

Digital transformation research: A bird's eye image of core knowledge and global trends

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ABSTRACT

Digital transformation has recently introduced itself as a groundbreaking phenomenon with profound impacts on societies, industries, businesses, and even individuals. Accordingly, several studies have attempted to give a literature review or analysis of digital transformation research during the last few years. However, most of them are domain-specific studies based on small data samples or subjective review methods, so we lack a general and robust understanding of the landscape of this field of research across different disciplines and domains. Taking a step toward filling this gap, the current study aims to shape an overall and reliable picture of the research realm on digital transformation. To the aim, a computational method namely topic modeling was applied to two big texts, one of which includes all digital transformation-related publications that were indexed in well-known Scopus and Web of Science databases (8639 documents), and the other one only contains studies that were published by high-quality JCR journals (1264 documents). As a result, 20 and 13 topics were respectively introduced as the underlying themes of the global trends and core knowledge in digital transformation research along with their temporal evolutionary paths throughout the recent years. Also, by comparing these two groups of topics, it was known that there are nine developing trends in this field of research that require more attention and advancements to establish themselves as the core knowledge of the field. Complementing the contributions of previous domain-specific or subjective reviews on digital transformation, this study tries to favor a better understanding of this scholarship through multidisciplinary and multidimensional analyses of digital transformation-related publications by using the topic modeling approach.

1. Introduction

Generally, emerging digital technologies such as big data and analytics have recently brought about profound changes for societies, businesses, and individuals (Martínez-Caro et al., 2020) as well as for different industries (Ustundag & Cevikcan, 2017). These technologies have been the cause of a new generation of societies in which people's daily activities are mediated by computers and algorithms (Dufva & Dufva, 2019), a new generation of businesses in which novel digital business models are implemented to create and deliver more value (Hajiheydari, Talafidaryani, & Khabiri, 2019a; Verhoef et al., 2021), a new generation of life in which everyone has access to huge amounts of data and information via various devices (Abiteboul, André, & Kaplan, 2015), and a new generation of industries in which all processes of manufacturing environments and all components of service systems are revolutionized by modern technological advancements (Ustundag & Cevikcan, 2017).

Due to these pervasive impacts that everyone has obviously witnessed in her/his life and work, now is the time to assert that virtually no dimension of the modern world has remained untouched by new digital technologies and digitalization (Talafidaryani et al., 2023). Accordingly, in order to explore such consequences and exploit their benefits, the digital transformation topic has recently flourished and been discussed as an important phenomenon in both research and practice domains (Talafidaryani et al., 2021). Digital transformation is defined as "a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies [i.e., digital technologies]" (Vial, 2019, p. 118). Accordingly, given different entities, different topics such as the digital transformation of society, digital transformation of business, and digital transformation of industry are being increasingly developed and argued with regard to various aspects of the digital transformation phenomenon.

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Given the acknowledged importance of digital transformation, this term has pervaded the modern world and has shaped independent research realms by spawning various conversations among both academic and practical communities (Hausberg, Liere-Netheler, Packmohr, Pakura, & Vogelsang, 2019; Talafidaryani et al., 2021). Consequently, it can be witnessed that a surge of publications has been released on the digital transformation theme in recent years. A quick search in Google Scholar indicates that the interest in this topic has exponentially grown from hundreds to tens of thousands of outlets within the last ten years between 2012 and 2022. As a natural consequence of this remarkable growth in the productivity of research on digital transformation and due to such a rapid expansion in the size of this scholarship, several researchers have recently attempted to evaluate this field of research by performing a literature review or analysis study. Without such studies, it is not clear what is included in the digital transformation literature and what is not, and it is difficult to trace the research and its scope (Van Veldhoven et al., 2021).

By using the terms “digital transformation” and “review” for searching in titles of publications indexed in Google Scholar, it can be realized that there are over three hundred papers aimed at reviewing and analyzing the literature related to the digital transformation theme regardless of their quality. However, although these studies give useful information and help to further the current knowledge on digital transformation, most of them are restricted to a single area (e.g., Kraus, Schiavone, Pluzhnikova, and Invernizzi (2021)) or limited to one aspect of digital transformation (e.g., Jewer and Van Der Meulen (2022)). Also, in the extant review studies that the researchers attempted to analyze the overall literature or phenomenon of digital transformation (e.g., Chawla and Goyal (2022), Kraus, Jones, et al. (2021), and Plekhanov et al. (2022)), only small literature samples were explored based on qualitative review methods which might be subject to human judgment; or, bibliometric techniques were utilized that are responsible for revealing research streams and trends from specific lenses of bibliographical attributes.¹ Therefore, these works lack in providing a global and reliable picture of the research landscape of digital transformation across different disciplines and domains. This is remarkably important for two reasons: 1. The above-mentioned limitations have been also pointed out by other scholars such as Zhu et al. (2021), and accordingly, they raised the need for other literature analyses on digital transformation to provide a more exhaustive view. In this regard, Chawla and Goyal (2022) stated that an overall comprehensive insight into digital transformation research is missing, and this shortcoming in the literature calls for an all-encompassing review to consolidate the multifaceted dimensionality of this field. 2. The previous studies (e.g., Verhoef et al. (2021)) emphasized that digital transformation is a broad and interdisciplinary concept, so instead of only relying on one domain or a single context, a multidisciplinary approach and design should be employed to holistically analyze the literature.

Taking a step toward addressing these limitations and considering these suggestions, the current study is aimed at revealing the dominant topics in research on digital transformation and their temporal evolutionary paths by using big samples of relevant research outlets across different disciplines and domains. To do so, we use the topic modeling method which is a machine learning-based text analysis approach enabling us to analyze large-scale texts. Topic modeling lets us reveal the salient themes in a big text constituting a massive and unstructured collection of documents and accordingly, helps us organize the underlying knowledge and semantic structure behind the revealed themes (Blei, 2012; Blei, Carin, & Dunson, 2010; Blei & Lafferty, 2009). Compared to traditional text analysis methods, topic modeling techniques have several advantages such as automatically organizing and

summarizing a large collection of documents without prior human knowledge-based labeling of the documents (Lee & Kang, 2018; Yau et al., 2014). Additionally, it should be noted that using such a computational technique enables researchers to overcome the inherent subjectivity and potential biases of traditional and qualitative review methods. This method also scales with a large number of papers without slowing down the process. In this regard, it is particularly helpful to note that drawing on the framework developed by Quinn et al. (2010), Asmussen and Møller (2019) explained that topic model-supported literature reviews, specifically on a large number of papers, reduce some costs of reading and human coding-based literature reviews such as the costs of person-hours spent conceptualization, person-hours spent analysis, and person-hours spent interpretation along with the required level of substantive knowledge. Asmussen and Møller (2019) discussed that topic model-based frameworks for automatic and smart literature reviews enable huge amounts of papers to be reviewed in a transparent, reliable, fast, and reproducible way. Leveraging these advantages, several studies have recently and widely used topic modeling for discovering research topics and trends in different areas such as Internet of Things (Inaam ul Haq et al., 2022), intellectual capital (Givi et al., 2022), human-computer interaction (Gurcan, Cagiltay, & Cagiltay, 2021), business model (Hajiheydari, Talafidaryani, Khabiri, & Salehi, 2019b), personal information privacy (Choi, Lee, & Sohn, 2017), dynamic capabilities (Heidari & Talafidaryani, 2021; Talafidaryani, 2019, Talafidaryani, 2021), IS business value (ZareRavasan & Jeyaraj, 2022), public administration (Walker et al., 2019), sustainability and social media (Lee et al., 2021), and emergency medicine (Porturas & Taylor, 2021). In the present study, we apply the topic modeling method on two big datasets one of which includes all digital transformation-related publications indexed in Scopus and Web of Science as the most comprehensive and well-acknowledged research platforms, and the other one includes only research outlets that appeared in high-quality JCR² journals. Using these two datasets enables us to respectively unearth the global trends and core knowledge in research on digital transformation that, in turn, leads to uncovering the developing trends in this field of research. The results of our topic modeling can help to understand the extent, range, and nature of the digital transformation phenomenon at a glance.

The remainder of this article is organized as follows. **Section 2** presents a comprehensive list of the related works along with some critical discussions on their limitations. **Section 3** introduces the research methodology and its constituent stages. **Section 4** provides an informative description of the research results followed by **Section 5** discussing the results, their implications, the limitations of the current study, and the possibilities for further research in the future. Finally, a brief conclusion is provided in **Section 6**.

2. Related works

We used the terms “digital transformation” and “review” in the title, abstract, and keywords sections of the Scopus and Web of Science databases in order to find the publications that could be relevant to our work. As a result, it was known that there are three main categories of literature reviews or analyses related to the field of digital transformation. Some of these studies explored the topic of digital transformation in a single area such as construction (Adekunle, Aigbavboa, Ejobwomu, Adekunle, & Thwala, 2021), health (Kraus, Schiavone, et al., 2021; Marques & Ferreira, 2020), tourism (Madzik et al., 2023), IS (Kutzner et al., 2018; Nadkarni & Prügl, 2021; Vial, 2019), strategy (Hanelt, Bohnsack, Marz, & Antunes Marante, 2021; Rêgo et al., 2021), innovation (Gao, Wu, & Yang, 2022), and service (Chin, Marasini, & Lee, 2023; Rha & Lee, 2022). Some others investigated only one aspect of the digital transformation phenomenon like governance of digital

¹ Please note that a comprehensive list of the relevant reviews along with some critical discussions on their limitations are provided in the related works section.

² Journal Citation Reports.

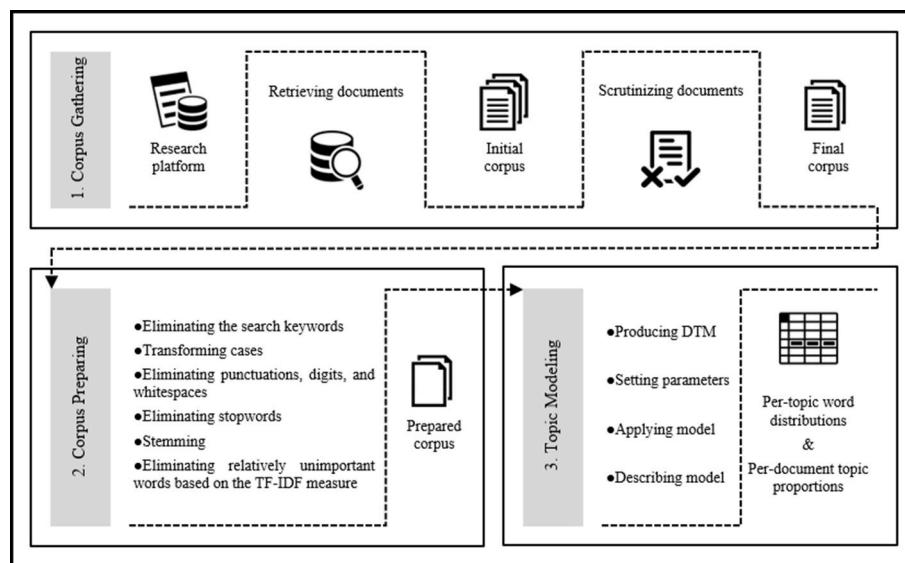
Table 1

Previous literature reviews on digital transformation.

Study	Period	No. of publications	Type	Key contributions
Chawla and Goyal (2022)	1997–2020	234	Bibliometric analysis	The salient attributes of research progression along with the dominant research themes and trends in the literature were explored.
Facin, Barbosa, Matsumoto, Cruz, and Salerno (2022)	2015–2020	294	Structured literature review and bibliometric analysis	The literature structure along with the themes that have gained prominence in recent years were introduced.
Hajishirzi, Costa, Aparicio, and Romão (2022)	1968–2021	3900	Bibliometric analysis	The most cited papers and the most occurred terms were explored to understand the main research clusters.
Hausberg et al. (2019)	1997–2017	1876	Structured literature review and bibliometric analysis	The major research streams and possible gaps for further research were identified.
Jedynak, Czakon, Kuźniarska, and Mania (2021)	2009–2019	288	Structured literature review	A conceptual map was developed to aggregate and present the overarching themes, topics, and gaps in the academic and non-academic literature.
Kraus, Jones, et al. (2021)	1981–2020	832	Structured literature review and bibliometric analysis	The main research clusters and the most influential publications were identified and examined.
Kraus et al. (2022)	2010–2020	217	Structured literature review and bibliometric analysis	The thematic evolution of the research and the recent research strands and topics were identified and discussed.
Pihir et al. (2019)	2000–2019	528	Structured literature review and bibliometric analysis	Some insights into academic publishing trends were provided. An analysis of scientific fields in which researches were made was offered. The most influential articles were briefly analyzed. Key determinants and influence factors along with some emerging trends and technologies were identified and discussed. Also, a framework of the mainstream concepts was developed.
Plekhanov et al. (2022)	2003–2021	537	Structured literature review	The identified themes of the literature were structured and discussed according to a multi-layer conceptual framework. In addition, a set of future research avenues was proposed.
Reis and Melão (2023)	2015–2021	34	Meta-review	The most relevant thematic areas were identified. The literature was categorized. And, future research was proposed based on recent studies.
Reis et al. (2018)	1968–2017	206	Structured literature review and bibliometric analysis	A general overview of the literature (authors, journals, approaches, keywords, definitions, themes, and categories) along with some suggestions for future research was delivered.
Shi et al. (2022)	1999–2021	4853	Bibliometric analysis	The status of collaboration among researchers, the distribution and trend of keywords, and the most influential researchers, publications, journals, countries, and institutions were identified.
Talafidaryani et al. (2021)	2000–2019	2820	Bibliometric analysis	The most recurring research themes and their respective subthemes along with the main research collaborations and central actors were introduced.
Van Veldhoven et al. (2021)	2000–2020	2367	Bibliometric analysis	The research growth, the most influential outlets, the research hubs, and the structure of the research field were described.
Verhoef et al. (2021)	2000–2018	84	Structured literature review	The studies, conceptualizations, and themes were assessed across different fields and discussed based on a flow model. Also, a research agenda for future research was developed.
Zhu et al. (2021)	2000–2020	865	Bibliometric analysis	The development stages of the research and the influential countries, institutions, and journals along with the research themes and directions for future contributions were presented.

transformation (Jewer & Van Der Meulen, 2022), *inertia in digital transformation* (Haskamp, Marx, Dremel, & Uebenickel, 2021b), and *success of digital transformation* (Levkovskyi et al., 2020). Although these two categories of studies offered meaningful insights and impactful contributions, they are “very narrow in perspective” (Kraus et al., 2022, p. 2) and “have mostly focused on specific topics, making it difficult to provide a comprehensive and systematic view” (Zhu et al., 2021, pp. 1–2) so might bias our knowledge of digital transformation which is a multidisciplinary field of research (Verhoef et al., 2021). Previous studies such as Verhoef et al. (2021) stated that a broad phenomenon like digital transformation with substantial implications for individuals, organizations, and society cannot be totally grasped by only investigating it within, for example, the IS field (Loebbecke & Picot, 2015). A concept that is developed at the nexuses between various fields should be explored using an integrative approach rather than focusing on a single discipline (Taradar & Davison, 2018). Accordingly, with the aim of avoiding this limitation, the third category of literature reviews or analyses was performed to cover the digital transformation literature without relying on a single area or one aspect. These studies, which are presented in Table 1 and directly related to the current work, tried to offer some interesting understandings of the bibliographical attributes, research topics, thematic evolutions, recent trends, and future studies in the digital transformation literature. It is understood that these related works were carried out based on various methodologies such as bibliometric analysis and structured literature review. Particularly, it is known that their researchers were significantly interested in employing a

multi-method approach using both qualitative and quantitative methods, especially scientometrics techniques. Employing such varied sort of review designs over the digital transformation scholarship is impressive. However, we do believe that these review studies still have some notable limitations specifically regarding their research designs that are targeted to be tackled in our work. 1. In most of these investigations, a limited number of publications was included. Nevertheless, in this work, we analyze two collections of studies including 8639 and 1264 publications which is far higher than the size of the corpora in the related works. 2. In most of these studies, the research themes and trends were revealed based on analyzing the bibliographical attributes of the papers such as citations, references, and keywords which have limited capacities to present the main contributions of a study; or, they used some traditional qualitative methods to review or analyze the literature that might be subject to the scholars’ personal interests and limited to the authors’ time, energy, and understanding. However, we apply the topic modeling approach as a semi-automated content analysis technique to reduce the extent of subjective explorations and the effect of human factors. And, we use the abstract section of the publications that could better reflect the core ideas and premises of a study. It is worth noting that these two limitations of the extant literature reviews or analyses on digital transformation have been also mentioned by Zhu et al. (2021): The previous reviews on digital transformation are insufficiently objective. These studies were performed on the basis of traditional methods and only covered a small part of the literature. They are mainly based on subjective investigations by senior scholars in the field,

**Fig. 1.** An overview of the research methodology.Source: [Talafidaryani \(2021\)](#)

which inevitably affects the interpretations ([Zhu et al., 2021](#)). Finally, it should be asserted that our work is the first attempt to compare the global trends and core knowledge and accordingly, reveal the developing trends in digital transformation research. To the best of our knowledge, there is not any similar work that divided the publications into two collections one of which includes all digital transformation-related publications that were indexed in well-known Scopus and Web of Science databases (8639 documents representing the global trends), and the other one only contains studies that were published by high-quality JCR journals (1264 documents representing the core knowledge). This would be considered as the main contribution and advantage of the present research over the previous works.

3. Methodology

In the current study, we have used the topic modeling approach in order to uncover the core knowledge and global trends of digital transformation research. Topic modeling as a set of unsupervised machine learning algorithms aimed at clustering an unstructured collection of documents and revealing its latent thematic formation ([Yau et al., 2014](#)) has recently introduced itself as a powerful approach for unlocking grounded conceptual relationships and extracting unknown phenomenon-based knowledge from text data in management field and organization science ([Hannigan et al., 2019](#); [Schmiedel et al., 2019](#)).

In this study, Latent Dirichlet Allocation (LDA) ([Blei, Ng, & Jordan, 2003](#)) as the most prevalent algorithm for topic modeling ([Jelodar et al., 2019](#)) has been employed. This algorithm supposes that a set of documents (i.e., a corpus) contains a limited number of topics with different proportions, each of which is a probabilistic distribution over a fixed set of words ([Blei, 2012](#)). Based on this assumption, the LDA algorithm tries to use the words of the given documents to render the latent topical structure of the corpus. To this end, LDA defines the conditional probabilistic distribution of hidden topical structure variables given the

observed words and uses a technique, such as Gibbs sampling ([Griffiths & Steyvers, 2004](#)) to approximately compute it.

We decided to use the LDA algorithm for our topic modeling due to the following reasons: 1. LDA is the most popular and commonly used algorithm for topic modeling ([Jelodar et al., 2019](#); [Li & Lei, 2021](#); [Vayansky & Kumar, 2020](#)). 2. Li and Lei (2019) discussed that LDA could overcome the limitations of the preceding algorithms such as latent semantic indexing (LSI) which might fall into ignoring the relevant documents that don't contain the synonyms of the search terms and probabilistic latent semantic analysis (pLSA) which may have shortcomings in assigning probabilities to untrained documents and lead to overfitting if employed for a large corpus. 3. In our investigations, our main interest was not revealing the complex relationships between the topics and their temporal evolutions. Instead, we mainly aimed at identifying the topics underlying the core knowledge and global trends in digital transformation research and consequently, comparing them to reveal the developing trends. Accordingly, LDA is considered the appropriate choice for our analyses given the decision tree on topic modeling methods developed by [Vayansky and Kumar \(2020\)](#). Finally, it should be acknowledged that every algorithm of topic modeling has its own advantages and disadvantages ([Zengul et al., 2023](#)), and maybe the best decision is to use multiple topic modeling methods to benefit from their complementary attributes ([Williams & Betak, 2018](#)). However, we should also consider the limitations of research that force us to only focus on the most frequent techniques.

To implement an LDA-based topic modeling, we have followed the three stages depicted in [Fig. 1](#) and described by [Talafidaryani, 2021](#). In the first stage, we gathered the required corpus. Due to the aim of this study, we retrieved two collections of documents as the required corpus. First, we gathered all scholarly documents published on the digital transformation topic by using the Scopus and Web of Science databases as the most comprehensive and well-acknowledged research platforms. To do so, we searched the “digital transformation” term among titles,

Table 2
An overview of the gathered corpus.

Corpus no.	Representative of	Search database	Search term	Document type	Time span	No. of documents
Corpus 1	Global trends	Scopus Web of Science	“Digital transformation”	All types	–2021	8639
Corpus 2	Core knowledge	SSCI & SCIE		Journal article		1264

Table 3

Dominant topics in research on digital transformation.

Topic number	Topic name	Topic top terms	Examples of most correlated publications	Topic proportion
Core knowledge				
t ₁	Digital transformation of business	digit, innov, busi, manag, technolog, valu, model, process, capabl, firm	Hadjielias et al. (2021) Liu et al. (2011) Cui, Li, and Kamoche (2021) Mathieson et al. (2020) de Beer and Depew (2021) Denner, Püschel, and Röglinger (2018)	26.19 %
t ₂	Digital transformation of process/system	process, model, digit, develop, use, project, system, manag, implement, approach	Mai et al. (2021) Curry and Sheth (2018) Xu et al. (2020) Tortorella et al. (2022) Cho, Cheon, Jun, and Lee (2022) Ram-rez and López-Zapata (2022)	8.465 %
t ₃	Advanced digital technologies use	data, system, technolog, smart, intellig, internet, applic, iot, develop, big	Kim (2021) Perkins and Schreiber (2019) Lewis and Molyneux (2018)	8.544 %
t ₄	Digital transformation adoption	use, digit, technolog, effect, model, relationship, factor, inform, adopt, perceiv	Sun et al. (2020) Sun et al. (2021a) Sun et al. (2021b)	7.595 %
t ₅	Digital transformation of media	media, digit, social, commun, technolog, cultur, futur, societi, field, present	Kuhlmann and Heuberger (2021) Castro and Lopes (2022) Muñoz and Bolívar (2021)	8.307 %
t ₆	Digital transformation method	use, data, model, network, method, time, predict, energi, algorithm, imag	Lu et al. (2020) Williams et al. (2020)	7.120 %
t ₇	Digital transformation of public administration	public, digit, govern, develop, polici, sector, countri, citi, servic, sustain	Hawley et al. (2021) Babin and Grant (2019)	6.408 %
t ₈	Digital transformation of health	health, care, patient, digit, healthcar, hospit, system, medic, clinic, implement	Nell et al. (2021) Kohli and Johnson (2011)	6.092 %
t ₉	Digital transformation management	busi, digit, compani, market, technolog, strategi, new, platform, transform, custom	Amaral and Peças (2021a) Beliatius, Jensen, Ellegaard, Aagaard, and Presser (2021)	6.013 %
t ₁₀	Digital transformation of manufacturing/production	industri, manufactur, product, chain, compani, suppli, technolog, enterpris, sme, model	Amaral and Peças (2021b) Pachidi et al. (2021)	3.323 %
t ₁₁	Digital transformation of work	work, digit, human, technolog, chang, employe, new, manag, individu, skill	Dengler and Matthes (2018) Strohmeier (2020)	4.509 %
t ₁₂	Digital transformation of education	educ, learn, digit, student, univers, use, compet, teach, higher, skill	Temdee (2021) Bhagat and Kim (2020)	4.193 %
t ₁₃	Digital transformation of user experience	servic, pandem, covid, custom, social, bank, consum, user, experi, onlin	Beardsley, Albó, Aragón, and Hernández-Leo (2021) Lian (2021) Rhee and Lee (2021) Rodgers et al. (2021)	3.244 %
Global trends				
T ₁	Digital transformation of economy	digit, develop, technolog, economi, process, system, inform, use, econom, manag	Kurochkina et al. (2021) Ershova, Hohlov, and Shaposhnik (2018)	12.20 %
T ₂	Digital transformation of business	busi, digit, new, technolog, compani, chang, custom, market, model, servic	Abylyazov and Petrov (2019) Arkhipova, Abaev, and Gurieva (2017) Gigova, Valeva, and Nikolova-Alexieva (2019) Pînzaru et al. (2019)	8.577 %
T ₃	Digital transformation research evaluation	research, studi, literatur, digit, review, paper, technolog, identifi, analysi, use	Haskamp, Dremel, and Uebenickel (2021a) Boughzala, Garmaki, and Chourabi (2020)	6.355 %
T ₄	Digital transformation management	manag, organ, digit, project, chang, organiz, transform, process, organis, success	Jedynak et al. (2021) Singh and Hess (2017) Horlacher and Hess (2016)	7.073 %
T ₅	Digitally transforming capabilities	digit, innov, busi, valu, firm, model, sme, capabl, technolog, develop	Caluwe, De Haes, Wilkin, and Huygh (2021) Lan and Hou (2021)	6.748 %
T ₆	Digital transformation of society	digit, new, social, work, chang, human, technolog, societi, commun, challeng	Savastano et al. (2022) Sousa-Zomer et al. (2020)	6.448 %
T ₇	Advanced digital technologies use	data, technolog, intellig, big, iot, internet, cloud, use, ai, smart	Pohle and Thiel (2020) Arias-Maldonado (2020) Pawlak (2019)	5.892 %
T ₈	Digital transformation of education	educ, learn, univers, student, digit, compet, teach, train, higher, skill	Banafa (2019) Pautasso et al. (2020)	7.073 %
T ₉	Digital transformation of process/system	system, model, process, architectur, design, busi, enterpris, develop, manag, softwar	Vermesan and Bacquet (2019) Monteiro and Leite (2021) Pisoni et al. (2020)	5.788 %

(continued on next page)

Table 3 (continued)

Topic number	Topic name	Topic top terms	Examples of most correlated publications	Topic proportion
T ₁₀	Digital transformation of manufacturing/production	industri, product, manufatur, chain, process, technolog, suppli, digit, system, develop	Koschmider (2017) Oberhauser and Stigler (2017) Siedler and Aurich (2018) Bellalouna (2021) Kayikci (2018) Buchmann, Buchs, and Gnehm (2020) Özkan et al. (2022) Khoa (2020) Sehgal and Khan (2020) Lau et al. (2020) Boutrot (2017) Sun et al. (2020) Wittbold Jr et al. (1980) Yaroslavsky (2007)	5.093 %
T ₁₁	Digital transformation adoption	use, factor, perform, effect, technolog, influenc, impact, adopt, relationship, level	Buchmann, Buchs, and Gnehm (2020) Özkan et al. (2022) Khoa (2020) Sehgal and Khan (2020) Lau et al. (2020) Boutrot (2017) Sun et al. (2020) Wittbold Jr et al. (1980) Yaroslavsky (2007)	3.114 %
T ₁₂	Digital transformation of operation	data, oper, energi, industri, construct, process, manag, time, oil, well	Sehgal and Khan (2020) Lau et al. (2020) Boutrot (2017) Sun et al. (2020) Wittbold Jr et al. (1980) Yaroslavsky (2007)	4.156 %
T ₁₃	Digital transformation method	use, system, method, data, time, model, algorithm, learn, network, control	Wittbold Jr et al. (1980) Yaroslavsky (2007)	4.202 %
T ₁₄	Digital transformation for development	countri, develop, economi, digit, econom, sector, agricultur, industri, polici, region	Broz, Buturac, and Parežanin (2020) Mentsiev et al. (2020)	3.044 %
T ₁₅	Digital transformation of public administration	govern, public, servic, citi, smart, administr, citizen, sector, digit, develop	Jurčević, Lulić, and Mostarac (2020) Pandurangi et al. (2019) Claudio Diogo Reis et al. (2021)	3.669 %
T ₁₆	Digital transformation maturity assessment	digit, model, matur, assess, compani, process, use, develop, exclus, level	Avaner and Fedai (2019) Gökalp and Martinez (2021) Schäffer et al. (2018)	2.141 %
T ₁₇	Digital transformation of media/user experience	covid, pandem, media, onlin, social, retail, tourism, consum, market, use	Büyüközkan and Güler (2020) Hu, Tsai, Feng, and Chen (2020) Beretta (2021) Goyanes (2020)	2.211 %
T ₁₈	Digital transformation and security risks	bank, financi, risk, secur, blockchain, inform, system, legal, cyber, data	Uddin et al. (2020) Park et al. (2018) Petratos (2021)	1.713 %
T ₁₉	Digital transformation of health	health, care, patient, healthcar, medic, digit, system, hospit, clinic, use	Lu et al. (2020) Hubmann, Pätzmann-Sietas, and Morbach (2021) Strametz et al. (2019)	2.685 %
T ₂₀	Digital transformation of scholarship	inform, data, use, open, research, librari, access, publish, articl, book	Van Peursem (2011) Stauffer (2012) Green (2019)	1.817 %

abstracts, and author keywords. As a result, we retrieved 12,372 digital transformation-related scientific works which were reduced to 8639 documents after eliminating the duplicates and the records without an abstract. Topic modeling of this corpus including all types of publications regardless of their quality leads to revealing the global trends of digital transformation research. Second, we repeated the above-mentioned corpus gathering process by using the Social Sciences Citation Index (SSCI) and Science Citation Index Expanded (SCIE) collections of Web of Science that only index high-quality scholarly outlets reported annually in the Journal Citation Reports (JCR) list. As a result, 1300 journal articles were retrieved which were reduced to 1264 ones after eliminating the records without an abstract. Topic modeling of this corpus including the high-quality journal articles leads to revealing the core knowledge of digital transformation research. It is worth noting that these retrieval procedures were performed at the end of 2021. Table 2 presents a summary of the main characteristics of the gathered corpus.

After gathering the required documents, we utilized their abstracts as the input corpus for topic modeling. We only used the abstract section of publications because this section reflects the main ideas and core findings of a study. In the next stage, we prepared the gathered corpus for topic modeling. This stage is necessary to enhance the quality of input data which will lead to a higher-quality output. In doing so, we first eliminated the search keyword (i.e., “digital transformation”) from the corpus because it doesn’t add new insight and could jeopardize the cohesion of the topics given its high frequency (Guerreiro, Rita, & Trigueiros, 2016; Loureiro et al., 2019). Then, we performed some routine text preparation tasks including transforming uppercases to lowercases; removing punctuations, digits, and whitespaces; eliminating stopwords (i.e., commonly occurring trivial words); reducing words to their stems; and deleting relatively unimportant words based on the Term

Frequency-Inverse Document Frequency (TF-IDF) measure. In this study, we followed the approach proposed by Jiang, Qiang, and Lin (2016) to calculate the TF-IDF index which is one of the best term valuing approaches in automatic text retrieval (Salton & Buckley, 1988).

Following that, the prepared corpus was transformed into a Document-Term Matrix (DTM) as the required input of the LDA algorithm. Next, a widely adopted lda package³ developed based on the Gibbs sampling estimation algorithm was utilized to generate per-topic word distributions and per-document topic proportions as the main results of topic modeling (i.e., the topical composition of the corpus). In this stage, following the suggestion by Griffiths and Steyvers (2004), the number of topics was tuned based on the log-likelihood measure. Also, the model’s hyper-parameters were set equal to the reciprocal of the number of topics. It is worth noting that we used the resulting per-document topic proportions to identify the topical trend of the corpus based on the approach proposed by Sun and Yin (2017). It should be noticed here that in the current study, the above-described computational tasks in corpus cleaning and topic modeling stages were performed by using the Python programming language.

4. Results

As the main result of the topic modeling of the gathered corpus, Table 3 presents two groups of topics as the underlying themes of the core knowledge and the global trends in digital transformation research. In each topic, the top terms (i.e., the terms that have the highest probabilities in the topic) and the most correlated publications (i.e., the publications in which the topic has the highest proportion) are reported.

³ <http://pythonhosted.org/lda>.

It is worth noting that these terms and publications were automatically identified by the LDA algorithm, and we only reported them in the following table. Table 3 contains a name (i.e., title or label) for each topic that was subjectively defined by the authors based on the underlying theme of the topic's terms and publications. In other words, we reviewed the topics' terms and publications introduced by the algorithm and subsequently, tried to choose a name for each topic that would be well representative of the topic's main theme. Also, this table reports the proportion of each topic in the corpus that was calculated by dividing the number of documents in the topic by the total number of documents in the corpus. Accordingly, it can be seen that "digital transformation of business" and "digital transformation of economy" are respectively the most prevalent themes in the core knowledge and among the global trends of digital transformation research. Also, the results indicate that although digital transformation research has diffused to several branches of knowledge such as economics, engineering, medicine, and environmental sciences, this interdisciplinary scholarship has mainly developed across organizational, business-related, and managerial subject areas. And, in these subject areas, researchers have predominantly focused on strategic issues (e.g., capability and value) and behavioral aspects (e.g., adoption and use).

Fig. 2 depicts the inter-topic distance map of the core knowledge and global trends in digital transformation research. This map was generated based on the multidimensional scaling method (Sievert & Shirley, 2014). In this graphical view, each topic is represented by a circle the area of which is correlated with the prevalence of the topic in the corpus based on the marginal topic distribution legend. Also, the distance between two circles represents the semantic relevancy of the topics based on their shared terms. Accordingly, this visual plot provides us with some insights about "how prevalent each topic is" and "to which extent topics are relevant to each other". Based on this result, it is interesting to note that the underlying topics of the field's core knowledge have clearly established their boundaries and positions apart from each other. However, the global trends are being developed very close to one another, so they may be integrated together within the course of the coming years. Also, it can be observed that most of the global trends have more or less the same proportions in the research landscape. In contrast, there are remarkable differences between the distributions of the smallest and biggest themes in the core knowledge.

Fig. 3 shows the temporal evolution of the identified topics of the core knowledge and the global trends in digital transformation research. In this figure, the horizontal axes represent the publication years from

2010 to 2021, and the vertical axes indicate the topics' proportions. Please note that the indicators $t_1 - t_{13}$ and $T_1 - T_{20}$ are used to refer respectively to the 13 topics introduced as the core knowledge and the 20 topics introduced as the global trends on digital transformation in Table 3. By looking at the figure, it is known what topics can be generally considered as upward, steady, fluctuating, or downward trends in digital transformation research. Based on these results, it is evident that most of the topics and trends had fluctuating evolutionary trajectories in their early stages of development. In contrast, they have established their rising or falling paths during the recent few years.

Finally, Fig. 4 shows the word clouds of the topics. Like the previous figure, the indicators $t_1 - t_{13}$ and $T_1 - T_{20}$ are used to refer respectively to the 13 topics introduced as the core knowledge and the 20 topics introduced as the global trends on digital transformation in Table 3. Each word cloud contains the top 50 terms with the highest probabilities in the pertinent topic. In these word clouds, the size of a term is correlated with its probability in the relevant topic. By looking at this figure, readers would judge if the names of the topics reported in Table 3 were selected properly or not.

5. Discussion

In this study, the dominant topics in digital transformation research were identified by applying the topic modeling approach to two big texts, one of which includes all digital transformation-related publications that were indexed in well-known Scopus and Web of Science databases so represent the global trends (8639 documents), and the other one only contains studies that were published by high-quality JCR journals so represents the core knowledge (1264 documents). Apparently, there is a remarkable difference in the sizes of these two collections of documents inferring the fact that at this time, a huge proportion of this field of research is being developed outside of the top acclaimed outlets so is mainly at the infancy stages and needs more verifications. In fact, given our research design, the core knowledge is constituted by the topics that appeared in high-quality refereed journals which have a very strict process for reviewing and have a tendency to often publish completed and empirical explorations. However, the global trends are constituted by the topics that were published as different types of outlets such as journal articles, conference papers, and book chapters, so they could be at different research stages and include various sorts of scholarly investigations like empirical and conceptual. It should be clarified here that the core knowledge is a part of the global trends. However, the

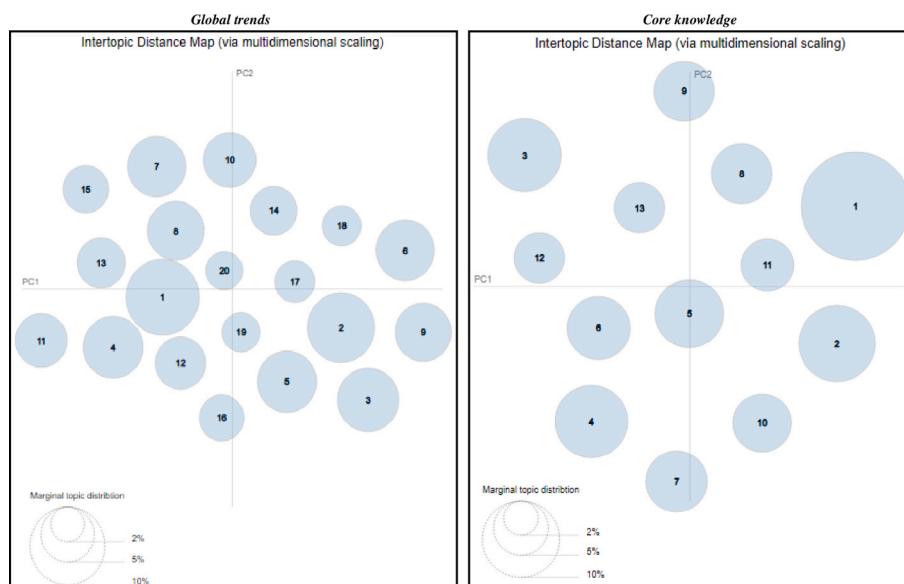


Fig. 2. Topic map of research on digital transformation.

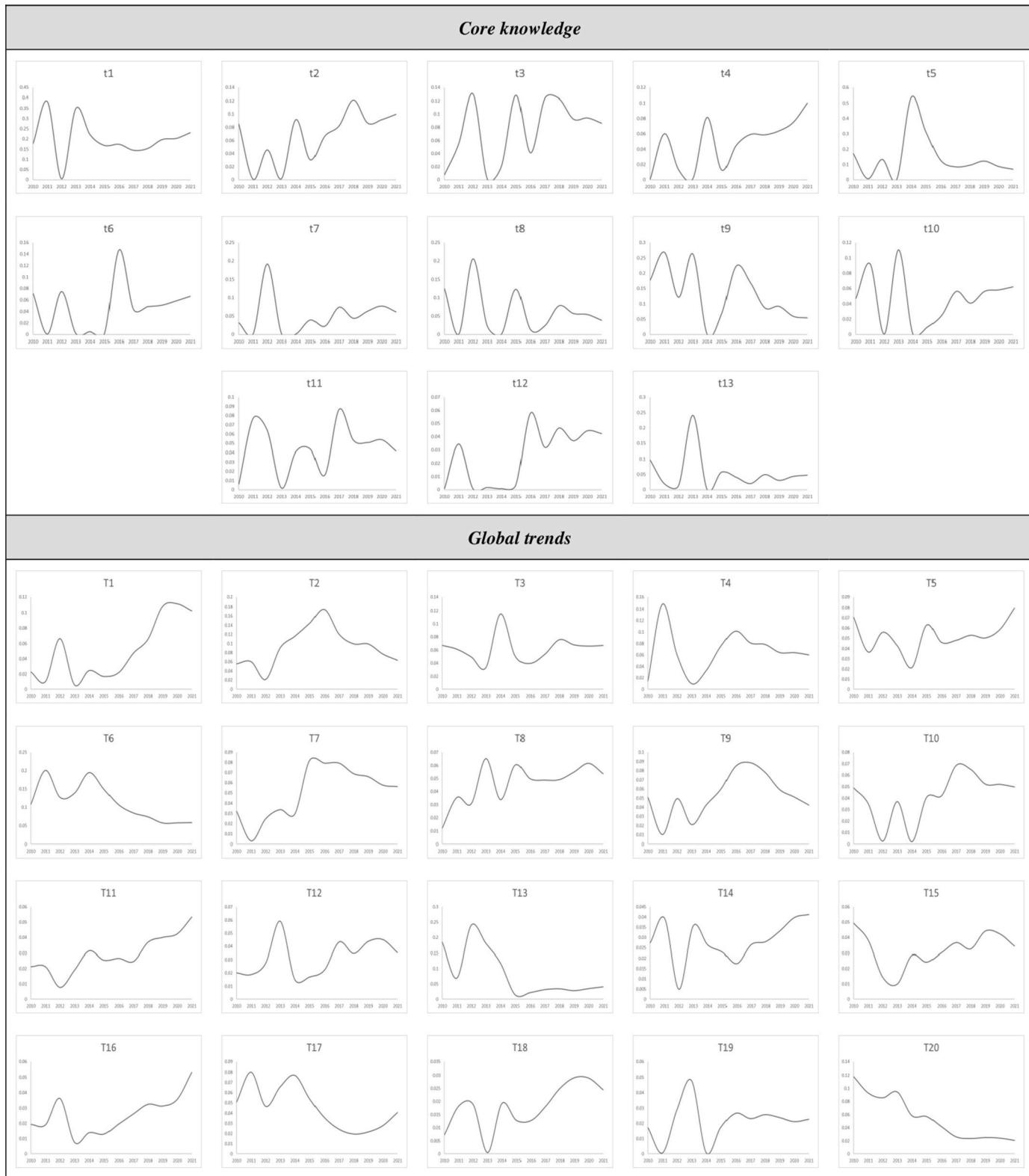


Fig. 3. Temporal evolution of dominant topics in research on digital transformation (2010–2021).

global trends are more than only the core knowledge. By comparing these two groups of topics, we can identify the themes that would represent the developing trends in digital transformation research. The developing trends refer to the frontier topics which have not appeared in top-tier outlets and are mostly conceptual so need more empirical explorations to establish themselves as the core knowledge of the field.

These topics which are present among the global trends but not present in the core knowledge are mainly at the ideation and theoretical phases and are predominantly proposed in book chapters or presented at the scholarly conferences. The importance of these developing trends is due to the fact that they most probably can be considered the next generation of research in the digital transformation field of study. Fig. 5 shows the



Fig. 4. Word cloud of dominant topics in research on digital transformation

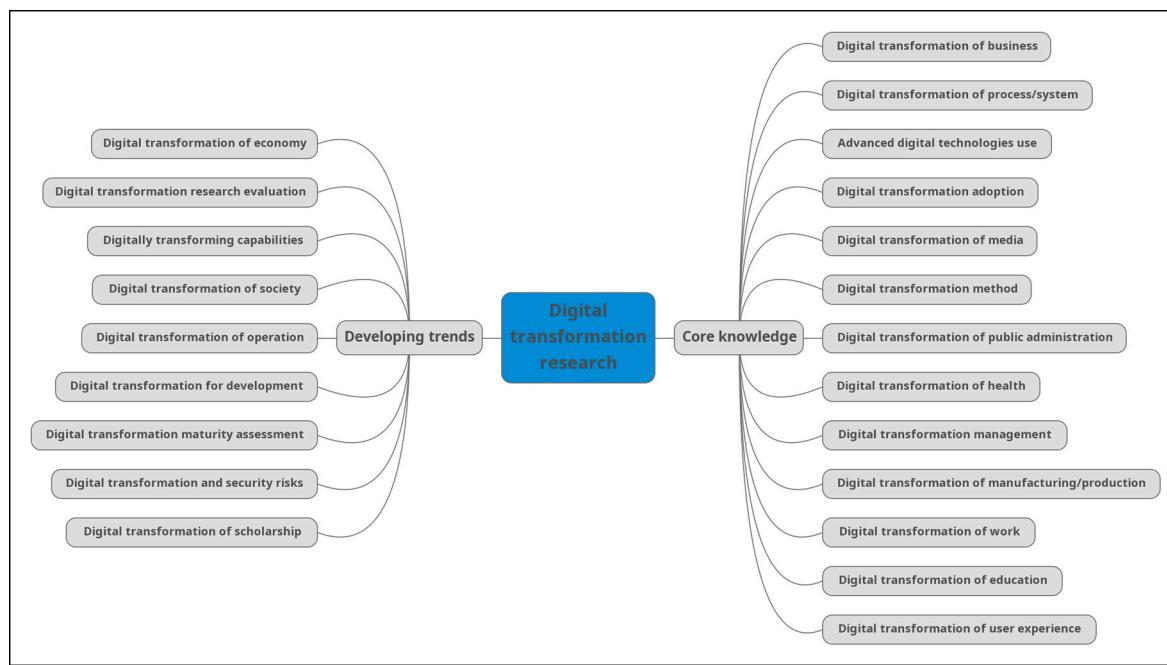


Fig. 5. The core knowledge and developing trends on digital transformation.

core knowledge and the developing trends of digital transformation research at a glance in the form of a mind map. By comparing these two categories, it is known that although the underlying themes of the core knowledge of the digital transformation field are dominantly related to business-related or managerial sciences, the developing trends have diffused to other branches of the scholarship. Also, it is interesting to see that evaluating both academic and practical initiatives on digital transformation has become a popular but developing topic among researchers. Moreover, based on Table 3 and Fig. 2, it can be understood that “digital transformation of economy” is the largest topic and “digitally transforming capabilities”, “digital transformation for development”, and “digital transformation maturity assessment” are the fastest-growing topics among the identified developing trends on digital transformation. Researchers would devote specific attention and effort to these three emerging topics in the next years.

Table 4 presents a comparison between our findings and those of previous literature reviews on digital transformation. In this table, the headings represent the topics of core knowledge and developing trends that were identified in the present study, and the rows belong to the existing reviews that were introduced in the related works section. Accordingly, it is understood that each topic we identified in the present study has been mentioned in at least one of the previous reviews. Also, it is known that some of these topics specifically those of core knowledge (e.g., digital transformation of manufacturing/production) have higher frequency, and some others specifically the topics of developing trends (e.g., digital transformation maturity assessment) have less mention in the previous literature reviews on digital transformation.

The findings of this study have some implications for scholars who are interested in digital transformation research. First, they can generally become familiar with the underlying themes of the core knowledge in this field of research. In other words, they can get to know the main research streams on digital transformation developed based on firm scientific evidence within recent years. Researchers should mind the direction based on which they want to contribute to the core knowledge of the field. In this respect, performing confirmatory studies on the identified topics of the core knowledge could be considered a good research agenda for them. In addition, these researchers can become familiar with the underlying themes of the developing trends in digital transformation research. They can get to know what topics could most

probably shape the future of this field of research and accordingly, invest their current time and efforts in studying them. In this regard, conducting exploratory investigations on the identified developing trends could be considered another interesting research agenda for digital transformation scholars.

As with all research, the present study has its limitations. There are at least five areas of improvement for this research each of which would be considered as a ground for tackling the main limitations and developing further research: First, the research design selected to analyze the global trends did not guarantee the inclusion of all research and knowledge available on digital transformation. In this work, we relied on the proxy that searching the term “digital transformation” in the titles, abstracts, and keywords of documents indexed in Scopus and Web of Science allows us to collect the literature on digital transformation. However, in the next works, it could be possible to use multiple relevant keywords in several scientific platforms to cover a broader extent of the literature, and even include the papers that do not contain the search term in the topic section but are related to the digital transformation phenomenon. Moreover, it is important to note that we considered the JCR list as our point of reference to find high-quality journals and articles for analyzing the core knowledge of digital transformation scholarship. Nevertheless, it could be discussed in further investigations that this is a subjective and approximate quality criterion that might not be accepted by some scholars, so another finer and more accurate proxy would be considered in future works. Also, it was assumed in our work that the abstract section of a paper reflects a correct impression of a study. Nonetheless, we know that reviewing the full text of a paper could give more precise information on the study’s contributions. Thus, consequent studies may decide to add some other sections of documents to their corpus in order to address this limitation. Second, although we employed a computational technique to uncover the themes and trends in the digital transformation literature, it was still necessary to interpret the results based on the authors’ knowledge. Hence, we cannot claim that the issue of human subjectivity was completely eliminated. In this regard, in the next articles, instead of only relying on the authors’ understanding, the initial results could be presented to the experts on the digital transformation topic in order to benefit from their opinions in labeling the topics and describing them. This could be done in the form of an interview study, a panel discussion, or a questionnaire survey. Third, in

Table 4

Comparing the findings of this study and the existing literature.

	Digital transformation of business	Digital transformation of process/system	Advanced digital technologies use	Digital transformation adoption	Digital transformation of media	Digital transformation method	Digital transformation of public administration	Digital transformation of health	Digital transformation management	Digital transformation of manufacturing/production	Digital transformation of work	Digital transformation of education	Digital transformation of user experience	Digital transformation of economy	Digital transformation research evaluation	Digital transforming capabilities	Digital transformation of society	Digital transformation of operation	Digital transformation for development	Digital transformation maturity assessment	Digital transformation and security risks	Digital transformation of scholarship
Chawla and Goyal (2022)	•							•							•							
Facin et al. (2022)	•	•			•											•						
Hajishirzi et al. (2022)	•		•	•												•						
Hausberg et al. (2019)	•		•	•	•			•	•		•	•				•			•		•	
Jedynak et al. (2021)	•		•		•			•		•	•				•				•		•	
Kraus et al. (2021a)	•	•				•			•	•	•					•	•	•	•	•	•	•
Kraus et al. (2022)	•	•	•	•	•	•			•	•	•					•			•		•	
Pihir et al. (2019)	•	•	•	•	•			•	•	•	•					•			•		•	
Plekhanov et al. (2022)	•	•			•	•			•	•						•			•		•	
Reis and Melão (2023)	•	•	•				•			•	•					•	•	•	•	•	•	
Reis et al. (2018)	•	•			•			•	•		•	•						•	•		•	
Shi et al. (2022)	•	•	•					•	•		•	•				•			•		•	
Talafidaryani et al. (2021)	•		•		•			•	•		•	•				•	•	•	•	•		
Van Veldhoven et al. (2021)	•	•	•	•	•			•	•	•	•	•				•	•	•	•	•		
Verhoef et al. (2021)	•	•				•					•	•				•			•			
Zhu et al. (2021)	•	•	•	•	•	•		•		•	•	•				•	•	•	•	•	•	

this manuscript, we could not provide a thorough description for each topic because of the lack of space and the high number of topics. However, in the next papers, the identified topics can be introduced and explained in more detail in order to move from initial descriptions to insightful interpretations. To accomplish this aim, the exemplary documents in each topic could be overviewed by using the methods of thematic or content analysis. Fourth, we specified the topics of the core knowledge and global trends in digital transformation research based on LDA-based topic modeling analyses, yet some meaningful topics were no doubt not included in this study. This is significantly one of the limitations that could occur as a result of using only one model for analysis while employing multiple models would provide the opportunity for reviewing the literature and revealing the topics from various perspectives along with avoiding the inherent shortcomings that a specific algorithm could have. Different tools and techniques may yield different topics and trends. In this regard, in the next works, the extent and variety of analyses could be broadened. To do so, researchers would employ other forms of textual data analyses or combine the topic modeling approach with some advanced artificial intelligence techniques. As a case in point, scholars could utilize emerging machine learning and deep learning-based time-series algorithms for forecasting the topics' trends over the course of the coming years. In addition, more computational efforts could be invested in improving the quality of the input text and the robustness of the data analysis to generate results with higher quality. Also, the next researchers may decide to benefit from the potentialities of scientometrics and bibliometrics methods for depicting the intellectual structure of each topic as well as for the overall literature. Finally, it would be interesting to include the grey literature in the corpus. By doing so, we can clarify the boundaries of the literature more precisely. As a part of this suggestion, it is also recommended to specifically focus on the practical sources and organizational documents in order to uncover the underlying conversations among practitioners and discover the gaps between the research and practice on digital transformation.

6. Conclusion

In this study, we used the topic modeling approach to reveal the dominant topics in digital transformation research. By gathering two collections of publications, we could divide these topics into two categories named the global trends and the core knowledge of the field. Also, by comparing these topics, we could identify the developing trends in digital transformation. The main contribution of this research is that its results give an overall picture of the landscape of the field. Accordingly, researchers can generally find what has been done so far and what is going to be done in the digital transformation scholarship. The results of our topic modeling can help to understand the extent, range, and nature of the digital transformation phenomenon at a glance without which, it is not clear what is included in the digital transformation literature and what is not, and it is difficult to trace the research and its boundaries.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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