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Digital Transformation in the Start-up World: Bibliometrics on Research Trends

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Abstract. Digital transformation has become a major factor in accelerating growth and innovation in startups. This study aims to provide an overview of the evolution of digital transformation studies in startups globally, as well as propose future research directions to strengthen studies related to digital transformation in resilient startups. The method used was a systematic literature review with a bibliometric analysis and content analysis approach. The research protocol involved 29 articles collected from the Scopus database through a search using Publish or Perish, with the help of Excel and Mendeley for quantitative analysis of the sample and bibliographic management. Bibliometric analysis was conducted using Biblioshiny R Studio and VOSviewer software. Research on digital transformation (DT) in Start-up increased significantly from 2017 to 2024, with the highest number of publications reached in 2023. Through bibliometric analysis and science mapping, four main focuses of research were found, namely innovation, digital business models, digital technology, and digital transformation. In addition, the research also identified five key future trends in DT studies on startups, namely digital business innovation, sustainability, technology adoption, social innovation, and digital entrepreneurship.

Keywords: Biblioshiny; Digital Entrepreneurial Ecosystem; Digital Transformation; Start-up; VOSviewer

1. INTRODUCTION

Digital transformation has had a major impact on various industries, including the start-up sector. Technological advancements such as artificial intelligence, big data, and the Internet of Things (IoT) are forcing start-ups to adapt to remain competitive (Brynjolfsson & Hitt, 2000). These rapid developments have changed the global business landscape, where companies no longer have a choice but to adapt to the era of digital disruption in order to survive.

Digital transformation is now an urgent need for companies, including start-ups, to thrive. This process involves implementing technologies that can increase operational efficiency, improve customer experience, and create innovative new business models (Westerman et al., 2014). Digital technologies open up new opportunities for start-ups to innovate and compete with larger companies, through better efficiency and business model flexibility (Felicetti et al., 2024). However, this journey also presents challenges such as limited resources and market uncertainty.

Previous research shows the importance of digital transformation as a driver of business innovation and growth (Aaldering & Song, 2021; Baber et al., 2019; Basly & Hammouda, 2020). However, there are still gaps in the understanding of how start-ups can effectively leverage these technologies to improve competitiveness, especially in the face of rapidly changing consumer needs and evolving technologies (Brunetti et al., 2020; Jafari-Sadeghi et

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al., 2021; Karimi & Walter, 2021). Although digital transformation offers the potential to increase efficiency and scalability, many start-ups still face barriers in the application of these technologies, such as limited resources, immature technological infrastructure, and difficulty integrating digital strategies into daily operations (Heubeck, 2023; Hansen, 2019; Gupta & Bose, 2022).

While the adoption of digital technologies can provide many benefits, this process also demands significant changes in organizational culture and strategy (Li et al., 2020; Lichtenthaler, 2020). Therefore, this study aims to analyze the trend of digital transformation among start-ups through a bibliometric analysis approach, and further explore the role of digital transformation in supporting start-up success. It will also identify key factors that influence the implementation and outcomes of such transformation (Felicetti et al., 2024; Ruggieri et al., 2018; Steiber & Alänge, 2020).

To achieve this goal, this study will address the following research questions:

RQ1. What are the global trends of digital transformation in the start-up sector based on existing scientific literature?

RQ2. What are the key factors that influence the success of building digital transformation in resilient start-ups?

RQ3. What is the future research framework for digital transformation in start-ups?

This research is expected to provide important insights for start-ups in overcoming the challenges of digital transformation and maximizing the potential that digital technology offers. Therefore, bibliometric analysis is important for answering research questions as it provides deep insights into research developments and trends in a field (Zhai *et al*., 2023). Bibliometric analysis has proven to be a powerful tool for examining research trends in various fields, enabling an objective understanding of knowledge flows and collaboration patterns in different disciplinary areas (Marino-Romero *et al*., 2024; Moral-Muñoz et al., 2020).

As such, it is effective in understanding knowledge flows and collaboration patterns across different disciplines. It is important to choose the right bibliometric tool, as each database has strengths and limitations (Archambault et al., 2009). With the increasing use of bibliometric analysis, this approach is proving important in determining the direction of future research.

2. LITERATURE REVIEW

Digital Transformation

Digital transformation has been widely discussed as an important factor in improving organizational competitiveness. Digital transformation enables companies to achieve higher efficiency, expand market reach, and improve customer experience (Westerman et al., 2014). However, some critics of this view point out that digital transformation is not a universal solution for all companies. Organizational readiness and a culture that supports innovation are key to successful digital transformation (Li et al., 2018). Many companies fail in this transformation due to the lack of an integrated strategy between technology and business. Thus, the argument that technology alone can solve organizational problems may not be entirely accurate, given the important role of human and cultural factors.

Furthermore, there is a clear relationship between the use of information technology and improved organizational performance (Brynjolfsson and Hitt, 2000). However, the question remains: are these results universally applicable to all industries and business contexts? In the context of small and medium-sized enterprises (SMEs), digital transformation may face more challenges related to limited resources and access to technology (Chen et al., 2021). This suggests that the application of digital transformation is not always universal, and needs to be considered in the specific context of each organization.

While much of the literature supports the benefits of digital transformation, some studies highlight limitations in the models for measuring its success. For example, (Aydiner et al., 2019) show that business analytics have a major impact on organizational performance, but many organizations fail to link these analytics to specific business process performance. This suggests that while digital transformation offers great potential, there are still gaps in implementation that need attention.

Digital transformation models are often too technology-centric, neglecting the importance of other aspects such as leadership, cultural change, and change management. Digital transformation should be seen as a more holistic strategic change, involving a redefinition of processes, strategies, and organizational structures **(**Besson & Rowe, 2012). They also point out that much of the current literature focuses too much on technology adoption, but pays little attention to measuring the long-term impact of this transformation on the organization.

Start-up

A start-up is a company known for its flexibility and innovation. Start-ups are companies designed to find repeatable and scalable business models (Steve Blank, 2013). This view is

widely accepted, but not all start-ups manage to achieve scalability or find the right business model. The importance of international entrepreneurship in driving start-up growth, especially through the adoption of digital technologies **(**Baier-Fuentes et al., 2019). However, the challenges faced by start-ups are often related to market uncertainty and high risk of failure, which are not always overcome by digital transformation alone.

Government support is crucial in helping start-ups to digitally transform, especially in the context of SMEs (Chen et al., 2021). This begs the question: can all start-ups succeed without such external support? This argument contradicts the view that innovation and technology are the main keys to start-up success, without the need for government intervention. This contradiction suggests that start-up success in digital transformation may be more complex than previously thought, depending on the ecosystem and other external factors.

Some conceptual models used to analyze startup success may not take into account the diversity of different industries and market dynamics. Models applied to tech start-ups may not be relevant for other sectors such as manufacturing or traditional services. In this case, a more holistic approach is needed to understand the specific challenges faced by different types of start-ups in the context of digital transformation.

From the existing literature, it appears that digital transformation has great potential to improve the competitiveness and performance of organizations, including startups. However, implementation challenges and resource limitations are often barriers, especially for SMEs and start-ups operating under high uncertainty. Existing models also focus too much on technology, without taking into account non-technological aspects such as organizational culture and leadership strategy.

A more holistic and contextual approach is needed in understanding digital transformation, especially in the context of start-ups. Critical evaluation shows that successful digital transformation cannot be viewed as a "one-size-fits-all" solution. Instead, success depends on organizational readiness, external support, as well as the ability to integrate technology with existing business processes. This is where further research is needed to fill the gaps in our understanding of how different factors interact in the digital transformation process, especially for start-ups facing rapidly changing market dynamics.

3. METHODS

This study used a mixed methods approach (Venkatesh et al., 2016). In general, the structure of this study followed the three stages proposed by similar studies (Denyer & Tranfield, 2009; Amiri et al., 2023; Theodoraki et al., 2022), we conducted a systematic

literature review that included descriptive analysis, bibliometrics, as well as content analysis to review the literature related to start-up business models. The descriptive and bibliometric approaches applied allowed for an objective and unbiased evaluation of the research topic (Zupic and C'ater, 2015), while the content analysis provided a thorough and integrated systematization of this area of research (Hassan et al., 2023; Wu et al., 2020).

Data Collection

The data collection process in this study was conducted through access to the Scopus database, which is known to have a broader coverage compared to other databases such as Web of Science. Scopus covers more journals from various disciplines and provides more comprehensive publication metrics (Powell & Peterson, 2017; Pranckutė, 2021). The search string used in this study is: "digital transformation" AND "startups" OR "start-up" OR "entrepreneurship" OR "entrepreneur", with searches conducted on the titles, abstracts, and keywords of articles published between 2011 and December 8, 2024. This search approach followed the steps of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework as applied in previous studies (Ramos et al., 2024; Moher et al., 2011), as shown in Figure 1. This approach enabled the identification and in-depth analysis of publications relevant to the topics of digital transformation and start-ups.

The initial step in database processing began by excluding articles in the form of book chapters and conference articles. Next, a filtering process was carried out to eliminate articles that had less than 20 citations. In the eligibility stage, title, abstract, and keywords were read to narrow down the number of articles, so that only relevant articles were retained. In the final stage, a full reading of the selected articles was conducted. As a result, 29 articles were identified for analysis using bibliometric methods with the help of Biblioshiny and VOSviewer.

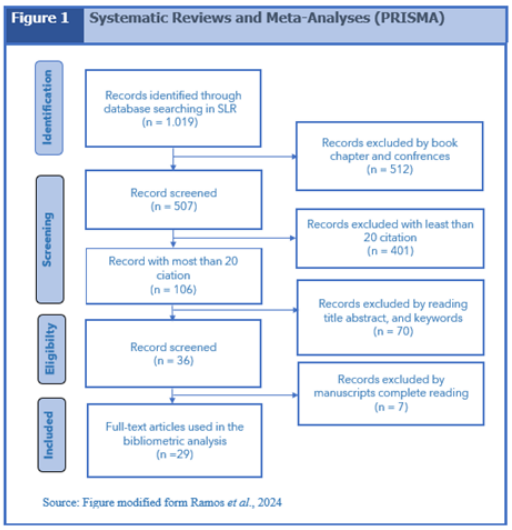

Figure 1. Systematic Reviews and Meta-Analyses (PRISMA).

Data Analysis

At this stage, the tool used was chosen because it provides a wide range of features that support quantitative bibliometric research and is a unique open-source tool for thorough scientific mapping analysis. It supports recommended workflows for bibliometric analysis and has been widely applied across a growing range of disciplines (Aria & Cuccurullo, 2017). In addition, Bibliometrix enables scientific mapping and is freely available (Rodríguez-Soler et al., 2020). In this analysis, we took an in-depth look at 29 selected documents, using a combination of the Biblioshiny program from R Studio and VOSviewer (Cobo et al., 2011). The process began with retrieving the 29 documents from the Scopus database, which were downloaded in BibTex format. The data was then processed through Biblioshiny's Bibliometrix online platform, and the analysis results were visualized in the form of graphs, tables, spreadsheets, and other visual features (Srisusilawati et al., 2021; Pontieri et al., 2022; Biancone et al., 2022).

This bibliometric analysis makes use of the visualization of similarity (VOS) technique (van Eck and Waltman, 2010). Using the VOSviewer software (version 1.6.20) (van Eck and Waltman, 2010), we performed two complementary types of bibliometric analysis: co-occurrence analysis (Callon et al., 1983, 1991) and bibliographic clustering analysis of documents (Kessler, 1963). This co-occurrence analysis identifies the most frequently used words in the articles, revealing the conceptual structure of the analyzed research streams.

4. RESULTS

Descriptive Analysis

This study found 1,019 articles from 2011 to December 8, 2024 that discussed digital transformation (DT) in start-ups, as shown in Figure 2. There was a significant increase in the number of DT-related studies in start-ups from 2017 to 2024, with the peak of publications occurring in 2023. This shows the great interest of researchers in digital transformation, especially in recent years.

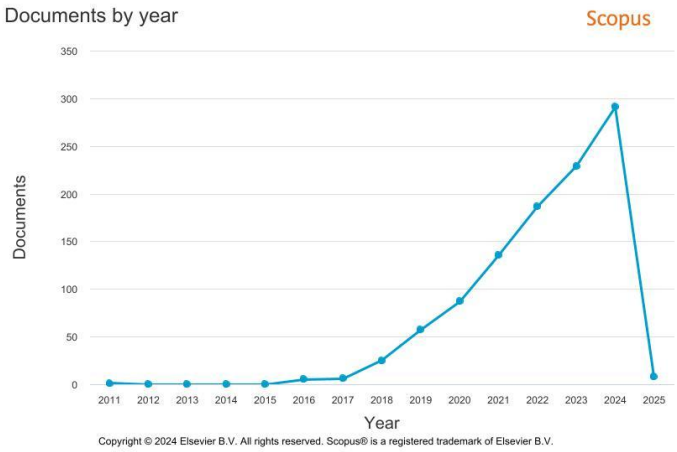

Figure 2. Distribution of DT Research on Startups.

Table I shows the ten most influential articles based on the number of citations in this topic. All articles show a high number of citations according to this criterion, with Soto-Acosta et al. (2020) taking the top spot with 301 global citations, followed by Jafari-Sadeghi et al. (2021) who had 275 citations. However, this order is reversed when looking at average citations per year. Bican et al. (2020) showed a significant impact, both in terms of total number of citations and average citations per year, signaling its relevance in this research area.

Table 1. Ten most influential articles.

Article	Total Citations	Article	Average citation per year
Soto-Acosta et al. (2020)	301	Jafari-Sadeghi et al. (2021)	68,7
Jafari-Sadeghi et al. (2021)	275	Soto-Acosta et al. (2020)	60,2
Bican et al. (2020)	223	Bican et al. (2020)	44,6
Brunetti et al. (2020)	220	Brunetti et al. (2020)	44
Li et al. (2020)	214	Felicetti et al. (2024)	44
Gupta et al. (2022)	88	Li et al. (2020)	42,8
Puschmann et al. (2020)	87	Gupta et al. (2022)	29,3
Rohn et al. (2021)	64	Heubeck et al. (2023)	19
Ruggieri et al. (2018)	56	Puschmann et al. (2020)	17,4
Kupp et al. (2017)	49	Rohn et al. (2021)	16

Source(s): Table by author.

Table II displays the ten most influential journals based on the number of articles published and total citations. Our research shows that Sustainability (Switzerland) is the most productive journal, with five articles published. It is at the forefront of business and management research. In the next position, Information and Management and Journal of Business Strategy are also important platforms for research in this field, although they contribute fewer articles, publishing only two each.

Table 2. Ten most influential journals.

Journal	Number of articles	Journal	Total citations
Sustainability (Switzerland)	5	Sustainability (Switzerland)	396
Information And Management	2	Information Systems Management	301
Journal Of Business Strategy	2	Journal Of Business Research	275
Business Strategy and Development	1	Tqm Journal	220
Digital Business	1	Electronic Commerce Research And Applications	214
Electronic Commerce Research And Applications	1	Information And Management	130
European Journal Of Innovation Management	1	Journal Of Business Strategy	75
Ieee Software	1	Journal Of Engineering And Technology Management - Jet-M	64
Information Systems Management	1	Management And Marketing	56
International Journal Of Innovative Technology And Exploring Engineering	1	Review Of Managerial Science	44

Source(s): Table by author.

Figure 3 displays the development of leading authors' production over time. Authors such as Bican PM, Brem A, Alange S, Basly S, and Bonfanti A showed the highest research activity in 2020, with significant contributions to the topic of DT at startup. This shows that they not only produce quality publications, but also have a continuous involvement in the development of literature in this area. Some authors reached their productivity peak in 2021, and only Amirato emerged in 2024. For example, Amirato (2022) highlights that digital transformation in startups is one of the main drivers of innovation and growth. This research emphasizes that successful digital transformation not only improves operational efficiency, but also enables startups to offer more innovative and relevant products and services to customers.

Figure 4 highlights the institutional contributions in this area. Several universities, such as Coventry University, Free University of Bozen-Bolzano, University of Münster, University of Southern Denmark, and University of Stuttgart, contributed with two studies each. Meanwhile, Athens University of Economics and Business, Baruch College, Chalmers University of Technology, Changchun University of Science and Technology, and Complexity Science Hub Vienna each contributed one study. The significant contributions from these institutions demonstrate the important role universities play in supporting DT-related research in startups.

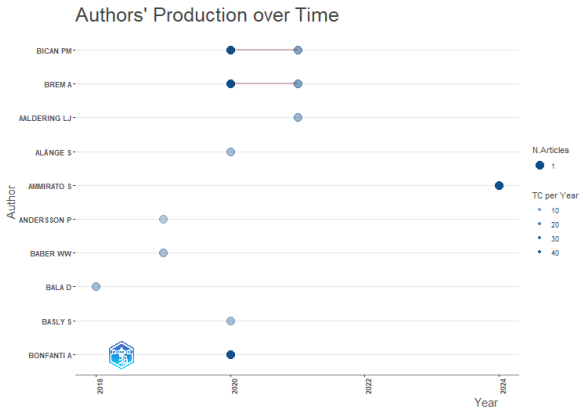

Figure 3. Production of Leading Authors over Time.

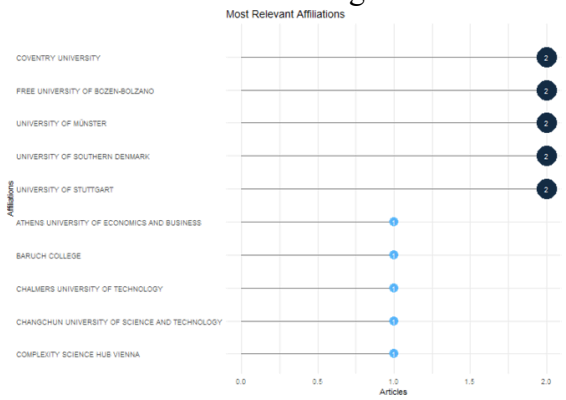

Figure 4. Most Relevant Affiliations.

Figure 5 shows the ten countries with the highest number of publications related to digital transformation (DT) in startups. Germany ranks first with 12 scientific contributions, signaling the country's dominance in research in the field. The high scientific production from these countries reflects the importance of the topic of DT in startups in the context of the global economy and innovation.

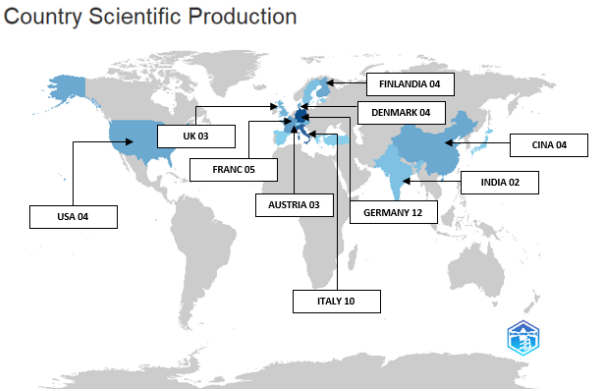

Figure 5. Top Ten Publication Countries.

Analysis of Shared Word Occurrence

The co-occurrence analysis resulted in the formation of four clusters covering 23 keywords, which are displayed in Figure 6. Table III provides a description of the keywords by cluster, including their number of occurrences and total link strength. Figure 6 shows that the co-occurrence analysis identified the key terms most frequently discussed in the literature

(marked with larger nodes in the figure), namely Red Cluster-"Innovation", Green Cluster-"Digital Business Model", Blue Cluster-"Digital Technologies", and Yellow Cluster-"Digital Transformation."

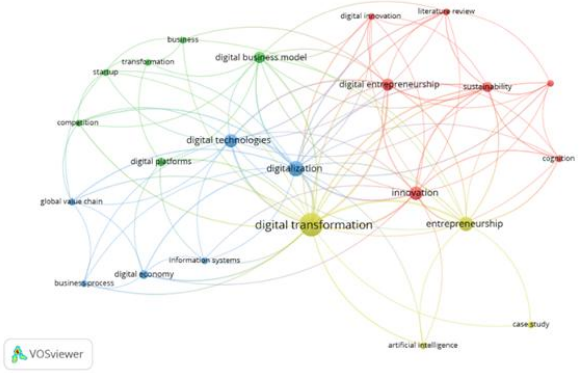

Figure 6. Co-word occurrence analysis: network map.

Table 3. Co-word occurrence clusters.

Cluster	**Occurrences**	***Total link strength***	**Main Research Topic**
Red cluster (n=7) Keyword			
Business development	2	11	
Cognition	2	10	
Digital entrepreneurship	6	22	
Digital innovation	2	11	Innovation
Innovation	7	28	
Literature review	2	12	
Sustainability	4	22	
Green cluster (n=6)			
Business	2	5	
Competition	2	8	
Digital business model	5	16	Digital business model
Digital platforms	3	7	
Statrup	2	7	
Transformation	2	4	
Blue (n=6)			
Business process	2	6	
Digital economy	3	10	
Digital technologies	9	40	Digital technologies
Digitalization	7	24	
Global value chain	2	9	
Information systems	2	7	
Yellow cluster (n=4)			
Artificial intelligence	2	5	
Case study	2	2	Digital transformation
Digital transformation	21	61	
Innovation	2	6	

4.2.1 Red cluster- "innovation". This cluster emphasizes that the success of digital transformation in startups depends on a combination of adaptive business development, understanding of digital entrepreneurship, continuous innovation, and insights from relevant

literature to help understand trends and challenges in digital innovation, strengthening the foundation for more adaptive and relevant business development in the digital era.

4.2.2 Green Cluster-"Digital business model". This cluster emphasizes that the success of digital transformation in startups depends on their ability to develop innovative digital business models, face competition with rapid adaptation, and leverage digital platforms to expand reach and operational efficiency.

4.2.3 Blue Cluster- "Digital technologies". This cluster emphasizes the key to digital transformation of resilient startups. The use of digital technologies improves *business processes* through efficiency and automation, and opens up opportunities in the *digital economy*. Process *digitalization* helps startups adapt quickly, while participation in the *global value chain* expands market access. *Information systems* support data management and operations, ensuring the overall success of digital transformation. These factors enable startups to be more competitive, innovative, and resilient in the digital era.

4.2.4 Yellow cluster-"Digital transformation". This cluster emphasizes that success includes the adoption of appropriate digital technologies and effective strategies for integrating these technologies into all aspects of a startup's business. The success of digital transformation in startups also depends on the startup's ability to overhaul traditional business models, change organizational culture, and innovate quickly. In addition, effective utilization of data to support strategic decision-making and improved customer experience plays an important role. This transformation requires readiness to adapt to rapid market and technological changes, making startups more flexible, innovative, and able to compete in the global market.

Bibliographic Merger of Document Analysis

Using *Bibliographic coupling*, the literature screening results from the Scopus database yielded five clusters of 29 articles, grouped by similar references. These clusters represent studies with similar approaches or topics. Through the analysis of these clusters, frequent themes and methodologies that have proven effective in supporting the success of digital transformation in startups can be identified. The co-citation network map shown in Figure 8, created with VOSviewer, shows five clusters with 352 links formed from the analysis.

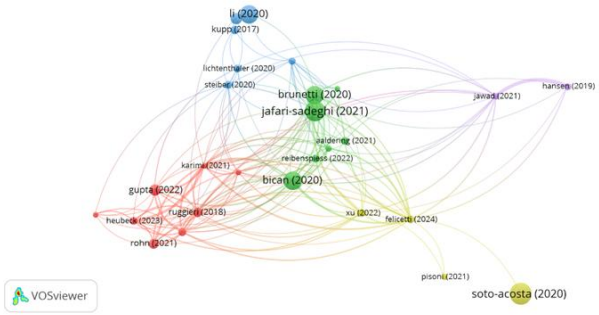

Figure 7. Bibliographic coupling of document analysis: network map.

The content analysis of each article included in the article allowed the identification of the main themes that form the intellectual structure of this research stream as follows:

Red cluster

The red cluster highlights factors that support innovation and the development of effective business models in the face of digital change. In this context, startup entrepreneurs often use *effectuation* logic to cope with market and technological uncertainty (Baber et al., 2019). This approach encourages innovation by building and remodeling resilient digital business models. In addition, dynamic managerial skills are necessary to facilitate successful digital transformation (Heubeck et al., 2023). Startups that are able to integrate feedback and data from the external environment, such as customers, partners, and competitors, can respond quickly to market changes and adjust their digital business models, thereby maintaining a competitive advantage (Gupta & Bose, 2022).

Overall, the Red cluster shows that factors such as flexibility in decision-making, dynamic managerial capabilities, and close interaction with the operational environment play an important role in the successful digital transformation of resilient startups (Lanamaki, 2020; Mattsson, 2019; Rohn, 2021; Ruggieri, 2018).

Green Cluster

The Green Cluster identifies important factors related to digital business model development and sustainable digital transformation, which greatly influence the success of resilient startups. Startups that succeed in digital transformation not only focus on innovation and short-term growth, but also take into account the long-term impact and sustainability of their business models, especially in the face of market and technological changes (Bican & Brem, 2020). In addition, startups that involve various stakeholders, such as customers, partners, and regulators, in the decision-making process can design more adaptive and holistic strategies, which support the success of their digital transformation (Brunetti et al., 2020).

Moreover, the establishment of clear and theory-based performance indicators helps startups monitor their progress and ensure that they stay on track to achieve strategic and operational goals (Satalkina & Steiner, 2020). Overall, the Green cluster shows that the sustainability of digital business models, a multi-stakeholder approach, and the implementation of core performance indicators are key factors that influence the success of digital transformation in resilient startups (Aldering & Song, 2021; Inel, 2019; Jafari-Sadeghi et al., 2021; Reibenspiess et al., 2022).

Blue Cluster

The Blue Cluster addresses factors related to digital technology adoption and innovation strategies that play an important role in the successful digital transformation of resilient startups. One of the key aspects is digital entrepreneurship, which provides opportunities for startups to thrive amidst increasingly complex market challenges and enables them to integrate more flexible and responsive digital innovations (Basly & Hammouda, 2020). In addition, effective collaboration between large enterprises and startups has also proven to be crucial in the digital transformation process, where both parties can support each other to accelerate adaptation to technological change (Steiber & Alänge, 2020). To accelerate innovation, startups also benefit from combining design thinking and lean startup methods, which enable rapid experimentation and adaptation to market feedback, thus creating more efficient and innovative solutions in their digital transformation journey (Lichtenthaler, 2020).

Overall, the Blue cluster emphasizes that the adoption of digital entrepreneurship, collaboration between large enterprises and startups, and the adoption of an agile innovation approach that combines design thinking and lean startup, are key factors that support the success of digital transformation in resilient startups (Kupp, 2017; Li, 2020; Puchman, 2020).

Yellow Cluster

The Yellow Cluster addresses factors that influence DT success in resilient startups, with an emphasis on digital innovation, sustainability, and social and environmental value creation. Digital innovation serves as a key driver that enables startups to adapt to market changes and develop more efficient and relevant solutions for customers (Felicetti et al., 2024). Sustainability in digital entrepreneurship is strongly influenced by startups' ability to direct digital innovation to create broader social and environmental value (Xu et al., 2022). In addition, successful digital transformation depends not only on technology, but also on cultural and managerial changes that support the full integration of digital in company operations (Pisoni, 2021).

Overall, the Yellow cluster suggests that success in digital transformation of startups requires a focus on sustainable digital innovation, social and environmental value creation, and the adoption of a holistic approach to digitalization that encompasses technological, cultural, and managerial aspects (Felicetti et al., 2024; Xu et al., 2022; Pisoni, 2021; Soto-acosta, 2020).

Purple Cluster

The Purple Cluster is concerned with the factors that influence DT success in resilient startups, with a focus on digital entrepreneurship and the challenges faced by startups in emerging economies. The digital revolution in big cities is driving many startups to adopt new technologies as part of their transformation strategy (Hansen, 2019). Digital entrepreneurship is a key factor that enables startups to innovate and survive in a competitive market. Moreover, in developing countries, digital transformation plays an important role in accelerating startup growth by utilizing technology to expand market reach and improve operational efficiency (Jawad et al., 2021).

Overall, the Purple Cluster shows that digital entrepreneurship that drives innovation and adoption of new technologies is critical to the success of digital transformation in startups, especially in fast-growing markets. The success of DT startups is heavily influenced by their ability to adapt to technological change and capitalize on the opportunities offered by the digital revolution (Hansen, 2019; Jawad et al., 2021).

Future Research Agenda

Based on the systematization of the co-occurrence analysis and content analysis of the bibliographic coupling document clusters, Table IV presents a future research agenda to advance research in the area of digital transformation in start-up.

Table 4. Future Research Agenda.

Research Domain	Future Research Agenda
Digital Business Innovation	▪ How can innovative digital business models adapt quickly to disruptive market changes? ▪ What is the role of effectuation logic in driving business innovation in startups facing technological and market uncertainty? ▪ How can startups integrate the latest technological innovations in their business models to create long-term value? ▪ What are the main challenges startups face in creating sustainable innovation in the digital age, and how can they overcome them?

Sustainability	▪ How can sustainability be integrated into a digital startup's business model without sacrificing short-term profits? ▪ What are the factors that influence the adoption of sustainability practices in startup digital transformation? ▪ How can sustainability in digitalization affect a startup's reputation and competitiveness in the global market? ▪ What is the role of external stakeholders (e.g., customers, government, partners) in encouraging startups to adopt sustainability practices in their digital business models?
Technology Adoption	▪ How can the adoption of disruptive technologies (such as AI, IoT, Blockchain) improve operational efficiency and innovation in startups? ▪ What are the biggest challenges startups face in adopting digital technology to support their business transformation? ▪ How can startups use digital platforms to leverage data to improve customer experience and create more efficient solutions? ▪ What is the relationship between technology adoption and digital business model success in digitally transformed startups?
Social Innovation	▪ How can digital innovation be used to create social and environmental value through social entrepreneurship? ▪ What is the role of technology in creating opportunities for social startups that are not only financially profitable but also have a positive impact on society and the environment? ▪ How can startups develop a business model that not only focuses on profit but also contributes to the creation of sustainable social value? ▪ What are the factors that influence the success of digital social innovation in startups, and how does it impact the wider community?
Digital Entrepreneurship	▪ What are the key factors that support digital entrepreneurship in the face of rapid changes in technology and global markets? ▪ How can digital entrepreneurship be a key driver in the technology revolution to create new business opportunities across sectors? ▪ What challenges do family companies face in adopting digital entrepreneurship, and how can they collaborate with startups to drive business transformation? ▪ How can startups leverage digital entrepreneurship to address global challenges and create disruptive innovations in their markets?

Digital Business Innovation

Digital business innovation includes the application of digital technologies to develop new business models or improve existing ones. Resilient startups typically focus their

innovation on the ability to adapt quickly to market changes and capitalize on new opportunities through the use of technology (Bican & Brem, 2020). This involves the development of digital platforms, mobile applications, or the integration of new technologies that provide added value to both customers and the company.

In addition, digital business innovation also refers to the application of new technologies to improve efficiency and effectiveness in various industrial processes (Aaldering & Song, 2021). The aim is to facilitate broader digitization in organizations. This innovation is not only limited to technology adoption, but also includes changes in the way businesses operate and interact with consumers. Digital business model transformation, in turn, involves the process of changing traditional approaches towards a more dynamic and flexible business model through the utilization of digital technology (Baber & Martinez, 2019).

Sustainability

Sustainability in the context of digitalization refers to the ability of startups to operate efficiently in the long term while taking into account environmental, social, and economic factors. Digital innovations that support sustainability may include technological solutions that are more environmentally friendly or that contribute to sustainable social and economic development (Bican & Brem, 2020; Xu, Hou, & Zhang, 2022). To achieve success in digitalization, startups must be able to create social and environmental value alongside economic gains. Sustainability in digital entrepreneurship is created through innovation that not only focuses on economic aspects, but also supports social and environmental goals, along with the implementation of an innovation orientation that focuses on achieving these goals (Xu, Hou & Zhang, 2022).

Technology Adoption

The success of digital transformation in startups is greatly influenced by the extent to which companies are able to adopt new technologies. Technology plays an important role in accelerating innovation and creating competitive advantage. Therefore, startups need to have the ability to identify and integrate relevant technologies, such as artificial intelligence (AI), big data, or cloud computing, which can improve company performance and efficiency (Gupta & Bose, 2022; Heubeck, 2023). Technology adoption is a crucial factor in driving the digitalization process, which enables companies to gain competitive advantage through the use of information and digital technologies (Doukidis, Spinellis & Ebert, 2020).

Social Innovation

Social innovation refers to efforts to create positive social impact by addressing social issues through the utilization of digital technology. Startups that adopt this approach can

develop business models that focus not only on economic returns, but also on community empowerment, reducing inequality, and solving various other social problems. Social innovation includes technological solutions that support the empowerment of specific individuals or communities, such as apps that improve the quality of education or healthcare (Felicetti, Corvello, & Ammirato, 2024). The COVID-19 pandemic has accelerated the adoption of digital technologies, which in turn drives social innovation through digital platforms that facilitate collaboration, community empowerment, and more efficient delivery of social solutions (Soto-Acosta, 2020).

Digital Entrepreneurship

Digital entrepreneurship refers to efforts to create and manage new businesses based on digital technology. In a digital world, a resilient startup needs to have entrepreneurs who are able to take risks, innovate quickly, and adapt to market changes. In addition, digital entrepreneurship also involves utilizing digitalization to introduce new products or services that are more efficient and effective in meeting consumer needs (Soto-Acosta, 2020; Baber, Ojala, & Martinez, 2019). Digital entrepreneurship encompasses the creation and utilization of new business opportunities driven by digital technologies (Karimi & Walter, 2021). It involves utilizing digital resources to develop products or services that can meet evolving market needs. Digital entrepreneurship also plays a role in creating value through digital platform-based business models, which can support inclusive and sustainable economic growth (Satalkina & Steiner, 2020). These concepts are thus interconnected and form a clearer foundation of how digitalization can drive innovation, sustainability and positive social change in the context of entrepreneurship.

5. DISCUSSION

The main objectives of this study are to provide an overview of the evolution of digital transformation research on start-ups, find the critical success factors in building digital transformation on resilient start-ups, and explain the framework for digital transformation research on start-ups in the future.

Global Trends in Digital Transformation in the Start-up Sector

A significant increase in the number of studies on digital transformation (DT) in startups from 2017 to 2024. The peak of publications occurred in 2023, indicating increased attention to this phenomenon in recent years. In addition, a number of authors also showed a peak in their productivity in 2021. To analyze these trends, we used descriptive analysis with

the help of the biblioshiny software R Studio, which allowed us to gain a more comprehensive understanding of the development of research in this field.

The approach we take in this study differs from previous literature reviews which generally focus more on specific aspects. We chose to adopt a broader and holistic approach, which does not only highlight certain elements but provides a comprehensive overview of the existing literature related to digital transformation in startups. With this approach, we seek to provide a deeper insight into the global trends of digital transformation taking place in the startup sector.

In addition to the bibliometric-based quantitative analysis, which provides an overview of the development of publication counts and author trends, this study also integrates content analysis. Content analysis allowed us to identify new opportunities in research as well as directions that need to be further explored in the future. As such, this study not only provides a comprehensive overview of the current state of research, but also helps map out paths that can be taken in future research related to digital transformation in startups.

Determinants of successful digital transformation in resilient start-ups

The research identified five main interrelated clusters, namely the Red (Innovation), Green (Digital Business Model), Blue (Digital Technology), Yellow (Digital Transformation), and Purple (Digital Entrepreneurship) clusters. Each of these clusters highlights the key factors that play an important role in the success of startups in undergoing the digital transformation process.

The Red Cluster - "Innovation" emphasizes that the success of DT in startups is highly dependent on the ability to innovate sustainably and have an adaptive business model. In this regard, successful startup entrepreneurs typically apply a digital entrepreneurship approach that prioritizes the ability to respond quickly to market uncertainty and change. The emphasis on flexible innovation and the ability to adapt to the external environment, such as customers and partners, are key factors in creating a competitive advantage. In addition, dynamic managerial capabilities are required to drive changes in business models that can support successful digital transformation (Baber et al., 2019; Heubeck et al., 2023; Gupta & Bose, 2022).

The Green Cluster - "Digital Business Models" highlights the importance of developing innovative digital business models as a critical success factor for DT. In an ever-changing environment, startups must be able to face competition by quickly adapting and utilizing digital platforms to expand their reach and improve operational efficiency. Sustainability in business models, engagement of various stakeholders (such as customers and partners), as well as the implementation of clear performance indicators, are important elements that support startups'

success in their digital transformation. Startups that can design holistic business strategies and are adaptive to market and technological changes have a greater chance of surviving and thriving in the long run (Bican & Brem, 2020; Satalkina & Steiner, 2020).

The Blue Cluster - "Digital Technology" emphasizes the role of digital technology in improving operational efficiency and enabling startups to adapt more quickly to market changes. The use of technologies such as information systems, automation, and integration in the digital economy opens up new opportunities for startups to participate in global value chains and expand access to broader markets. In addition, the application of digital entrepreneurship and collaboration with large companies gives startups greater access to adopt new technologies that support innovation and accelerate their digital transformation process (Basly & Hammouda, 2020; Steiber & Alänge, 2020; Lichtenthaler, 2020).

The Yellow Cluster - "Digital Transformation" suggests that the success of digital transformation depends not only on the technology adopted, but also on changes in organizational culture and the ability to overhaul traditional business models. Startups that are able to integrate technology into all aspects of their operations, change internal culture, and innovate quickly tend to be more flexible and able to compete in the global market. Effective use of data for strategic decision-making and improved customer experience are also important factors in supporting successful digital transformation (Felicetti et al., 2024; Xu et al., 2022).

The Purple Cluster - "Digital Entrepreneurship" emphasizes the importance of digital entrepreneurship in capitalizing on the opportunities offered by the digital revolution. In the context of emerging markets, digital entrepreneurship enables startups to innovate, survive fierce competition, and leverage technology to expand market reach and improve operational efficiency. In developing countries, digital transformation plays a key role in accelerating the growth of startups, enabling them to access new technologies that support growth and market expansion (Hansen, 2019; Jawad et al., 2021).

Overall, the success factors for digital transformation in these resilient startups include the ability to innovate sustainably, develop adaptive digital business models, leverage digital technologies effectively, and transform organizational culture to support rapid change. Each cluster provides a complementary perspective, showing that successful digital transformation depends on synergies between innovation, technology, digital entrepreneurship, and adaptive and sustainable business management.

Research framework for digital transformation in future start-ups

A future research agenda could explore how startups combine innovation, sustainability, technology, and digital entrepreneurship to adapt and thrive in the digital age. The research

focus could include the application of digital technologies to develop or improve business models, including digital platforms and mobile applications, that provide added value to customers and increase operational efficiency (Bican & Brem, 2020; Aaldering & Song, 2021). In addition, startups should adopt green technologies that support social goals to achieve long-term sustainability, not just economic gains, and create competitive advantages through digital transformation (Xu, Hou, & Zhang, 2022; Gupta & Bose, 2022; Heubeck, 2023). Digital entrepreneurship also plays an important role in supporting inclusive economic growth through digital platform-based business models (Soto-Acosta, 2020; Baber et al., 2019). All these factors contribute to successful digitization in resilient startups.

6. CONCLUSION

DT research on Star-up has increased significantly, especially after 2016. Using bibliometric analysis and science mapping, four main research themes were found, namely innovation, digital business models, digital technologies, digital transformation. Five future DT research trends were also found, including digital business innovation, sustainability, technology adoption, social innovation, and digital entrepreneurship.

Future research agendas should integrate elements from digital business innovation, sustainability, technology adoption, social innovation, and digital entrepreneurship to create startups that are resilient to the challenges of digital transformation. By focusing research on these areas, we can deepen our understanding of how startups can build sustainable competitiveness and adapt quickly in the ever-changing digital economy.

Limitation

This study was derived from imported bibliographic data taken from Scopus. The results of the bibliometric analysis may be affected by the choice of database used, which may result in different findings. Although literature review procedures were applied, it is possible that some articles related to the topic were missed. Differences in the use of indicators and mapping methods can also lead to varying results. Therefore, in the future, researchers need to further optimize these aspects. It is recommended for future researchers to: use more databases or reference sources to minimize the potential omission of important works, combine various databases for more representative results, and apply various analytical methods to increase the validity and accuracy of the findings. This aims to contribute more to the development of knowledge about DT in startups, as well as provide more appropriate recommendations for policies and practices that support sustainability and innovation in startups.

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