small and medium businesses. Among the technologies that SMEs have adopted are Artificial Intelligence, Big Data, Cloud Computing, Data Analytics, Electronic Commerce and the Internet of Things, which allows us to appreciate the technology adoption capacity of SMEs when they have the guidance of a CIO leading the digital transformation process.

**3.2.2 Burst references analysis.** Identifying the most active research areas in digital transformation for SMEs can provide insights into this field's evolving topics and research trends. Publications related to digital transformation in SMEs started to emerge in 2016, and as the years passed, the number of available publications on the topic increased. One way to identify these areas is by analysing citation bursts, which reflect works that have received a sudden surge in citations over a short period, indicating increased attention from researchers. These bursts can help trace the development of the research focus over time. Table 8 presents a list of the references with the strongest citation bursts identified in the literature, offering valuable insights into the most active research topics in digital transformation for SMEs. We can appreciate the seven burst references graphically in Figures 1 and 2.

**3.2.3 Top 10 co-citation references.** Regarding the most co-cited references on digital transformation in small and medium enterprises, Table 9 presents the top 10 co-citation references. The purpose and citation behaviour of the top 10 co-citation references is below.

Vial (2019) conducted a literature review on digital transformation based on the review of 282 documents, which were the basis for building a framework for digital transformation and

**Table 8.**  
Top 7 Burst references

Begin	End	Span	Strength	Year	Citation	Cluster-ID
2019	2020	2	5.06	2015	Matt <i>et al.</i> (2015)	4
2020	2021	2	4.16	2016	Schumacher, Erol, and Sihn (2016)	1
2020	2021	2	3.01	2016	Hess, Matt, Benlian, and Wiesböck (2016)	2
2019	2021	3	2.17	2018	Goerzig & Bauernhansl (2018)	4
2019	2020	2	2.01	2018	Neirotti, Raguseo, and Paolucci (2018)	4
2020	2021	2	1.87	2017	Schwab (2017)	2
2021	2023	3	1.63	2018	Müller <i>et al.</i> (2018)	1

**Source(s):** Table by authors

**Table 9.**  
Top 10 co-citation  
references

Rank	Count	Centrality	Year	Cited reference	Cluster-ID
1	42	0.11	2019	Vial (2019)	0
2	29	0.11	2018	Mittal <i>et al.</i> (2018)	1
3	27	0.04	2018	Li <i>et al.</i> (2018)	0
4	23	0.12	2021	Verhoef <i>et al.</i> (2021)	0
5	23	0.08	2018	Müller <i>et al.</i> (2018)	1
6	20	0.04	2018	Moeuf <i>et al.</i> (2018)	1
7	19	0.02	2019	Ulas (2019)	0
8	17	0.03	2020	Garzoni <i>et al.</i> (2020)	0
9	17	0.02	2021	Matarazzo <i>et al.</i> (2021)	0
10	15	0.10	2019	Cenamor <i>et al.</i> (2019)	2

**Source(s):** Table by authors

offering a research agenda for future research on digital transformation. The document has received 1,376 citations in Scopus, mainly for publications in business, management, accounting, computer science, social sciences, engineering and decision sciences. The document achieved the largest number of citations in 2022, with 539.

*Mittal et al. (2018)* reviewed Smart Manufacturing (SM) and Industry 4.0 maturity models, recognising the specific requirements of small and medium enterprises. The authors presented the characteristics of SMEs and identified research gaps that scientific literature must address to support manufacturing SMEs in their progress towards Industry 4.0 successfully. The document has received 503 citations in Scopus, mainly for publications in engineering, computer science, business, management, accounting, decision sciences and social sciences. The largest number of citations was achieved in 2022, with 170 citations.

*Li et al. (2018)* studied how entrepreneurs of small and medium enterprises with inadequate capabilities and limited resources drove digital transformation in their companies. The author conducted qualitative research on the digital transformation of seven SMEs on the Alibaba digital platform, concluding that digital platform service providers can help SMEs transform and compete. The document has received 400 citations in Scopus, mainly for publications in engineering, business, management, accounting, computer science, decision sciences and social sciences. The largest number of citations was achieved in 2022, with 135 citations.

*Verhoef et al. (2021)* identified three stages of digital transformation: digitisation, digitalisation and digital transformation. The authors delineated growth strategies for digital firms and the assets and capabilities required to transform digitally successfully. In addition, they provided a research agenda to stimulate and guide future research on digital transformation. The document has received 744 citations in Scopus, mainly for publications in business, management, accounting, computer science, engineering, social sciences, economics, econometrics and finance. The largest number of citations was achieved in 2022, with 327 citations.

*Müller et al. (2018)* analysed how Industry 4.0 impacts manufacturing SMEs' business models by conducting qualitative research with 68 German SMEs from three industries (automotive suppliers, mechanical and electrical engineering and ICT companies). The authors delineated four SME categories to help managers evaluate their company's positioning towards Industry 4.0: craft manufacturers, preliminary stage planners, Industry 4.0 users and full-scale adopters. The document has received 579 citations in Scopus, mainly for publications in business, management, accounting, engineering, computer science, social sciences and decision sciences. The largest number of citations was achieved in 2022, with 184 citations.

*Moeuf et al. (2018)* conducted a literature review about Industry 4.0 and small and medium enterprises to identify the targeted performance objectives, the required managerial capacities and the selected group of technologies for each selected case. The results show that SMEs do not exploit all the resources for implementing Industry 4.0 and often limit themselves to adopting digital technologies such as Cloud Computing and the Internet of Things. The document has received 590 citations in Scopus, mainly for publications in engineering, business, management, accounting, computer science, decision sciences and social sciences. The largest number of citations was achieved in 2022, with 161 citations.

*Ulas (2019)* provided a comprehensive view of the factors affecting the digital transformation process and described the digital transformation of the manufacturing sector in Turkey. The findings indicate that SMEs exhibit erratic investment patterns in information and communications technology and require external assistance to incorporate digital transformations into their overall business strategy. The document has received 110 citations in Scopus, mainly for publications in computer science, business, management,

---

accounting, social sciences, engineering, economics, econometrics and finance. The largest number of citations was achieved in 2022, with 57 citations.

Garzoni, De Turi, Secundo, and Del Vecchio (2020) analysed how digital technologies trigger changes in the business processes of manufacturing small and medium enterprises in the Apulia Region (South Italy). The authors examined the enablers of Industry 4.0 in a regional context characterised by delays in research and development and innovation performance. The results introduce a four-level approach to the engagement of SMEs in adopting digital technologies: digital awareness, digital requirement, digital collaboration and digital transformation. The document has received 88 citations in Scopus, mainly for publications in business, management, accounting, computer science, social sciences, engineering, economics, econometrics and finance. The largest number of citations was achieved in 2022, with 42 citations.

Matarazzo, Penco, Profumo, and Quaglia (2021) examined the impact of digital transformation on customer value creation in small and medium enterprises. The authors used multi-case study research on the digital transformation of six Made in Italy SMEs. The results show that, for the selected SMEs, digital instruments contribute to the innovation of their business model by creating new distribution channels and new ways to create and deliver value to customer segments. The document has received 221 citations in Scopus, mainly for publications in business, management, accounting, computer science, social sciences, engineering and decision sciences. The largest number of citations was achieved in 2022, with 104 citations.

Cenamor *et al.* (2019) examined the effect of digital platform capability and network capability on SMEs' financial performance. The authors analysed 230 SMEs. The results indicate that digital platform capability positively affects small and medium enterprises' performance via network capability. The document has received 229 citations in Scopus, mainly for publications in business, management, accounting, computer science, social sciences, economics, econometrics, finance and decision sciences. The largest number of citations was achieved in 2022, with 92 citations.

In summary, the top 10 co-citation references focused mainly on the construction of frameworks and maturity models to measure the readiness of SMEs, the impact of Industry 4.0 on small and medium enterprises, the development of guides to help managers evaluate their positioning towards Industry 4.0, the development and implementation of digital business strategies for SMEs, the presentation of cases of SMEs that have driven digital transformation and future research opportunities. The top 10 is led by a literature review, showing the document's usefulness for researchers working on digital transformation in SMEs. Regarding the citations received, the documents generated considerable interest in 2022, receiving many citations from various areas of knowledge.

#### 4. Discussion

Digital transformation is a topic that has gained importance for small and medium enterprises worldwide, leading to a significant increase in the scientific production of digital transformation in SMEs. Before undertaking the scientometric analysis, a preliminary review of the domain of digital transformation in SMEs was conducted. This review illustrated various publication trends, the top 10 most productive countries, the top 10 sources publishing about digital transformation in SMEs, the top 10 authors in digital transformation in SMEs, the top 10 most productive affiliations and the top 10 most frequently used keywords. Subsequently, using CiteSpace, the scientometric analysis was performed to identify research trends, clusters and hotspots in the literature, allowing us to appreciate how SMEs have begun to face digital transformation processes when adopting digital

technologies, such as Artificial Intelligence, Big Data, Cloud Computing, Data Analytics, Electronic Commerce and the Internet of Things.

This literature review is a valuable reference point for stakeholders interested in exploring digital transformation within small and medium enterprises. Compared to related studies found in the literature, our distinctive contribution lies in utilising CiteSpace for conducting scientometric analysis. We examined a total of 448 documents, encompassing 21,676 references. Building upon prior research identified in the literature, this field of study represents a relatively recent research focus that has gained significant traction in recent years, underscoring the pivotal role of SMEs in the social and economic development of nations. It is worth noting that our information retrieval was exclusively conducted using the Scopus database. In future endeavours, we may consider exploring data from the Web of Science as well.

Regarding studies in the literature, [Bin \*et al.\* \(2021\)](#) identified the factors influencing the digital transformation of SMEs using the TOE model. Through our scientometric analysis, we identified foundational studies that employed technology adoption frameworks and statistical models, focussing on adopter perceptions, to examine the factors affecting digital transformation in SMEs. This analysis highlighted the ongoing need to explore the determinants of digital transformation within SMEs. Notably, technology readiness—a company's capability to adopt, utilise and benefit from information and communication technologies while adapting to technological changes to remain competitive—emerges as a pivotal factor. The technology readiness level can dictate how an SME incorporates digital technologies to revamp its business model. For instance, a low level of technology readiness in decision-making regarding digital technology adoption is often tied to a CEO's limited awareness of digital technologies, an underdeveloped technological infrastructure and a workforce with minimal or no digital skills for utilising such technologies.

Another notable research area is the nexus between digital transformation and sustainable development ([Philbin \*et al.\*, 2022](#)). Digital transformation transcends technological advancement, presenting a golden opportunity to usher in a more sustainable era. By harnessing efficiency in utilising corporate resources, businesses can diminish waste, streamline production and achieve dual benefits: minimised environmental impact and heightened profitability. Enhanced data monitoring and management, bolstered by cutting-edge technologies like the Internet of Things and big data analytics, pave the way for decisions rooted in rich insights and empower organisations to precisely gauge their ecological footprint and adopt proactive measures to curtail it. The concept of a circular economy gains momentum from digitalisation. It encourages the design of products and services primed for reuse and recycling, tapering the strain on natural resources and curbing waste accumulation. The proliferation of digital services, exemplified by electronic banking, negates the demand for expansive physical infrastructure. This translates to a reduction in material and energy consumption. In conclusion, embracing digital strategies in SMEs has become a potent tool for curtailing carbon emissions. By championing practices such as telecommuting and virtual collaborations, the reliance on physical commutes diminishes, thereby attenuating the overarching carbon footprint.

As we delve into the trajectory of digital transformation within SMEs, it becomes evident that the infusion of digital technologies plays a pivotal role in enhancing their operational prowess ([Cenamor \*et al.\*, 2019](#); [Denicolai \*et al.\*, 2021](#)). The integration of these technologies not only streamlines operations and processes but also amplifies the financial gains of the enterprise. At the heart of this transformation is organisational agility—the inherent ability of a firm to agilely navigate environmental shifts, tackle unforeseen challenges and capitalise on emergent opportunities. Such agile entities invariably position themselves as resilient front-runners in volatile markets. Supporting this notion, numerous research findings underscore a tangible link between digital transformation and augmented corporate financial

---

outcomes. Companies that seamlessly weave digital technologies into their operational fabric often register amplified revenues, achieve optimal resource utilisation and elevate customer satisfaction—all of which cumulatively fuel sustained profitability and expansion.

From the findings, it is evident that SMEs have ripe opportunities to embark on their digital transformation journeys, guided by experienced CIOs. In ICT policies, the widespread adoption of state-of-the-art digital technologies, like artificial intelligence and the Internet of Things, is gaining prominence. Consequently, it is imperative for governmental bodies, under the support of the Ministry of Information Technology and Communications, to formulate and implement strategic policies that propel SMEs towards digital transformation. This not only augments their performance but also stimulates innovation, bolsters productivity and equips them to rival more established enterprises. A promising avenue for subsequent research is to explore the strategies SMEs employ to prime themselves technologically, ensuring seamless integration and optimisation of these emergent digital tools.

## 5. Conclusion and future work

Digital transformation in SMEs has gained importance in recent years, showing the need to strengthen the theoretical background on the subject so that more and more SMEs can adopt digital technologies aligned with their business model, strengthening productivity and competitiveness. It should be noted that adopting digital technologies is associated with technology readiness, which refers to the organisation's ability to adopt, use and benefit from digital technologies. Based on the literature review, we identified some earlier experiences of small and medium enterprises adopting digital technologies, such as Cloud Computing, the Internet of Things and Artificial Intelligence. These previous experiences have made SMEs explore the digital ecosystem and acquire ICT resources. Companies have contemplated security and privacy issues, allocated a budget for modernising, implementing and maintaining digital technologies and training employees with digital skills.

The overview of the field of digital transformation in SMEs explored the following analysis: the publication trend in the research topic, the top 10 most productive countries, the top 10 sources that published about digital transformation in SMEs, the top 10 authors in digital transformation in SMEs, the top 10 most productive affiliations and the top 10 keywords related to the research topic. Meanwhile, with the scientometric analysis, we conducted the following analysis: the co-cited reference network, the burst references analysis and the top 10 co-citation references. Both analyses were essential to identify primary studies that the scientific community can explore to continue advancing the definition of digital transformation strategies aimed at small and medium enterprises. Regarding the research question based on the analyses carried out, the growth in the number of publications is appreciated, which demonstrates the scientific community's interest in studying and contributing strategies to support the digital transformation of SMEs.

In summary, the paper is a valuable resource for academics and researchers in Information Systems, decision-makers in digital transformation in small and medium enterprises and governmental organisations concerned with digital technologies adoption in SMEs to achieve digital transformation and increase competitiveness and productivity. The field of digital transformation in small and medium enterprises is just beginning to flourish, and this document can be a guide for researchers starting on the subject of study, CIOs of small and medium enterprises and policymakers. For future work, the authors will explore specific case studies of adopting technological trends such as the Internet of Things and Artificial Intelligence in small and medium enterprises to identify adoption barriers and define digital transformation strategies by technological trend. Likewise, the authors will propose digital transformation strategies aimed at SMEs considering the role of the CIO to achieve the technology readiness of SMEs.

---

**References**

- Bin, M., Hui, G., Qifeng, W., & Ke, Y. (2021). A systematic review of factors influencing digital transformation of SMEs. *Turkish Journal of Computer and Mathematics Education*, 12(11), 1673–1686.
- Bouwman, H., Nikou, S., & de Reuver, M. (2019). Digitalization, business models, and SMEs: How do business model innovation practices improve performance of digitalizing SMEs?. *Telecommunications Policy*, 43(9), 101828. doi: [10.1016/j.telpol.2019.101828](https://doi.org/10.1016/j.telpol.2019.101828).
- Büyükközkın, G., & Göçer, F. (2018). Digital Supply Chain: Literature review and a proposed framework for future research. *Computers in Industry*, 97, 157–177. doi: [10.1016/j.compind.2018.02.010](https://doi.org/10.1016/j.compind.2018.02.010).
- Cenamor, J., Parida, V., & Wincent, J. (2019). How entrepreneurial SMEs compete through digital platforms: The roles of digital platform capability, network capability and ambidexterity. *Journal of Business Research*, 100, 196–206. doi: [10.1016/j.jbusres.2019.03.035](https://doi.org/10.1016/j.jbusres.2019.03.035).
- Chanias, S., Myers, M. D., & Hess, T. (2019). Digital transformation strategy making in pre-digital organizations: The case of a financial services provider. *The Journal of Strategic Information Systems*, 28(1), 17–33. doi: [10.1016/j.jsis.2018.11.003](https://doi.org/10.1016/j.jsis.2018.11.003).
- Chen, C. (2022). How to use CiteSpace.
- Chen, C. (2023). CiteSpace. Available from: <https://citespace.podia.com/> (accessed 11 April 2023).
- Coreynen, W., Matthyssens, P., & Van Bockhaven, W. (2017). Boosting servitization through digitization: Pathways and dynamic resource configurations for manufacturers. *Industrial Marketing Management*, 60, 42–53. doi: [10.1016/j.indmarman.2016.04.012](https://doi.org/10.1016/j.indmarman.2016.04.012).
- Costa Melo, I., Queiroz, G. A., Alves Junior, P. N., Sousa, T. B.de, Yushimito, W. F., & Pereira, J. (2023). Sustainable digital transformation in small and medium enterprises (SMEs): A review on performance. *Heliyon*, 9(3), e13908. doi: [10.1016/j.heliyon.2023.e13908](https://doi.org/10.1016/j.heliyon.2023.e13908).
- Denicolai, S., Zucchella, A., & Magnani, G. (2021). Internationalization, digitalization, and sustainability: Are SMEs ready? A survey on synergies and substituting effects among growth paths. *Technological Forecasting and Social Change*, 166, 120650. doi: [10.1016/j.techfore.2021.120650](https://doi.org/10.1016/j.techfore.2021.120650).
- Eller, R., Alford, P., Kallmünzer, A., & Peters, M. (2020). Antecedents, consequences, and challenges of small and medium-sized enterprise digitalization. *Journal of Business Research*, 112, 119–127. doi: [10.1016/j.jbusres.2020.03.004](https://doi.org/10.1016/j.jbusres.2020.03.004).
- Gartner (2021). Gartner glossary: Digital transformation. Available from: <https://www.gartner.com/en/information-technology/glossary/digital-transformation> (accessed 27 October 2021).
- Garzoni, A., De Turi, I., Secundo, G., & Del Vecchio, P. (2020). Fostering digital transformation of SMEs: A four levels approach. *Management Decision*, 58(8), 1543–1562. doi: [10.1108/MD-07-2019-0939](https://doi.org/10.1108/MD-07-2019-0939).
- Ghobakhloo, M., & Iranmanesh, M. (2021). Digital transformation success under industry 4.0: A strategic guideline for manufacturing SMEs. *Journal of Manufacturing Technology Management*, 32(8), 1533–1556. doi: [10.1108/JMTM-11-2020-0455](https://doi.org/10.1108/JMTM-11-2020-0455).
- Ghobakhloo, M., Iranmanesh, M., Vilkas, M., Grybauskas, A., & Amran, A. (2022). Drivers and barriers of industry 4.0 technology adoption among manufacturing SMEs: A systematic review and transformation roadmap. *Journal of Manufacturing Technology Management*, 33(6), 1029–1058. doi: [10.1108/JMTM-12-2021-0505](https://doi.org/10.1108/JMTM-12-2021-0505).
- Goerzig, D., & Bauernhansl, T. (2018). Enterprise architectures for the digital transformation in small and medium-sized enterprises. *Procedia CIRP*, 67, 540–545. doi: [10.1016/j.procir.2017.12.257](https://doi.org/10.1016/j.procir.2017.12.257).
- Hess, T., Matt, C., Benlian, A., & Wiesböck, F. (2016). Options for formulating a digital transformation strategy. *MIS Quarterly Executive*, 15(2), 123–139.

- 
- Horváth, D., & Szabó, R. Zs. (2019). Driving forces and barriers of Industry 4.0: Do multinational and small and medium-sized companies have equal opportunities?. *Technological Forecasting and Social Change*, 146, 119–132. doi: [10.1016/j.techfore.2019.05.021](https://doi.org/10.1016/j.techfore.2019.05.021).
- International Telecommunication Union. (2018). *Measuring the information society report 2018*. Geneva: International Telecommunication Union (ITU).
- International Telecommunication Union. (2019). *Digital transformation and the role of enterprise architecture*. Geneva: International Telecommunication Union (ITU).
- Khurana, I., Dutta, D. K., & Singh Ghura, A. (2022). SMEs and digital transformation during a crisis: The emergence of resilience as a second-order dynamic capability in an entrepreneurial ecosystem. *Journal of Business Research*, 150, 623–641. doi: [10.1016/j.jbusres.2022.06.048](https://doi.org/10.1016/j.jbusres.2022.06.048).
- Li, L., Su, F., Zhang, W., & Mao, J.-Y. (2018). Digital transformation by SME entrepreneurs: A capability perspective. *Information Systems Journal*, 28(6), 1129–1157. doi: [10.1111/isj.12153](https://doi.org/10.1111/isj.12153).
- Matarazzo, M., Penco, L., Profumo, G., & Quaglia, R. (2021). Digital transformation and customer value creation in made in Italy SMEs: A dynamic capabilities perspective. *Journal of Business Research*, 123, 642–656. doi: [10.1016/j.jbusres.2020.10.033](https://doi.org/10.1016/j.jbusres.2020.10.033).
- Matt, C., Hess, T., & Benlian, A. (2015). Digital transformation strategies. *Business & Information Systems Engineering*, 57(5), 339–343. doi: [10.1007/s12599-015-0401-5](https://doi.org/10.1007/s12599-015-0401-5).
- Mittal, S., Khan, M. A., Romero, D., & Wuest, T. (2018). A critical review of smart manufacturing & Industry 4.0 maturity models: Implications for small and medium-sized enterprises (SMEs). *Journal of Manufacturing Systems*, 49, 194–214. doi: [10.1016/j.jmsy.2018.10.005](https://doi.org/10.1016/j.jmsy.2018.10.005).
- Moëuf, A., Pellerin, R., Lamouri, S., Tamayo-Giraldo, S., & Barbaray, R. (2018). The industrial management of SMEs in the era of Industry 4.0. *International Journal of Production Research*, 56(3), 1118–1136. doi: [10.1080/00207543.2017.1372647](https://doi.org/10.1080/00207543.2017.1372647).
- Müller, J. M., Buliga, O., & Voigt, K.-I. (2018). Fortune favors the prepared: How SMEs approach business model innovations in Industry 4.0. *Technological Forecasting and Social Change*, 132, 2–17. doi: [10.1016/j.techfore.2017.12.019](https://doi.org/10.1016/j.techfore.2017.12.019).
- Müller, J. M., Buliga, O., & Voigt, K.-I. (2021). The role of absorptive capacity and innovation strategy in the design of industry 4.0 business models - a comparison between SMEs and large enterprises. *European Management Journal*, 39(3), 333–343. doi: [10.1016/j.emj.2020.01.002](https://doi.org/10.1016/j.emj.2020.01.002).
- Nasiri, M., Saunila, M., Ukko, J., Rantala, T., & Rantanen, H. (2020). Shaping digital innovation via digital-related capabilities. *Information Systems Frontiers*, 25. doi: [10.1007/s10796-020-10089-2](https://doi.org/10.1007/s10796-020-10089-2).
- Neirotti, P., Raguseo, E., & Paolucci, E. (2018). How SMEs develop ICT-based capabilities in response to their environment: Past evidence and implications for the uptake of the new ICT paradigm. *Journal of Enterprise Information Management*, 31(1), 10–37. doi: [10.1108/JEIM-09-2016-0158](https://doi.org/10.1108/JEIM-09-2016-0158).
- Omrani, N., Rejeb, N., Maaloufi, A., Dabic, M., & Kraus, S. (2022). Drivers of digital transformation in SMEs. *IEEE Transactions on Engineering Management*, 1–14. doi: [10.1109/TEM.2022.3215727](https://doi.org/10.1109/TEM.2022.3215727).
- Organisation for Economic Co-operation and Development (2019). *Measuring the digital transformation: A roadmap for the future*. Paris: OECD Publishing. doi: [10.1787/9789264311992-en](https://doi.org/10.1787/9789264311992-en).
- Organisation for Economic Co-operation and Development (2021). The digital transformation of SMEs. *OECD*. doi: [10.1787/bdb9256a-en](https://doi.org/10.1787/bdb9256a-en).
- Parra Sánchez, D. T., Talero-Sarmiento, L. H., Ortiz Cuadros, J. D., & Guerrero, C. D. (2022). Chief information officer's role for IoT-based digital transformation in Colombian SMEs. *Revista Colombiana de Computación*, 23(2), 43–54. doi: [10.29375/25392115.4607](https://doi.org/10.29375/25392115.4607).
- Parra-Sánchez, D. T. (2022). *A framework for IoT adoption in small and medium enterprises*. Bucaramanga: Doctoral Thesis, Universidad Autónoma de Bucaramanga.

- Parra-Sánchez, D. T., Talero-Sarmiento, L. H., & Guerrero, C. D. (2021). Assessment of ICT policies for digital transformation in Colombia: Technology readiness for IoT adoption in SMEs in the trading sector. *Digital Policy, Regulation and Governance*, 23(4), 412–431. doi: [10.1108/DPRG-09-2020-0120](https://doi.org/10.1108/DPRG-09-2020-0120).
- Pelletier, C., & Cloutier, L. M. (2019). Conceptualising digital transformation in SMEs: An ecosystemic perspective. *Journal of Small Business and Enterprise Development*, 26(6/7), 855–876. doi: [10.1108/JSBED-05-2019-0144](https://doi.org/10.1108/JSBED-05-2019-0144).
- Philbin, S., Viswanathan, R., & Telukdarie, A. (2022). Understanding how digital transformation can enable SMEs to achieve sustainable development: A systematic literature review. *Small Business International Review*, 6(1), e473. doi: [10.26784/sbir.v6i1.473](https://doi.org/10.26784/sbir.v6i1.473).
- Priyono, A., Moin, A., & Putri, V. N. A. O. (2020). Identifying digital transformation paths in the business model of SMEs during the COVID-19 pandemic. *Journal of Open Innovation: Technology, Market, and Complexity*, 6(4), 104. doi: [10.3390/joitmc6040104](https://doi.org/10.3390/joitmc6040104).
- Schumacher, A., Erol, S., & Sihm, W. (2016). A maturity model for assessing Industry 4.0 readiness and maturity of manufacturing enterprises. *Procedia CIRP*, 52, 161–166. doi: [10.1016/j.procir.2016.07.040](https://doi.org/10.1016/j.procir.2016.07.040).
- Schwab, K. (2017). *The Fourth Industrial Revolution*. Crown.
- Scopus (2023). Content coverage guide.
- Scuotto, V., Del Giudice, M., Bresciani, S., & Meissner, D. (2017). Knowledge-driven preferences in informal inbound open innovation modes. An explorative view on small to medium enterprises. *Journal of Knowledge Management*, 21(3), 640–655. doi: [10.1108/JKM-10-2016-0465](https://doi.org/10.1108/JKM-10-2016-0465).
- Silva, R. P., Saraiva, C., & Mamede, H. S. (2022). Assessment of organizational readiness for digital transformation in SMEs. *Procedia Computer Science*, 204, 362–369. doi: [10.1016/j.procs.2022.08.044](https://doi.org/10.1016/j.procs.2022.08.044).
- Soto-Acosta, P. (2020). COVID-19 pandemic: Shifting digital transformation to a high-speed gear. *Information Systems Management*, 37(4), 260–266. doi: [10.1080/10580530.2020.1814461](https://doi.org/10.1080/10580530.2020.1814461).
- Stentoft, J., Adsbøll Wickstrøm, K., Philipsen, K., & Haug, A. (2021). Drivers and barriers for Industry 4.0 readiness and practice: empirical evidence from small and medium-sized manufacturers. *Production Planning and Control*, 32(10), 811–828. doi: [10.1080/09537287.2020.1768318](https://doi.org/10.1080/09537287.2020.1768318).
- Tarutė, A., Duobienė, J., Kloviene, L., Vitkauskaitė, E., & Varaniūtė, V. (2018). Identifying factors affecting digital transformation of SMEs. In *Proceedings of the International Conference on Electronic Business (ICEB)* (pp. 373–381).
- Teng, X., Wu, Z., & Yang, F. (2022). Research on the relationship between digital transformation and performance of SMEs. *Sustainability*, 14(10), 6012. doi: [10.3390/su14106012](https://doi.org/10.3390/su14106012).
- Troise, C., Corvello, V., Ghobadian, A., & O'Regan, N. (2022). How can SMEs successfully navigate VUCA environment: The role of agility in the digital transformation era. *Technological Forecasting and Social Change*, 174, 121227. doi: [10.1016/j.techfore.2021.121227](https://doi.org/10.1016/j.techfore.2021.121227).
- Ulas, D. (2019). Digital transformation process and SMEs. *Procedia Computer Science*, 158, 662–671. doi: [10.1016/j.procs.2019.09.101](https://doi.org/10.1016/j.procs.2019.09.101).
- Verhoef, P. C., Broekhuizen, T., Bart, Y., Bhattacharya, A., Qi Dong, J., Fabian, N., & Haenlein, M. (2021). Digital transformation: A multidisciplinary reflection and research agenda. *Journal of Business Research*, 122, 889–901. doi: [10.1016/j.jbusres.2019.09.022](https://doi.org/10.1016/j.jbusres.2019.09.022).
- Vial, G. (2019). Understanding digital transformation: A review and a research agenda. *The Journal of Strategic Information Systems*, 28(2), 118–144. doi: [10.1016/j.jsis.2019.01.003](https://doi.org/10.1016/j.jsis.2019.01.003).
- Warner, K. S. R., & Wäger, M. (2019). Building dynamic capabilities for digital transformation: An ongoing process of strategic renewal. *Long Range Planning*, 52(3), 326–349. doi: [10.1016/j.lrp.2018.12.001](https://doi.org/10.1016/j.lrp.2018.12.001).

---

DTS

- Yeow, A., Soh, C., & Hansen, R. (2018). Aligning with new digital strategy: A dynamic capabilities approach. *The Journal of Strategic Information Systems*, 27(1), 43–58. doi: [10.1016/j.jsis.2017.09.001](https://doi.org/10.1016/j.jsis.2017.09.001).
- Zahoor, N., Zopiatis, A., Adomako, S., & Lamprinakos, G. (2023). The micro-foundations of digitally transforming SMEs: How digital literacy and technology interact with managerial attributes. *Journal of Business Research*, 159, 113755. doi: [10.1016/j.jbusres.2023.113755](https://doi.org/10.1016/j.jbusres.2023.113755).
- Zangiacomi, A., Pessot, E., Fornasiero, R., Bertetti, M., & Sacco, M. (2020). Moving towards digitalization: a multiple case study in manufacturing. *Production Planning and Control*, 31(2–3), 143–157. doi: [10.1080/09537287.2019.1631468](https://doi.org/10.1080/09537287.2019.1631468).
- 

**Corresponding author**

Diana Teresa Parra-Sánchez can be contacted at: [dianadelavalliere@gmail.com](mailto:dianadelavalliere@gmail.com)