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Mapping the Evolution of Critical Success Factors in Digital Transformation: A 25-Year Bibliometric Perspective

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Abstract

Over the past 25 years, digital transformation (DT) has evolved from a technology-centric initiative to a multidimensional strategic imperative, with Critical Success Factors (CSFs) playing a pivotal role in guiding implementation outcomes. Despite the growing body of DT literature, a lack of longitudinal synthesis remains, mapping how CSFs have emerged, evolved, and interconnected over time. This study conducts a comprehensive bibliometric analysis of DT-CSF research from 2000 to 2025, utilizing performance analysis and science mapping techniques to identify influential authors, institutions, countries, thematic clusters, and emerging research fronts. The results reveal an early research focus on IT infrastructure, system integration, and process automation, gradually shifting toward strategic leadership, organizational culture, agile project management, stakeholder engagement, and innovation ecosystems. Collaboration network analysis highlights the increasing interdisciplinarity of the field, with strong linkages between management, information systems, and industry-specific domains. Keyword co-occurrence mapping identifies emerging themes such as artificial intelligence adoption, sustainability-driven transformation, and cross-sector digital ecosystems. The study concludes that while the field has matured toward more holistic and context-sensitive perspectives, significant gaps remain in understanding CSFs in small-to-medium enterprises, developing economies, and rapidly evolving technological contexts. By

synthesizing 25 years of scholarly discourse, this research offers a longitudinal framework for understanding the evolution of CSFs in DT, providing valuable guidance for future academic inquiry, industry practice, and policy development.
Keywords: Digital Transformation, Critical Success Factors, Bibliometric Analysis

Introduction

Over the past two and a half decades, the global business landscape has undergone profound shifts, largely driven by the rise of digital technologies. Digital transformation (DT), the integration of digital technologies into all areas of an organization to enhance performance and value creation has emerged as a key strategic imperative for enterprises across sectors. Despite widespread recognition of its potential, successful DT implementation remains a complex and multifaceted challenge. This complexity has given rise to a growing body of research focused on identifying and understanding the critical success factors (CSFs) that contribute to effective digital transformation. Understanding how these success factors have evolved is vital for practitioners and scholars alike, as it provides guidance for navigating today's dynamic digital environment.

The academic discourse on digital transformation has expanded rapidly, with early research emphasizing technology infrastructure and IT capabilities (Leyh et al., 2022; Reinkemeyer, 2024), while more recent studies have highlighted the importance of strategic leadership, change management, and customer-centric approaches (Senarathna & Wickramarachchi, 2024; Pasqual et al., 2023). Studies have also explored the sector-specific nuances of DT, such as in the automotive industry (Daxbacher et al., 2024), education (Alojail et al., 2023), and small-to-medium enterprises (Barbieri et al., 2024). The literature demonstrates a shift from a technology-first paradigm to a more holistic perspective that encompasses organizational culture, stakeholder collaboration, agile project management, and continuous innovation (Carujo et al., 2022; Alsaeedi et al., 2023). However, a consolidated view of how these critical success factors have evolved remains limited.

To address this gap, this study adopts a bibliometric approach to systematically map and analyze the evolution of CSFs in digital transformation over the past 25 years. By synthesizing existing literature from a longitudinal perspective, this research identifies prevailing themes, emerging trends, and conceptual shifts within the DT landscape. Bibliometric analysis, with its ability to capture citation patterns, thematic structures, and intellectual linkages, serves as a valuable methodological tool in discovering the trajectory of research development and scholarly consensus within the field.

Despite the growing volume of research on digital transformation, a clear understanding of the temporal progression and interrelationships of CSFs is still underdeveloped. The central problem this study addresses is the fragmented nature of the literature, which lacks a comprehensive, chronological mapping of how key success factors in DT have changed in emphasis and configuration. The primary aim of this study is to provide a comprehensive bibliometric analysis of Critical Success Factors (CSFs) in digital transformation (DT) research over the past 25 years, with a focus on mapping their intellectual development and thematic evolution.

By systematically synthesizing literature published between 2000 and 2025, the research seeks to identify and categorize the major CSFs, assess how their prominence and applications have shifted from predominantly technology-driven factors toward more strategic, organizational, and holistic dimensions, and analyze patterns of scholarly collaboration across authors, institutions, and countries. In doing so, the study investigates five interrelated research questions: (1) What are the major CSFs identified in DT literature over the last 25 years, and how have they been categorized and prioritized? (2) How has the thematic and conceptual focus on these CSFs evolved? (3) Who are the key contributors, and what patterns of collaboration and scholarly networking characterize the DT-CSF research domain? (4) What dominant thematic trends and emerging conceptual structures can be revealed through bibliometric techniques such as keyword co-occurrence and term mapping? and (5) What trends, patterns, and gaps emerge that can guide future research and inform the effective implementation of DT initiatives? Addressing these questions will not only enhance scholarly understanding of the historical and conceptual trajectory of CSFs in DT but will also provide actionable insights for practitioners navigating the complex and evolving digital business landscape.

This study contributes to both theory and practice in several ways. From an academic perspective, it provides a longitudinal synthesis of how the DT-CSF research landscape has matured, moving from a technology-centric approach to one emphasizing organizational culture, leadership, and strategic alignment. This understanding enriches theoretical frameworks related to digital innovation and organizational change. From a practical standpoint, the findings offer actionable insights for managers, consultants, and policymakers. By identifying emerging trends and research gaps, the study helps practitioners prioritize investments, design more effective DT strategies, and anticipate challenges in implementation. Policymakers can also benefit by formulating evidence-based policies and capacity-building programs that foster digital readiness across industries. Ultimately, this study is significant because it bridges the academic-practice divide, which offers both a macro-level understanding of DT-CSF evolution and a micro-level roadmap for organizations seeking sustainable and inclusive digital transformation.

The remainder of this paper is structured as follows: Section 2 outlines the methodology, including data collection and bibliometric techniques. Section 3 presents the findings of the analysis, detailing the evolution of CSFs across different time periods. Section 4 discusses the implications of these findings within both theoretical and practical contexts. Finally, Section 5 concludes the study with a summary of key insights, limitations, and directions for future research. Through this structure, the paper aims to offer a comprehensive, data-driven understanding of the CSFs that have shaped and continue to shape the trajectory of digital transformation. Finally, Section 6 concludes the study by summarizing key insights, identifying limitations, and proposing directions for future research.

Literature Review

Over the past 25 years, DT has transitioned from a technology-focused initiative to a complex, strategic undertaking embedded in organizational ecosystems. A growing body of literature highlights that DT success is contingent on the identification and implementation of CSFs. Early DT efforts were heavily reliant on IT infrastructure and digital tools as enablers, with technology acting both as a facilitator and a barrier (Tsiavos & Kitsios, 2022). As the concept

of transformation matured, researchers emphasized the role of intangible assets such as leadership, vision, culture, and innovation as essential determinants of DT success (Pasqual, Jung, & Fraunholz, 2023). These studies collectively show a shift from purely technical inputs to strategic and behavioral enablers that foster enterprise-wide digital readiness.

Recent literature identifies key CSFs including leadership style, agile mindset, strategic alignment, customer orientation, data usage, and organizational agility (Hernández-García et al., 2023; Bianchi et al., 2024). Leadership and culture, in particular, have surfaced as more influential than the digital platforms themselves, emphasizing the human and organizational dimensions of transformation (Pasqual et al., 2023). Meanwhile, studies such as Bianchi et al. (2024) highlight that agility not only accelerates innovation but also improves the organization's responsiveness to digital disruptions. Furthermore, data-driven decision-making and customer-centric approaches are emerging as essential capabilities in sustaining competitive advantage in digitally mature firms (Hernández-García et al., 2023).

The technological landscape has also evolved in tandem, with cloud computing, artificial intelligence (AI), the Internet of Things (IoT), and big data analytics serving as foundational enablers of digital transformation (Karim, 2021; Bianchi et al., 2024). These technologies facilitate automation, real-time analytics, and process innovation, though their implementation varies significantly across industries. Despite their potential, challenges persist—particularly in areas like legacy systems integration, data security, and the digital skill gap. Scholars have also pointed out that technological advancement alone is insufficient without supportive strategies and governance structures (Tian & Ou, 2024). This interdependence between technological and organizational readiness underscores the complexity of modern DT initiatives.

In exploring the organizational and leadership dimensions, a range of studies has examined how new leadership models and structural changes support DT. Traditional hierarchical leadership is being replaced with flatter, more collaborative models that favor adaptability, co-creation, and digital fluency (Jhawar, Vyas, & Kushwaha, 2025). Transformative leadership competencies such as visioning, communication, and stakeholder alignment are viewed as critical to shaping DT strategies and influencing organizational culture (Schiuma et al., 2024). Furthermore, Khalayleh, Rohaida, and Al-Khazaleh (2024) found that the impact of leadership practices on DT adoption is moderated by the organization's culture, indicating the need for alignment between leadership intent and internal values.

Although a considerable body of research exists, gaps remain particularly concerning comparative insights across industries and temporal shifts in CSFs. Studies like Tian and Ou (2024) suggest that industries adopt DT differently, guided by their unique operational requirements, customer expectations, and regulatory landscapes. However, little has been done to map the evolution of CSFs across industries and over time. This is the specific gap this study aims to address by applying a bibliometric approach to systematically chart the development of CSFs in DT literature over the last 25 years. Such an analysis is essential to understand the trajectory of scholarly inquiry, uncover emerging trends, and identify underexplored dimensions that require further investigation.

Methods

To systematically explore the evolution of CSFs in DT, this study adopts a rigorous bibliometric analysis using data retrieved from the Scopus database. Bibliometric analysis is a powerful quantitative research method used to examine the structure, development, and dissemination of scholarly knowledge across time (Donthu et al., 2021). It enables researchers to identify publication trends, prolific authors, influential journals, keyword co-occurrences, and global collaboration networks within a particular research domain (Zupic & Čater, 2015). This methodological approach is particularly suited to emerging interdisciplinary fields such as digital transformation, where research is rapidly expanding across various sectors and disciplines.

Scopus was selected as the primary data source for this study due to its broad and multidisciplinary coverage, rigorous indexing standards, and citation-tracking capabilities. Compared to other databases like Web of Science or Google Scholar, Scopus offers more comprehensive coverage of peer-reviewed journals, conference proceedings, and edited volumes across science, technology, engineering, business, and the social sciences (Mongeon & Paul-Hus, 2016). Furthermore, Scopus includes advanced analytical tools that support citation analysis, co-authorship patterns, and keyword mapping features essential for tracking the intellectual evolution and collaboration dynamics in DT research.

In this study, bibliometric techniques such as performance analysis and science mapping were applied. Performance analysis quantifies research output (e.g., number of publications, citations, most prolific authors or institutions), while science mapping reveals the intellectual structure and thematic evolution of the field through co-citation, bibliographic coupling, and co-word analysis (Aria & Cuccurullo, 2017). For instance, keyword co-occurrence analysis helps identify shifting research themes—such as how leadership, innovation, or customer-centricity have gained prominence in CSF-related DT studies over time. Co-authorship networks, on the other hand, illuminate global collaboration patterns, revealing the extent to which knowledge production in this area is internationally distributed and interconnected.
Bibliometric analysis not only helps in mapping the historical development of a field but also provides critical insights into its future trajectory. By uncovering gaps in the literature and identifying influential scholars and publications, this method supports strategic research planning, policy development, and knowledge management. In the context of digital transformation, where rapid technological and organizational changes demand continual adaptation, bibliometrics plays a key role in synthesizing fragmented research and providing a roadmap for future inquiry (Donthu et al., 2021). Ultimately, this approach contributes to advancing scientific knowledge by making sense of the vast, multidimensional data landscape surrounding DT and its critical success factors.

This bibliometric study investigates the theme of CSFs and DT, with the objective of identifying prevailing research trends, intellectual structures, and patterns of collaboration within the domain. As illustrated in Figure 1, the data collection process was carried out using a systematic and structured methodology in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework to ensure transparency and reproducibility.

The Scopus database was chosen for data retrieval due to its extensive indexing of peer-reviewed academic literature across multiple disciplines, which makes it a preferred source for bibliometric analyses. The search was restricted to the article title field, while no filters were applied to the time frame, language, or document type, thereby maximizing the breadth of the search. Only documents categorized under the subject area of Business, Management, and Accounting were included, and source types were limited to journal articles and conference proceedings to ensure academic rigor.

A carefully constructed Boolean search string was employed to extract relevant literature:
("digital transformation" OR "digital change" OR "digital shift" OR "digital evolution") AND ("success factors" OR "critical factors" OR "key factors" OR "determinants").
This combination was selected to encompass the diverse terminology associated with digital transformation initiatives and the factors that contribute to their success.

Data were extracted on 30 July 2025. The search process yielded a total of 283 documents, which were screened and included in the final dataset for bibliometric analysis. Although intermediate filtering steps such as duplicate removal and full-text screening are not detailed in the flow diagram, it is implied that standard inclusion criteria such as thematic relevance, academic quality, and full-text availabilitywere applied during the screening phase. These 283 documents form the basis for further bibliometric evaluation, including performance analysis (e.g., most productive authors, institutions, and sources) and science mapping techniques (e.g., keyword co-occurrence, co-authorship networks, and thematic clusters), to provide a comprehensive overview of the research landscape on critical success factors in digital transformation.

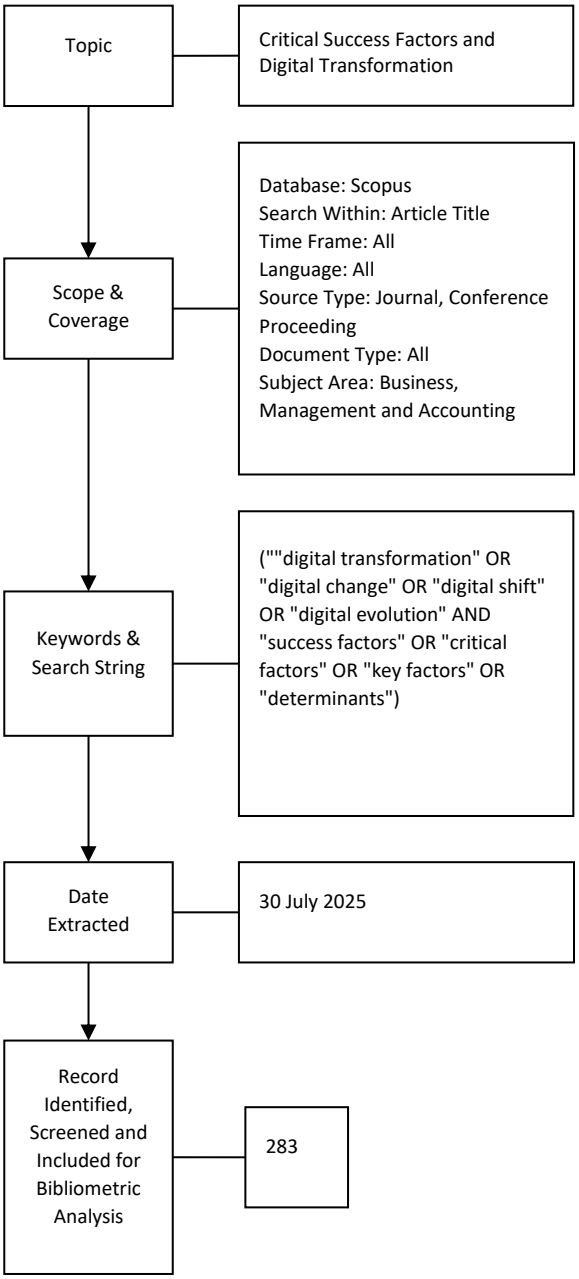

Figure 1. Flow diagram of the search strategy

Results

This section presents the findings of a comprehensive bibliometric analysis aimed at exploring the evolution of Critical Success Factors (CSFs) in Digital Transformation. Drawing on data extracted from the Scopus database and processed using a combination of bibliometric tools including Harzing's Publish or Perish, OpenRefine, and VOSviewer. The results are structured to highlight publication trends, influential authors, key research themes, and collaborative networks within the field. The analysis is organized around core dimensions such as annual publication output, citation metrics, co-authorship patterns, keyword co-occurrence, and co-citation networks. These findings provide a data-driven perspective on the intellectual structure and global research dynamics shaping the discourse on CSFs in digital transformation, offering valuable insights into its scholarly trajectory and future directions.

Documents Profiles

The document profile presented in Table 1 provides key bibliometric indicators that offer valuable insights into the overall productivity, impact, and scholarly engagement within the research domain of CSFs in Digital Transformation over the period of 2015 to 2025. A total of 300 papers were published within this timeframe, reflecting growing academic interest in this evolving field. These papers have accumulated 5,430 citations over 19 citation years, resulting in an average of 285.79 citations per year. This suggests that the topic has garnered significant scholarly attention and continues to influence ongoing research (Donthu et al., 2021).

The average number of citations per paper (18.1) demonstrates a relatively high impact per publication, indicating that the papers are not only being published but are also frequently cited, reflecting their relevance and influence. Additionally, the cumulative citation count per author is 1,828.12, while the average number of papers per author is 118.72. These values suggest a highly collaborative and productive author base, although the high value for papers per author may also reflect multiple authorships across different works, a common occurrence in interdisciplinary digital transformation research (Zupic & Čater, 2015).

The ratio of authors per paper stands at 3.18, reinforcing the collaborative nature of research in this domain, often requiring input from experts in technology, management, and organizational studies. The h-index of 34 indicates that 34 of the publications have been cited at least 34 times, which is a strong indicator of both productivity and citation impact. Furthermore, the g-index of 67 suggests that the top 67 papers received a substantial number of citations collectively, thus confirming the field's intellectual depth and sustained scholarly interest (Hirsch, 2005).

Together, these indicators suggest a robust and expanding body of literature on CSFs in digital transformation, underpinned by sustained academic contribution and high citation impact. The quantitative strength of these metrics underscores the significance and maturity of the topic within the academic landscape, justifying further exploration and mapping of intellectual trends through bibliometric techniques.

Table 1
Main information

Main Information	**Data**
Publication years	2015-2025
Citation years	19
Papers	300
Citations	5430
Cites_Year	285.79
Cites_Paper	18.1
Cites_Author	1828.12
Papers_Author	118.72
Authors_Paper	3.18
h_index	34
g_index	67

Source: Generated by the author(s) using biblioMagika® (Ahmi, 2024)

Publication Trends

The publication trend by year, as presented in Table 2, demonstrates a marked increase in scholarly interest in the topic of critical success factors and digital transformation over the past decade, with a notable surge beginning in 2020. The year 2024 recorded the highest number of publications, totaling 78 documents, which represents 26% of all documents analyzed. This was closely followed by 2025, with 66 documents (22%), and 2023 with 48 documents (16%). The steady growth from 2020 onwards reflects the escalating relevance of digital transformation initiatives, likely spurred by the acceleration of digital adoption due to the COVID-19 pandemic and the need for digital resilience in organizations (Dwivedi et al., 2021; Vial, 2019).

Between 2020 and 2025, over 85% of all publications were produced, signifying a recent and growing academic focus on this field. In contrast, publication activity between 2006 and 2019 was relatively minimal, with only sporadic outputs ranging from one to five publications per year suggesting that digital transformation was not yet a central theme in academic discourse. The earliest document recorded in the dataset was published in 2006, and for the years 2006, 2010, and 2011, only one document was published each year (0.33%).

This growth trajectory indicates not only the rising importance of understanding digital transformation and its success factors but also highlights a shift in research priorities in response to evolving technological landscapes. Scholars and practitioners are increasingly recognizing the need to explore this domain to guide policy, strategy, and implementation practices in both public and private sectors (Sebastian et al., 2017; Warner & Wäger, 2019).

Table 2
Publication by year

Year	Total Documents	Percentage (%)
2025	66	22.00%
2024	78	26.00%
2023	48	16.00%
2022	41	13.67%
2021	25	8.33%
2020	18	6.00%
2019	12	4.00%
2018	4	1.33%
2017	5	1.67%
2011	1	0.33%
2010	1	0.33%
2006	1	0.33%
TOTAL	300	100.00%

Based on Figure 2, which illustrates the trend of scholarly publications on the topic of CSFs and DT, the growth of related academic literature has significantly increased over the past two decades.

The trend in publication output from 2006 to 2025 indicates a slow start followed by a sharp increase in interest, especially in recent years. From 2006 to 2016, the number of publications

remained relatively low and stable, with fewer than five documents per year. This suggests that during this period, research on CSFs in the context of digital transformation was still in its nascent stage, with limited scholarly attention (Bibri, 2019).

A notable rise began in 2017, coinciding with the acceleration of digital transformation initiatives globally, particularly in both public and private sectors. From 2018 to 2020, there was a gradual increase in publications, reflecting the growing interest among researchers in exploring the enablers and challenges of digital initiatives (Vial, 2019).

The period between 2021 and 2024 witnessed a substantial surge in the number of documents, peaking at around 80 documents in 2024. This explosive growth can be attributed to several global trends, including the increased adoption of digital technologies due to the COVID-19 pandemic, which forced many organizations to rapidly digitize their operations (Dwivedi et al., 2021). Furthermore, digital transformation became a core strategic focus across industries, prompting more empirical and theoretical investigations.

Interestingly, there is a slight decline observed in 2025, with the number of publications decreasing to approximately 65. This may suggest a temporary saturation or a shift in focus to more specialized subtopics such as AI integration, cybersecurity, or sustainability in digital transformation frameworks (Susanti et al., 2023).

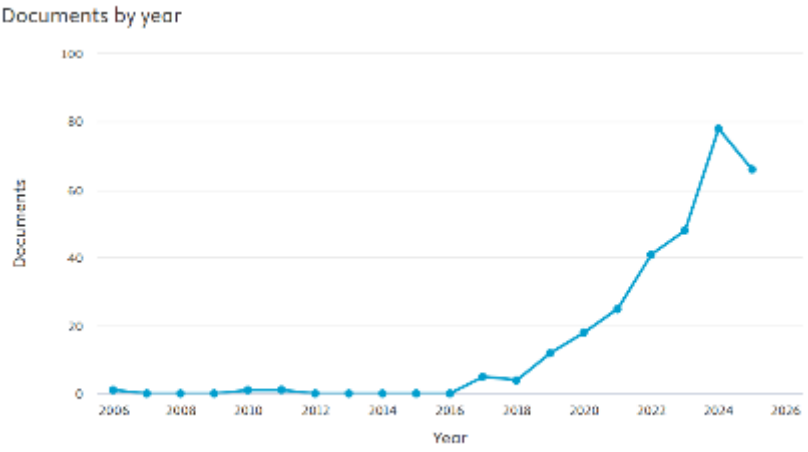

Fig. 2: Publications Over Time (2010-2025)
Source: Generated by the author(s) using Scopus database

Most Active Authors

Based on the bibliometric data presented in Table 3, the analysis of the most active authors in the field of digital transformation and critical success factors reveals several key contributors. The most prolific author is Ghobakhloo, M., who has published a total of four documents, accounting for 1.33% of the overall publications. Ghobakhloo is widely recognized in the literature for his extensive research on digital transformation strategies, Industry 4.0 adoption, and the role of technological innovation in organizational success (Ghobakhloo, 2018; Ghobakhloo & Ching, 2019). His work consistently contributes to shaping the discourse around the technological, organizational, and environmental (TOE) framework in digital transformation.

Following closely are Iranmanesh, M., Kostuhin, Y., Shkarupeta, E., and Tolstykh, T., each with three publications, making up 1.00% respectively. Iranmanesh has focused on the integration of digital technologies within small and medium-sized enterprises (SMEs) and the socio-technical factors that influence technology adoption. Kostuhin, Shkarupeta, and Tolstykh are primarily associated with research in digital industrialization and smart manufacturing, particularly in the context of Russia and Eastern Europe, often exploring frameworks that integrate both strategic planning and industrial policy in digital transformation initiatives (Shkarupeta et al., 2022).

Several other authors contributed with two publications each, representing 0.67% of the total output individually. These include Abbas, S., Alnoor, A., Atiyah, A.G., Ben-Daya, M., Chromjakova, F., Endres, H., Endri, E., Ferreira, F.A.F., Ferreira, J.J.M., and Grybauskas, A. These authors represent a diverse range of geographical and institutional backgrounds. For instance, Ben-Daya's contributions often examine supply chain resilience and performance during digital transitions (Ben-Daya et al., 2020), while Ferreira and Ferreira are notable for exploring strategic decision-making in digital environments using multi-criteria decision-making (MCDM) tools. Additionally, Alnoor and Abbas's work has highlighted the role of leadership and employee readiness in facilitating successful digital transformation in public and private sectors in the Middle East. In summary, the contributions of these active authors illustrate the multidisciplinary nature of digital transformation research, covering strategic management, technological adoption, supply chain integration, and socio-organizational dimensions. Their scholarly outputs not only enhance theoretical understanding but also offer practical frameworks for policymakers and industry players navigating digital change.

Table 3
Most active authors

Author Name	**TP**	**%**
Ghobakhloo, M.	4	1.33%
Iranmanesh, M.	3	1.00%
Kostuhin, Y.	3	1.00%
Shkarupeta, E.	3	1.00%
Tolstykh, T.	3	1.00%
Abbas, S.	2	0.67%
Alnoor, A.	2	0.67%
Atiyah, A.G.	2	0.67%
Ben-Daya, M.	2	0.67%
Chromjakova, F.	2	0.67%
Endres, H.	2	0.67%
Endri, E.	2	0.67%
Ferreira, F.A.F.	2	0.67%
Ferreira, J.J.M.	2	0.67%
Grybauskas, A.	2	0.67%

Note: TP=total number of publications

Document Type

Based on the data presented in Table 5, journal articles are the most dominant document type in the study of critical success factors and digital transformation, comprising 229 of the total 300 publications, which accounts for 76.33%. This overwhelming majority suggests that peer-reviewed journal articles are the preferred medium for disseminating research findings in this field. The high proportion reflects the academic community's emphasis on publishing in reputable journals, which often undergo rigorous peer-review processes that ensure the quality and credibility of the research (Podsakoff et al., 2005).

Conference papers constitute the second most common document type, with 54 publications representing 18.00% of the total. Conference papers often serve as preliminary research outputs, allowing authors to present early findings, receive feedback, and engage with fellow researchers (Rowe, 2014). Their substantial presence indicates the dynamic and evolving nature of the digital transformation topic, where rapid sharing of new developments is crucial.

Review papers, totaling 16 and representing 5.33% of the documents, play a vital role in synthesizing existing knowledge, identifying research gaps, and shaping future research directions (Snyder, 2019). Although fewer in number, these reviews are instrumental in consolidating the fragmented literature on digital transformation and critical success factors, offering scholars a foundation for further investigation.

Lastly, only one document (0.33%) is categorized as a note, which typically represents brief communications or commentary pieces. The negligible representation of this document type indicates a limited use of short-format publications in this area of research, possibly due to the complexity and depth required in discussing digital transformation topics.

Overall, the distribution of document types suggests a strong academic interest in comprehensive, peer-reviewed research articles, with significant contributions also coming from conference proceedings and review articles. This distribution highlights the robustness of the scholarly discourse and the diverse formats used to explore and communicate insights on critical success factors in digital transformation.

Table 5
Document type

Document Type	**TP**	**%**
Article	229	76.33%
Conference Paper	54	18.00%
Review	16	5.33%
Note	1	0.33%
Total	300	**100%**

Notes: TP=total number of publications

Source Title

Based on Table 6, the analysis of source titles reveals key scholarly outlets that have significantly contributed to the literature on topics related to digital transformation and

critical success factors. A total of 15 source titles are highlighted, accounting for various proportions of the total 300 documents analyzed.

The most productive source is Technological Forecasting and Social Change, contributing 8 publications or 2.67% of the total. This journal is well-known for its focus on technology trends, strategic foresight, and innovation, making it highly relevant in the discourse surrounding digital transformation, especially in forecasting its impact on society and business (Sung, 2021). Following closely are the International Journal of Production Economics and the Journal of Manufacturing Technology Management, each contributing 7 publications (2.33%). These journals often publish research on operational efficiency, supply chain digitalization, and innovation strategies, aligning well with the discussion on critical success factors in digital initiatives (Gunasekaran et al., 2017).

The Springer Proceedings in Business and Economics stands out with 6 publications (2.00%), indicating the contribution of conference-based research to the field. This reflects the dynamic and evolving nature of digital transformation studies, which are frequently shared in academic gatherings prior to journal publication.

Other important sources, such as Cogent Business and Management and IEEE Transactions on Engineering Management, each contribute 5 publications (1.67%). These platforms emphasize interdisciplinary approaches, technological adoption, and organizational performance—key themes in understanding success factors of digital initiatives (Ghobakhloo, 2018).

Several other journals—including Administrative Sciences, Journal of Innovation and Knowledge, Journal of Organizational and End User Computing, and Technology in Society—each contribute 4 articles (1.33%). Their presence underscores a holistic view, incorporating administrative processes, knowledge management, user behavior, and the societal impact of technology.

Lastly, source titles such as Economy of Regions, Engineering, Construction and Architectural Management, and Humanities and Social Sciences Communications (3 publications each, 1.00%) broaden the scope of analysis. They represent a multidisciplinary engagement, reflecting how digital transformation affects not only manufacturing or IT, but also regions, infrastructure, and the humanities.

In summary, the distribution of publications across diverse source titles demonstrates the multidisciplinary and cross-sectoral relevance of digital transformation. The prominence of both high-impact journals and emerging conference proceedings illustrates the evolving and active nature of research in this domain.

Table 6
Source title

Source Title	TP	%
Technological Forecasting and Social Change	8	2.67%
International Journal of Production Economics	7	2.33%
Journal of Manufacturing Technology Management	7	2.33%
Springer Proceedings in Business and Economics	6	2.00%
Cogent Business and Management	5	1.67%
IEEE Transactions on Engineering Management	5	1.67%
Administrative Sciences	4	1.33%
Journal of Innovation and Knowledge	4	1.33%
Journal of Organizational and End User Computing	4	1.33%
Lecture Notes in Information Systems and Organisation	4	1.33%
Problems and Perspectives in Management	4	1.33%
Technology in Society	4	1.33%
Economy of Regions	3	1.00%
Engineering Construction and Architectural Management	3	1.00%
Humanities and Social Sciences Communications	3	1.00%

Most Active Institutions

Based on the data presented in Table 7, the analysis of institutional productivity in the field of critical success factors and digital transformation reveals several key contributors. The Kaunas University of Technology stands out as the most active institution, contributing 5 publications, which account for 1.67% of the total documents. This university has shown a consistent commitment to research in digital transformation, particularly within the European context, emphasizing strategic management and innovation frameworks (Kaunas University of Technology, 2023).

Following closely behind, several institutions have each contributed 4 publications, representing 1.33% of the total output respectively. These include LUT University in Finland, Universidade Federal de Santa Catarina in Brazil, and Voronezh State Technical University in Russia. LUT University is widely recognized for its research in technology-based business innovations and sustainability-oriented digital transformation strategies (LUT University, 2023). Meanwhile, Universidade Federal de Santa Catarina's contributions likely focus on industrial and process-oriented digital transformation in emerging markets, reflecting the institution's emphasis on engineering and technological development in Latin America (Universidade Federal de Santa Catarina, 2023). Voronezh State Technical University's participation demonstrates the growing interest in digital transformation within Eastern European institutions, particularly in engineering education and digital industrialization.

Moreover, there are 12 institutions that each contributed 3 publications (1.00% each), highlighting a diversified global interest in the topic. These include Tomas Bata University in Zlin, Norges Teknisk-Naturvitenskapelige Universitet (Norwegian University of Science and Technology), University of York, Harbin Institute of Technology, Fachhochschule Dortmund, HSE University, Universität Potsdam, Zhejiang University of Technology, Iscte – Instituto Universitário de Lisboa, Pontifícia Universidade Católica do Rio de Janeiro, and National

University of Science & Technology MISIS. These institutions span various regions including Western and Eastern Europe, China, Brazil, and Russia, indicating that digital transformation research is not confined to a single geographic or economic region. Their research likely spans topics such as Industry 4.0, smart manufacturing, IT governance, and organizational change management (Tomas Bata University in Zlin, 2023; HSE University, 2023).

Overall, the data underscores a collaborative and international academic interest in understanding and implementing critical success factors for digital transformation across various sectors and contexts. The contributions from both developed and developing countries also reflect the global relevance and urgency of this research area.

Table 7
Most active institutions

Institution	**TP**	**%**
Kaunas University of Technology	5	1.67%
LUT University	4	1.33%
Universidade Federal de Santa Catarina	4	1.33%
Voronezh State Technical University	4	1.33%
Tomas Bata University in Zlin	3	1.00%
Norges Teknisk-Naturvitenskapelige Universitet	3	1.00%
University of York	3	1.00%
Harbin Institute of Technology	3	1.00%
Fachhochschule Dortmund	3	1.00%
HSE University	3	1.00%
Universität Potsdam	3	1.00%
Zhejiang University of Technology	3	1.00%
Iscte – Instituto Universitário de Lisboa	3	1.00%
Pontifícia Universidade Católica do Rio de Janeiro	3	1.00%
National University of Science & Technology MISIS	3	1.00%

Most Active Countries

Based on Table 8, which outlines the most active countries contributing to the literature on digital transformation and critical success factors, it is evident that global interest in this research area is substantial and widespread. China leads the list with 33 total publications (11%), indicating its strong academic focus and government-driven initiatives towards digitalization, especially in smart manufacturing and digital governance (Zhao et al., 2021). The country's massive investment in AI, big data, and Industry 4.0 has contributed to a robust stream of scholarly output.

Germany follows with 24 publications (8%), reflecting its leadership in industrial automation and digital engineering, particularly through initiatives like "Industrie 4.0." German

institutions have emphasized the transformation of traditional manufacturing into smart factories, aligning with both academic and industrial needs (Kagermann, 2015). The United States ranks third with 23 publications (7.67%), consistent with its dominance in technological innovation, software development, and digital entrepreneurship. American universities and tech firms often collaborate on digital transformation research with a focus on business model innovation and organizational change (Westerman et al., 2014).

The United Kingdom contributes 21 publications (7%), underlining its strategic push for digital innovation in both the public and private sectors. UK-based research often addresses digital government services and the adoption of digital technologies in SMEs and healthcare systems (Waller & Weerakkody, 2016). Italy and the Russian Federation each produced 17 publications (5.67%), showing their growing interest in digital technologies, with Italy focusing on digital transformation in manufacturing and logistics, and Russia emphasizing digital infrastructure in regional development (Gianluca & Monia, 2020; Sidorov et al., 2020).

India and Indonesia, each with 15 publications (5%), highlight the increasing research activity from emerging economies. In India, studies often explore digital transformation in government services and higher education, whereas Indonesia focuses on SME digitalization and policy-driven technology adoption (Dwivedi et al., 2020; Nugroho et al., 2022). Spain (4.67%), Australia (4%), and Poland (4%) follow closely, contributing to the dialogue particularly in areas of digital innovation ecosystems, public sector transformation, and sustainable technologies.

Brazil (3.33%), Romania (3%), and Taiwan (3%) also show growing involvement, particularly in localized applications of digital tools, education systems, and industrial digitization. Portugal, Canada, and Malaysia each contributed 7 publications (2.33%), showing moderate but consistent participation in the field. Notably, Malaysia's contributions reflect its national digital economy blueprint (MyDIGITAL), which fosters research in e-government and digital business transformation (Ahmad et al., 2021).

The Czech Republic, France, and Norway each have 6 publications (2%), further indicating the diverse and international nature of research into digital transformation. These countries contribute niche research, often focusing on policy integration, user experience, and sectoral analysis of digital technology adoption.
In summary, the active involvement of both developed and developing nations indicates a global recognition of the importance of digital transformation and its critical success factors across various sectors.

Table 8
Most active countries

Country	TP	%
China	33	11.00%
Germany	24	8.00%
United States	23	7.67%
United Kingdom	21	7.00%
Italy	17	5.67%
Russian Federation	17	5.67%
India	15	5.00%
Indonesia	15	5.00%
Spain	14	4.67%
Australia	12	4.00%
Poland	12	4.00%
Brazil	10	3.33%
Romania	9	3.00%
Taiwan	9	3.00%
Portugal	8	2.67%
Canada	7	2.33%
Malaysia	7	2.33%
Czech Republic	6	2.00%
France	6	2.00%
Norway	6	2.00%

Source Type

Based on the data presented in Table 9, the analysis of the source types indicates that journals dominate the scholarly communication on the topic of critical success factors and digital transformation, accounting for 246 documents, or 82% of the total publications. This predominance reflects the academic community's strong preference for publishing in peer-reviewed journals, which are widely recognized for their rigorous editorial standards and contribution to the dissemination of validated knowledge (Azmi et al., 2024). Journals often serve as the primary outlet for detailed research findings, theoretical developments, and empirical studies, thus playing a vital role in the advancement of knowledge within a field (Bryman, 2016).

In contrast, conference proceedings represent 54 documents or 18% of the total publications. Although smaller in proportion, conference proceedings remain an important component of academic output, especially in rapidly evolving fields such as digital transformation. Conferences provide a platform for researchers to present preliminary results, explore emerging ideas, and engage in scholarly discussions with peers. These proceedings often precede formal journal publications and help stimulate academic dialogue and collaboration (Rowley & Slack, 2004).

The disparity between journal articles and conference proceedings in this dataset suggests that most authors prefer to publish their mature and comprehensive research findings in journals rather than in conferences. This trend also implies a level of research maturity in the

field of digital transformation and critical success factors, where scholars seek to contribute long-term, citable knowledge rather than just present early-stage findings.

Table 9
Source type

Source Type	**TP**	**%**
Journal	246	82.00%
Conference Proceeding	54	18.00%
Total	300	100%

Languages
Based on the data in Table 10, it is evident that English is the dominant language in publications related to critical success factors and digital transformation, with 289 out of 304 documents, accounting for 95.07% of the total output. This overwhelming predominance underscores the role of English as the universal language of science and academia. As noted by Tardy (2004), English has become the primary medium for scholarly communication across disciplines, enabling broader dissemination and accessibility of research findings at the international level. The widespread use of English allows for easier collaboration among researchers from different countries and contributes to the global visibility of academic work (Ammon, 2010).

The remaining 4.93% of documents are published in a variety of other languages, including Spanish (1.64%), Russian (1.32%), German and Portuguese (each 0.66%), and French and Serbian (each 0.33%). While these languages represent a small proportion, their presence indicates regional scholarly activity and localized interest in digital transformation and critical success factors. For instance, Spanish and Russian publications may reflect research focused on specific national contexts, industries, or digital policies that are more relevant to those language communities. However, due to the limited reach of non-English publications in global academic indexing and citation databases, such works may receive less international recognition (Lillis & Curry, 2010).

The dominance of English-language publications also highlights a potential linguistic barrier for non-native English-speaking researchers, who may face challenges in publishing in high-impact journals or participating in global scholarly discourse (Flowerdew, 2015). Despite this, the prevalence of English continues to grow in academic publishing due to the international nature of research dissemination, particularly in areas like digital transformation, which are closely tied to global technology trends.

Table 10
Languages

Language	**TP**	**%**
English	289	95.07%
Spanish	5	1.64%
Russian	4	1.32%
German	2	0.66%
Portuguese	2	0.66%
French	1	0.33%
Serbian	1	0.33%

Highly Cited Papers

Based on the data in Table 11, the analysis of highly cited papers reveals the foundational and influential research contributions shaping the discourse on digital transformation and its critical success factors. The most cited publication is by Zhu et al. (2006), titled "Innovation diffusion in global contexts: Determinants of post-adoption digital transformation of European companies", with 572 citations. This study, published in the European Journal of Information Systems, is a seminal work that explores how firms adopt and sustain digital transformation in different institutional and market environments, highlighting the importance of contextual determinants (Zhu et al., 2006).

Another highly impactful study is Liu et al. (2011) with 352 citations, focusing on resource alignment during digital transformation, using a case study of CBC Bank's e-banking project. This work is significant for illustrating how internal capabilities and external pressures interact to affect transformation outcomes (Liu et al., 2011). Similarly, Cichosz et al. (2020), with 349 citations, investigated digital transformation in logistics service providers, identifying both success factors and barriers making it particularly relevant to operational and supply chain contexts (Cichosz et al., 2020).

The recurring presence of Ghobakhloo and Iranmanesh in the top-cited papers reflects their sustained scholarly contribution. For instance, their 2021 paper in the Journal of Cleaner Production has been cited 244 times, offering a bibliometric and systematic review of Industry 4.0, including its sustainability drivers. Another 2021 article by the same authors provides strategic guidelines for manufacturing SMEs navigating digital transformation and has garnered 228 citations, underscoring the practical implications of their work (Ghobakhloo et al., 2021a; 2021b).

Other notable studies include those addressing sector-specific transformations, such as in maritime transport (Tijan et al., 2021), banking (Filotto et al., 2021), and museums (Raimo et al., 2022), demonstrating the diverse application of digital transformation concepts across

industries. Furthermore, recent papers such as Wang et al. (2024) and Lai et al. (2023) highlight a growing interest in sustainability, education, and innovation in the digital era, reflecting the evolving thematic focus of current research.

These highly cited works not only provide empirical insights but also guide policy, managerial strategies, and future academic inquiries into digital transformation's multidimensional impacts.

Table 11
Highly cited papers

Authors	Year	Title	Source	Cites
K. Zhu, S. Dong, S.X. Xu, K.L. Kraemer	2006	Innovation diffusion in global contexts: Determinants of post-adoption digital transformation of European companies	European Journal of Information Systems	572
D.-Y. Liu, S.-W. Chen, T.-C. Chou	2011	Resource fit in digital transformation: Lessons learned from the CBC Bank global e-banking project	Management Decision	352
M. Cichosz, C.M. Wallenburg, A.M. Knemeyer	2020	Digital transformation at logistics service providers: barriers, success factors and leading practices	International Journal of Logistics Management	349
M. Ghobakhloo, M. Fathi, M. Iranmanesh, P. Maroufkhani, M.E. Morales	2021	Industry 4.0 ten years on: A bibliometric and systematic review of concepts, sustainability value drivers, and success determinants	Journal of Cleaner Production	244
M. Ghobakhloo, M. Iranmanesh	2021	Digital transformation success under Industry 4.0: a strategic guideline for manufacturing SMEs	Journal of Manufacturing Technology Management	228
E. Tijan, M. JoviÄ‡, S. AksentijeviÄ‡, A. Pucihar	2021	Digital transformation in the maritime transport sector	Technological Forecasting and Social Change	179
M. Ghobakhloo, M. Iranmanesh, M. Vilkas, A. Grybauskas, A. Amran	2022	Drivers and barriers of Industry 4.0 technology adoption among manufacturing SMEs: a systematic review and transformation roadmap	Journal of Manufacturing Technology Management	160
S. Chatterjee, R. Chaudhuri, D. Vrontis, G. Basile	2022	Digital transformation and entrepreneurship process in SMEs of India: a moderating role of adoption of AI-CRM capability and strategic planning	Journal of Strategy and Management	157
M. Nasiri, M. Saunila, J. Ukko	2022	Digital orientation, digital maturity, and digital intensity: determinants of financial	International Journal of Operations and Production Management	113

		success in digital transformation settings		
Ã. NicolÃ¡s-AgustÃ-n, D. JimÃ©nez-JimÃ©nez, F. Maeso-Fernandez	2022	The role of human resource practices in the implementation of digital transformation	International Journal of Manpower	111
K.-H. Lai, Y. Feng, Q. Zhu	2023	Digital transformation for green supply chain innovation in manufacturing operations	Transportation Research Part E: Logistics and Transportation Review	83
J. Gao, W. Zhang, T. Guan, Q. Feng, A. Mardani	2023	The effect of manufacturing agent heterogeneity on enterprise innovation performance and competitive advantage in the era of digital transformation	Journal of Business Research	81
C. Wang, X. Chen, T. Yu, Y. Liu, Y. Jing	2024	Education reform and change driven by digital technology: a bibliometric study from a global perspective	Humanities and Social Sciences Communications	77
L. MiÄ‡iÄ‡	2017	Digital Transformation and Its Influence on GDP	ECONOMICS - Innovative and Economics Research Journal	70
A. Florek-Paszkowska, A. Ujwary-Gil, B. Godlewska-DzioboÅ„	2021	Business innovation and critical success factors in the era of digital transformation and turbulent times	Journal of Entrepreneurship, Management and Innovation	63
N. Raimo, I. De Turi, A. Ricciardelli, F. Vitolla	2022	Digitalization in the cultural industry: evidence from Italian museums	International Journal of Entrepreneurial Behaviour and Research	62
F. Nwaiwu, M. Duduci, F. Chromjakova, C.-A.F. Otekhile	2020	Industry 4.0 concepts within the czech sme manufacturing sector: An empirical assessment of critical success factors	Business: Theory and Practice	62
U. Filotto, M. Caratelli, F. Fornezza	2021	Shaping the digital transformation of the retail banking industry. Empirical evidence from Italy	European Management Journal	61
N.C. Jackson, L.M. Dunn-Jensen	2021	Leadership succession planning for today's digital transformation economy: Key factors to build for competency and innovation	Business Horizons	59
R. Thekkoote	2022	Enabler toward successful implementation of Quality 4.0 inÂ digital transformation era: aÂ comprehensive review andÂ futureÂ research agenda	International Journal of Quality and Reliability Management	54

Co-authorship Analysis

Figure 3 illustrates a co-authorship network generated using VOSviewer, which maps the collaborative relationships among researchers in the field of digital transformation. Each node (or circle) represents an author, while the links between them signify co-authorship relationships based on shared publications. The density and number of connections reflect the level of collaboration among scholars.

In this visualization, we observe a highly interconnected structure, indicating a strong collaborative ecosystem. Authors such as Kalinowski, M., Teixeira, A. F., Barbosa, S., and Chueke, J. appear centrally located, suggesting that they act as bridges or central figures in the research community. These central positions typically correlate with high productivity or influence in network theory (Wasserman & Faust, 1994).

Additionally, several smaller clusters converge around more prolific authors, such as Da Costa, M. S., Pereira, J. A., Fischer, M., and Batista, S. T. These groupings highlight institutional or thematic collaboration patterns—possibly indicating that these authors frequently work together within the same institutions or research projects (Kumar et al., 2022).

The density of the connections, especially among central authors, indicates multi-author collaborations rather than isolated efforts. Such collaboration fosters knowledge integration, enhances research quality, and boosts citation impact (Glänzel & Schubert, 2005). The presence of authors like Villamizar, H., Kuramoto, A., and Teixeira, B. in the denser areas further supports the notion of international and interdisciplinary cooperation, which is crucial for advancing digital transformation research in diverse sectors.

In summary, the co-authorship network reveals a mature and collaborative research community, where knowledge exchange and joint efforts are prevalent. The structure not only highlights key contributors but also indicates the cohesive nature of scholarly interaction in the domain.

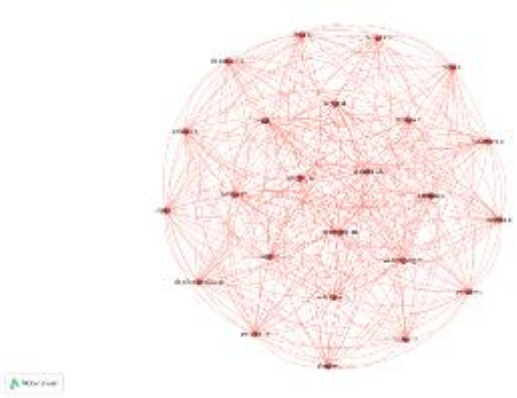

Fig 3. Co-authorship analysis
Source: Generated by the authors using VosViewer

Co-occurence of The Keywords

Figure 4 illustrates the co-occurrence network of keywords related to digital transformation, generated using VOSviewer. In this visualization, each node represents a keyword, with its

size indicating the frequency of occurrence, while the links between nodes reflect the strength of their co-occurrence relationships within the same publications. The different colors represent thematic clusters that group related concepts. At the core of the network, “digital transformation” appears as the largest and most connected keyword, highlighting its centrality and dominance in the research field (Zupic & Čater, 2015). Closely linked to it are high-frequency keywords such as “industry 4.0,” “decision making,” “success factors,” and “information management,” showing that the literature often discusses digital transformation in the context of technological innovation, organizational change, and performance improvement (Loonam et al., 2018). Several thematic clusters emerge from the map: the red cluster focuses on “digitization,” “innovation,” “business models,” and “electronic commerce,” representing the integration of digital technologies into business strategies; the green cluster includes “supply chain management,” “efficiency,” and “job performance,” reflecting operational and performance-oriented studies; the blue cluster covers “digital literacy,” “digital divide,” and “conceptual frameworks,” pointing to the social and educational dimensions of digital transformation; the orange cluster emphasizes technological infrastructure with terms like “cloud computing,” “internet of things,” and “digital platforms”; while the purple cluster highlights emerging technologies such as “artificial intelligence,” “disruptive technologies,” and “digital strategy.” The proximity of terms like “success factors,” “case studies,” and “key determinants” to the central themes suggests a strong methodological focus on identifying drivers of successful digital transformation initiatives (Susanti et al., 2023). Peripheral terms such as “digital public services” and “job satisfaction” indicate niche but potentially growing research areas. Overall, the co-occurrence analysis reveals that digital transformation research is multidimensional, covering technological, organizational, and societal aspects with strong interconnections between these core themes.

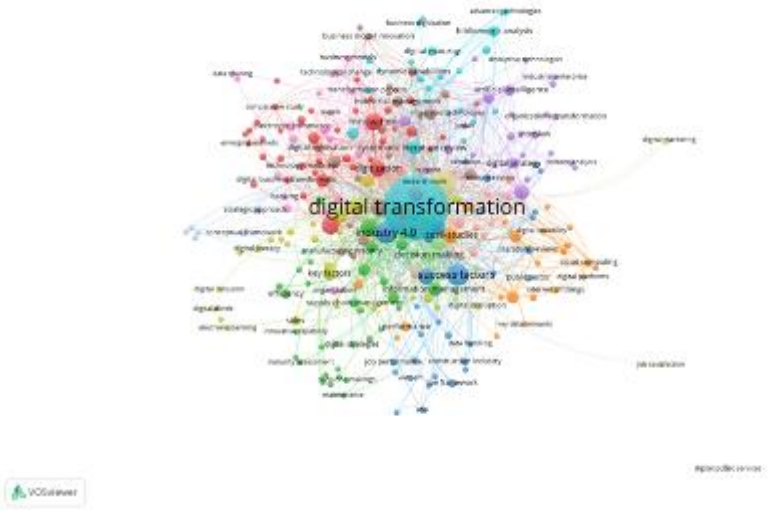

Fig 4. Co-occurence of the keywords
Source: Generated by the authors using VosViewer

Co-citation by Cited Authors

Figure 5 presents the co-citation network of cited authors in the domain of digital transformation, as visualized using VOSviewer. In this map, each node represents an author, with the node size reflecting the number of times the author has been cited, while the links

indicate the strength of co-citation relationships between authors. Different colors correspond to distinct clusters, which represent thematic or intellectual communities within the literature (Small, 1973).

The visualization reveals three dominant clusters. The green cluster includes highly influential scholars such as Benlian, A., Hess, T., Kane, G. C., and Weill, P., whose works predominantly focus on digital transformation frameworks, IT strategy, and organizational change (Kane et al., 2015; Hess et al., 2016). This cluster reflects the strategic management and organizational capabilities perspective on digital transformation. The red cluster contains authors like Wang, Y., Liu, Y., Gunasekaran, A., and Zhang, Z., who have contributed extensively to research on supply chain management, digital technologies adoption, and operational performance (Gunasekaran et al., 2017; Wang et al., 2016). This cluster represents the operational and performance-driven view of digital transformation, often intersecting with Industry 4.0 research. The blue cluster features authors such as Sarstedt, M., Venkatesh, V., Dubey, R., and Wamba, S. F., who are recognized for their work on technology acceptance models, structural equation modeling, and business analytics in the context of digitalization (Venkatesh et al., 2003; Wamba et al., 2017). This cluster focuses heavily on methodological approaches and digital innovation adoption.

The network also shows strong inter-cluster linkages, indicating that digital transformation research is interdisciplinary, with authors from different domains frequently co-cited in the same studies. Peripheral authors, such as Ferreira, F. and Nambisan, S., while not as frequently cited, contribute specialized insights—such as digital entrepreneurship and innovation ecosystems—that enrich the broader research field (Nambisan et al., 2017). The co-citation patterns suggest that the intellectual structure of digital transformation research is built on the interplay between strategic, operational, and technological perspectives, supported by robust methodological foundations.

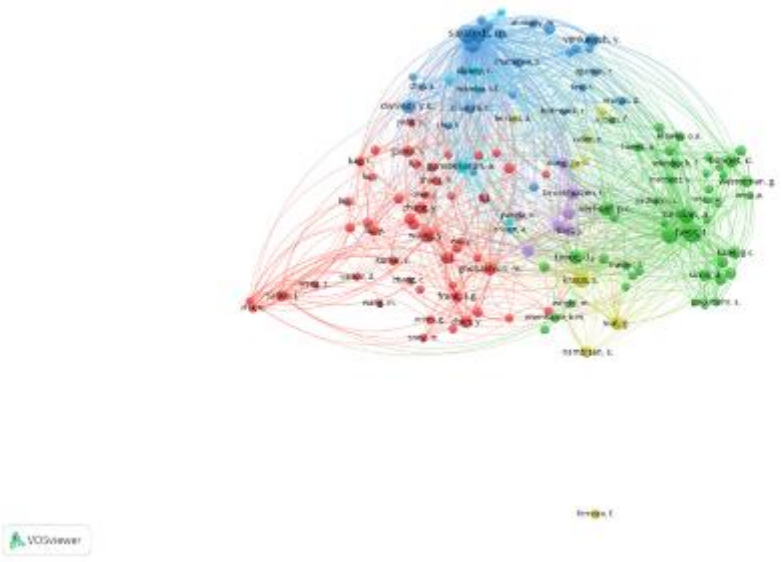

Fig 5. Citations by cited authors
Source: Generated by the authors using VosViewer

Network Visualization of terms of Title and Abstract

Figure 6 presents the network visualization of terms extracted from the titles and abstracts of the analyzed documents using a binary counting method, where each term is counted once per document regardless of its frequency (van Eck & Waltman, 2014). This visualization, generated through VOSviewer, maps the co-occurrence relationships among terms, grouping them into thematic clusters represented by distinct colors. The node size indicates the frequency of occurrence of the term across the dataset, while the thickness of the connecting lines represents the strength of their co-occurrence links.

The red cluster primarily focuses on themes related to digital transformation processes, change management, and success factors. Key terms in this cluster, such as “change,” “success factor,” “digital economy,” “leadership,” and “competitiveness,” suggest a strong emphasis on organizational transformation drivers, leadership roles, and performance outcomes. This reflects the scholarly interest in understanding the enabling conditions and challenges for effective digital transformation implementation (Matt et al., 2015; Susanti et al., 2023).

The green cluster contains terms such as “design methodology approach,” “determinant,” “effect,” “practitioner,” “firm,” and “SMEs,” indicating a methodological and empirical focus. This cluster highlights research that applies structured methods such as surveys, case studies, and statistical modeling to examine factors influencing digital adoption and its effects on organizational performance, particularly in small and medium-sized enterprises (SMEs) (Hess et al., 2016; Kraus et al., 2021). It also includes terms like “manager” and “employee,” emphasizing the human capital and managerial perspectives in digital transformation research.

The blue cluster contains terms like “critical success factor,” “systematic literature review,” “sustainability,” and “future research,” which point to meta-analyses and review-based studies. This cluster reflects a synthesis-oriented stream of research aiming to consolidate existing findings, identify research gaps, and suggest future directions for the field (Agarwal et al., 2022).

Overall, the visualization reveals a highly interconnected network where the boundaries between thematic areas are blurred, indicating the multidisciplinary nature of digital transformation studies. The proximity and dense linkages among terms show that concepts like success factors, methodology, organizational change, and sustainability are often discussed together, reinforcing the idea that digital transformation is both a technological and socio-organizational phenomenon requiring holistic research approaches (Vial, 2019).

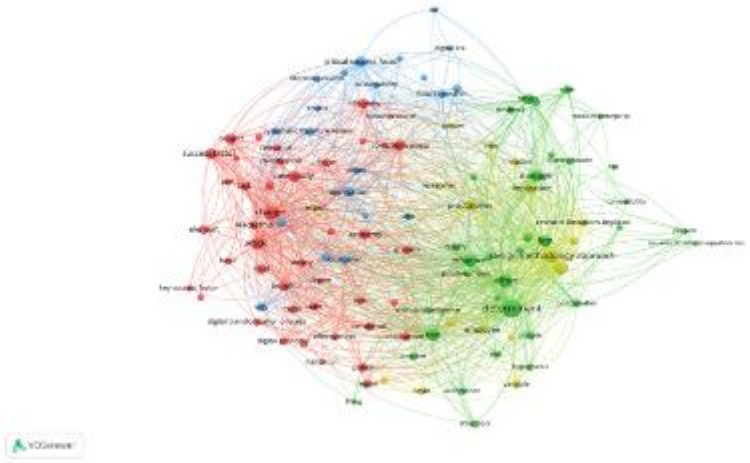

Fig 6. Network visualisation of terms of title and abstract (binary counting)
Source: Generated by the authors using VosViewer

Discussion

The present bibliometric analysis provides a longitudinal and structural understanding of the CSFs associated with DT research over the past twenty-five years. With respect to the first research question, the findings reveal that the most frequently discussed CSFs can be classified into two overarching categories: technology-centric and organization-centric factors. In the early stages of the DT discourse, literature predominantly emphasized technological readiness, IT infrastructure, and system integration (Leyh et al., 2022; Reinkemeyer, 2024). This technology-first paradigm reflected the prevailing business imperatives of the late 1990s and early 2000s, when digital initiatives were primarily focused on enterprise system deployment and digitization of operational processes. In contrast, more recent scholarship demonstrates a shift towards holistic frameworks incorporating strategic leadership, change management, innovation culture, and customer orientation (Senarathna & Wickramarachchi, 2024; Pasqual et al., 2023), signifying a maturation of the field wherein organizational adaptability and cultural alignment are recognized as indispensable to successful DT outcomes (Carujo et al., 2022; Alsaeedi et al., 2023).

In addressing the second research question, the temporal analysis reveals an evolution in thematic and conceptual focus. Between 2000 and 2010, the literature was dominated by topics such as ERP implementation, IT capability, and e-business adoption. The subsequent decade, however, witnessed an expansion in thematic scope to include agile project management, interdepartmental collaboration, and stakeholder engagement, underscoring the necessity of aligning technological advancements with human and organizational capabilities (Alojail et al., 2023; Barbieri et al., 2024). This thematic transition reflects the increasing complexity of DT processes, wherein technology serves as an enabler rather than the sole determinant of transformation success.

In response to the third research question, the co-authorship and collaboration network analysis identifies a globally distributed but regionally clustered research community. While Europe, North America, and Asia dominate publication output, the past decade has seen increased cross-regional collaborations, particularly between European and Asian

institutions. These partnerships not only enhance the diversity of research perspectives but also foster the development of more universally applicable DT-CSF frameworks (Daxbacher et al., 2024). The centrality of certain universities and research centers in these networks reflects their sustained leadership in advancing the intellectual and methodological foundations of the field.

Regarding the fourth research question, keyword co-occurrence and term mapping analyses revealed five dominant thematic clusters: digital innovation, organizational change, leadership, data analytics, and agility. In addition, emerging clusters particularly those involving sustainability, artificial intelligence, and ecosystem collaboration indicate a forward-looking research trajectory that integrates DT with broader global imperatives, including environmental responsibility and ethical technology adoption (Alsaeedi et al., 2023). This thematic diversification suggests that DT research is becoming increasingly interdisciplinary, drawing on fields such as sustainability science, organizational psychology, and data ethics.
Finally, in relation to the fifth research question, several trends and gaps were identified. Notable trends include the incorporation of human-centric and strategic management perspectives into DT-CSF frameworks, the proliferation of interdisciplinary methodologies, and the growing use of advanced bibliometric and scientometric techniques to map research landscapes. However, the literature remains fragmented with respect to longitudinal empirical studies, sector-specific analyses in emerging industries, and examinations of DT in developing economies where infrastructural and socio-cultural contexts differ markedly from those in developed nations (Pasqual et al., 2023). Furthermore, while constructs such as leadership and culture are frequently highlighted, there is limited empirical work operationalizing these factors into measurable constructs that can be systematically linked to DT performance outcomes.

The observed thematic and structural shifts in DT-CSF research can be attributed to multiple factors. Initially, the technology-centric orientation was a natural response to the rapid commercialization of enterprise systems and the imperative for operational digitization. As organizations increasingly encountered challenges in sustaining digital initiatives, scholarly focus expanded to encompass the socio-organizational dimensions of transformation, thereby acknowledging the interdependence of technological capability and organizational readiness (Carujo et al., 2022). More recently, the inclusion of sustainability, AI, and ecosystem collaboration within CSF discourse reflects a field attuned to megatrends shaping the global economy and digital governance.

Collectively, these findings reveal that the evolution of CSFs in DT is emblematic of the broader transformation of the digital economy itself from a phase characterized by discrete technology adoption to one defined by continuous, strategic, and ecosystem-oriented transformation.

Implications for Practice
The insights generated from this bibliometric analysis offer substantial value for industry practitioners, policymakers, and other stakeholders engaged in digital transformation (DT) initiatives. For industry, understanding the temporal evolution of Critical Success Factors (CSFs) provides a strategic roadmap for prioritizing investments and organizational changes. Early technology-centric approaches, while still relevant, must now be complemented by

leadership development, cultural alignment, and agile management practices to ensure transformation sustainability. By recognizing emerging themes such as sustainability integration, AI adoption, and ecosystem collaboration, organizations can proactively adapt their DT strategies to align with global market trends and societal expectations. Policymakers can leverage these findings to design supportive regulatory frameworks, capacity-building programs, and funding schemes that encourage cross-sector collaboration, knowledge exchange, and equitable access to digital infrastructure, particularly in underserved regions. Furthermore, the identification of research gaps, such as the limited longitudinal and context-specific studies, underscores the need for industry-academia partnerships to generate actionable, evidence-based insights tailored to sectoral and regional realities. Ultimately, by bridging scholarly knowledge with applied contexts, this study provides a blueprint for informed decision-making that enhances both the effectiveness and inclusivity of digital transformation efforts worldwide.

Recommendations for Future Research

The findings of this bibliometric analysis suggest several avenues for future research that can meaningfully extend the understanding and application of CSFs in DT. The observed thematic progression from technology-centric determinants toward strategic, cultural, and ecosystem-oriented factors underscores the need for longitudinal, mixed-method research designs capable of capturing both quantitative performance indicators and qualitative organizational narratives over extended periods. Such approaches would enable a more nuanced understanding of how CSFs interact and evolve within dynamic organizational contexts.

Emerging themes identified in the analysis such as the integration of artificial intelligence, the alignment of DT with sustainability agendas, and the development of cross-sector collaborative ecosystems warrant further empirical investigation through comparative case studies across industries and geographical regions, thereby revealing context-specific challenges, enablers, and scalability considerations. Additionally, the underrepresentation of small-to-medium enterprises (SMEs), public sector institutions, and organizations in developing economies highlights an important research gap; participatory action research in these contexts could facilitate the co-creation of transformation frameworks that are locally relevant yet globally adaptable.

Furthermore, the limited scholarly focus on failure factors alongside CSFs suggests an opportunity for systematic reviews and meta-analyses that integrate success and failure narratives, thereby generating more resilient and balanced models for DT implementation. Finally, the application of advanced bibliometric and science mapping techniques, in conjunction with social network analysis, could further elucidate evolving intellectual structures, collaboration patterns, and interdisciplinary linkages within the DT-CSF research domain. Collectively, these directions offer the potential to address current gaps, respond to emerging trends, and generate actionable insights that align with the rapidly evolving realities of digital transformation.

Conclusion

This bibliometric analysis has provided a comprehensive, data-driven examination of the evolution of CSFs in DT research over the past 25 years. The findings reveal a clear thematic shift from early emphases on technology infrastructure, IT capabilities, and process

automation toward more holistic perspectives encompassing strategic leadership, organizational culture, stakeholder collaboration, and agile innovation practices. Through performance and science mapping techniques, the study identified not only the most influential authors, institutions, and countries shaping the DT-CSF discourse, but also patterns of collaboration that demonstrate a growing interdisciplinary convergence across management, information systems, and sector-specific domains. Keyword co-occurrence and term mapping further illuminated dominant thematic clusters and emerging research frontiers, including artificial intelligence integration, sustainability-driven transformation, and cross-sector digital ecosystems.

Despite these contributions, the study acknowledges certain limitations. First, the analysis was constrained by its reliance on indexed publications within selected bibliographic databases, potentially omitting relevant grey literature, industry reports, and non-English contributions. Second, the bibliometric approach, while powerful in mapping intellectual structures and trends, does not directly assess the causal relationships or practical effectiveness of identified CSFs in organizational contexts. Third, the scope of temporal analysis, although spanning 25 years, may still overlook shorter-term, rapid shifts in focus areas driven by disruptive technological events or global crises such as the COVID-19 pandemic.

Building on these findings, future research should adopt longitudinal, mixed-method approaches to explore the interplay between CSFs over time and across diverse organizational settings. Greater attention should be paid to underrepresented contexts, including small-to-medium enterprises, public sector organizations, and institutions in developing economies. Comparative cross-industry and cross-national case studies could yield richer insights into contextual variability, while meta-analyses that integrate both success and failure factors could lead to more resilient DT implementation frameworks. Furthermore, employing advanced bibliometric and social network analytics alongside qualitative inquiry could deepen the understanding of evolving intellectual structures and collaboration networks in the field.
The enduring impact of this study lies in its ability to synthesize a fragmented body of literature into a coherent, longitudinal narrative, offering both scholars and practitioners a clearer map of where DT-CSF research has been, where it currently stands, and where it is heading. By highlighting prevailing themes, revealing emerging research trajectories, and identifying gaps, the study provides a robust foundation for informed decision-making in both academic inquiry and practical implementation of digital transformation initiatives. In doing so, it reinforces the critical role of CSFs as both guiding principles and adaptive levers for navigating the complexities of the digital age.

Ai Declaration

During the preparation of this work the author(s) used ChatGPT in order to brainstorm the idea and to assist in explaining the text clearly. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

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