

Is digitalization the engine of sustainability? A bibliometric analysis

FILOMENA IZZO *

University of Campania Luigi Vanvitelli
Economics Department
Assistant Professor in Management
Corso Gran Priorato di Malta 1, Capua (CE), Italy
E-mail filomena.izzo@unicampania.it
** Corresponding author*

MARILENA BREDICE

University of Molise
Economics Department
PhD student in Management
Via Francesco de Sanctis 1, Campobasso (CB), Italy
E-mail m.bredice@studenti.unimol.it

GABRIELE IANIRO

University of Molise
Economics Department
PhD student in Management
Via Francesco de Sanctis 1, Campobasso (CB), Italy
E-mail g.ianiro1@studenti.unimol.it

VIKTORIYA TOMNYUK

University of Turin
Department of Cultures, Politics and Society
PhD student in Innovation for the Circular Economy
Lungo Dora Siena, 100 A, 10153 Torino, Italy
E-mail viktoriya.tomnyuk@unito.it

MICHELE MODINA

University of Molise
Economics Department
Full professor in Management
Via Francesco de Sanctis 1, Campobasso (CB), Italy
E-mail michele.modina@unimol.it

Is digitalization the engine of sustainability? A bibliometric analysis

Abstract

The article aims to give a complete overview of the literature on how digitalization can help organizations to address sustainability challenges. We conducted a bibliometric analysis with Bibliometrix package. Two main clusters topic were identified, revealing the increasing attention of digital technologies in sustainable models and practices and a focus on circular economy. The topic position map highlights that the motor theme refers on how management practices and capabilities in specific fields enable firms to integrate digital systems and technologies into their operations, supply chains, and overall strategies. Integrating digital systems within firms and across systems in a given field can facilitate sustainability objectives and outcomes.

The study provides academics an picture of the topic themes and its challenges. It informs practitioners and policymakers about the tools and specific obstacles of digitalization in addressing sustainability challenges, thereby contributing to accelerating the achievement of sustainable development.

Keywords: digitalization, sustainability, bibliometric analysis, innovation technology, SDGs

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Introduction

As climate change, resource depletion, and inequality threaten our planet and its inhabitants, attaining sustainability has become a top priority for individuals, businesses, and governments. Sustainability, sure enough, represents the necessary means to enable ecosystems to maintain their productivity and functionality over time (Daly 1990; Clark and Dickinson 2003).

In the past twenty years, especially, the urge for sustainability transition (ST) has started to increase dramatically both in the policy and in the research worlds (Markard et al. 2012; Geissdoerfer et al. 2017), and guided by this pressure, governments all over the globe replied to this challenge with actions and policies resulting in a global commitment to a more sustainable and equitable future. It is the case of the Millennium Development Goals (MDGs) first, and the Paris Agreement and the Sustainable Development Goals (SDGs) later, developed respectively in 2000 and 2015 by the United Nations, which represented together a call to action to put an end to poverty, defend the ecosystems, and ensure peace and wealth for the whole world (Sachs, 2012; Le Blanc, 2015).

Despite these efforts, however, transitioning to a more sustainable society has shown some difficulties in the first years of SDGs' operationalization. This issue has been caused by the newness and complexity of the goals and the fact that countries worldwide experienced insufficient awareness and technical capacity in systems thinking, policy coherence, and integrated planning (Allen et al., 2018). These difficulties, the growing shadow of climate change darkening the world's perspectives for the future, and the speed of development and importance of digital technologies in our everyday lives led both the worlds of academia, business, and government to redirect their focus to other approaches.

From the standard sustainable transition practices, indeed, their attention shifted towards the implementation of innovations and digital technologies for sustainable development (SD) (Adam et al., 2013; Silvestre and Tîrca, 2019; Sachs et al., 2019; Vinuesa et al., 2020; Mondejar et al., 2021). Digitalization can play a central role in achieving SDGs by leveraging digital technologies to enhance access to information and knowledge, improving resource management, fostering innovation and entrepreneurship, enhancing transparency and accountability, facilitating collaboration and partnerships, mitigating the impact of climate change by contributing to reducing greenhouse gas emissions and improving energy efficiency.

After the European Union started to integrate the call for digitalization for sustainability in its policies¹, in particular, the relationship between digitalization and sustainability has evolved and strengthened considerably, with digital technologies accelerating sustainability achievement since then (Townsend and Coroama, 2018; Guandalini, 2022). Digitalization practices and tools have evolved significantly and started playing a pivotal role in driving the changes needed for a sustainable future, especially in the long term (Ching et al. 2022; Mondejar et al. 2021; Bildirici & Ersin 2023). Moreover, as a consequence, researchers started focusing more consistently on the phenomenon by studying its impact on the economy and society, its critical success factors, and also its barriers and limitations (Adamik & Nowicki, 2018; Kamble et al., 2018; Adamik & Nowicki, 2020; K et al., 2023) to advance knowledge both in the theory and the practice.

However, despite this level of knowledge and development, the world is still facing difficulties in integrating sustainable development through digital technologies effectively (Perez-Martinez et al., 2023), with barriers such as access to information, absence of solid incentives or financial resources, and poorly designed regulations; but also skill gaps, financial constraints, and operational complexities in I4.0 projects (Caiado et al., 2018; Cagno et al., 2021).

¹ See, for example, the European Green Deal, which has made explicit the importance of digital technologies and disruptive innovations for the achievement of net-zero-carbon emissions by 2050 (Eckert and Kovalevska, 2021)

That is why, given the global urge to provide an immediate response to the SdGs both in the theory and the practice (Berrone et al., 2023), and the parallel slow and uneven evolution of operations toward their achievement (Salvia et al. 2019), a question mark seems to be still present on the topic regarding how organizations are addressing the challenges of sustainability transition through digitalization.

Indeed, on the one side, while some studies analyzed the positive connection between digitalization and sustainability (Parida et al., 2019; Khan et al., 2021; Mondejar et al., 2021), the internal factors driving either digitalization or sustainability in SMEs (Isensee et al., 2020), or still explored the separate connection between industry and either sustainability or digitalization (Muñoz-Villamizar et al., 2019), they did not focus specifically on more comprehensive research on digitalization for sustainability. On the other side, while Guandalini (2022) delivers a comprehensive analysis of the academic literature regarding the relationship between digitalization and sustainability and describes the current macro-topics regarding the theme of digital sustainability (i.e., digitalization for sustainability), the author does not provide a review of the ways different types of organizations (e.g., universities and research centers, public and private companies, NGOs and non-profits, governments) address the challenges posed by sustainability transition, through digitalization.

Based on the above considerations, this article aims to give a complete overview of the literature on how digitalization can help organizations address sustainability challenges.

That said, the paper is structured as follows. Section 2 describes the literature background. Section 3 describes the methodological path, the methodological choice, and the dataset construction procedure. Section 4 presents the results and discussion of the bibliometric analysis. Finally, in the conclusion section, we present implications, limitations, and directions for future research.

2. Literature Background

2.1 On sustainable development and sustainable transitions

The literature on sustainable development and sustainability transitions is known for emphasizing the pressing need for transformative changes in the industrial world to address environmental challenges while promoting long-term well-being. However, the approaches to addressing such changes have evolved considerably over time, together with the debate around SD.

On the one side, while the roots of the discussion around social and environmental sustainability date back to the first works regarding the limits of economic development (Mebratu, 1998), sustainable development as a concept and term emerged only in the 1980s.

In those years, the United Nations started defining it as: “[...] *development that meets the needs of the present without compromising the ability of future generations to meet their own needs* [...]” (Brundtland, 1987). Thus, the question was not to what extent environmental protection and economic development were in conflict but how they could have been accomplished simultaneously (Lelé, 1991).

SD then began to emphasize reaching the goal of the responsible economic evolution of human society in harmony with the environment and proceed through three dimensions (or pillars): (1) environmental, (2) economic, and (3) societal sustainability (Glavič & Lukman, 2007; Olawumi & Chan, 2018; Purvis et al., 2018; Mensah, 2019). Moreover, it started to be seen more as an actual (4) process of change, made necessary by (5) the impact of traditional production systems on environmental degradation, and that should be (6) implemented through collaboration between actors (Lelé, 1991; Niesten & Jolink, 2020).

With these six characteristics in mind, we can then draft a picture of sustainable development as a process of transition, aiming to overcome the sustainability challenges caused by traditional economic systems and implemented thanks to the collaboration of different sets of actors.

On the other side, and coherently to the concept of SD, a transition to sustainability can be defined

as a: “[...] *radical transformation toward a sustainable society as a response to a number of persistent problems that plague contemporary modern societies*” (Grin et al., 2010). A long-term geographical and multi-level process that involves systemic transformations or transitions to sustainable configurations (Loorbach, 2010; Hansen & Coenen, 2015; Köhler et al., 2019; Schaltegger et al., 2020) for which a fundamental change in socio-technical systems is required (Markard et al., 2012).

Notably, according to Köhler et al. (2019), sustainability transitions are typified by three main characteristics, namely: multi-dimensionality and co-evolution – since transitions are dynamic processes involving different elements (such as technologies, policies, and markets); multi-actor structure – since they involve all the actors belonging to the groups of the quadruple helix (Carayannis et al., 2012); stability and change – despite the many ‘green’ innovations and practices diffused over time, the socio-technical systems around the world are still dependent on the traditional technologies and practices.

Indeed, innovations for sustainability transitions and their challenges depend highly on these characteristics, on innovation’s characteristics such as complexity, dynamism, and uncertainty (Silvestre & Tîrca, 2019), and on factors related to the SD paradigm, such as the rising environmental challenges, the growth of industrial systems (under a micro, meso and macro points of view), the emerging technologies, and the ability of ecosystem actors to collaborate (Hart & Milstein, 2003; Smith et al., 2010).

Moreover, the challenges that innovation faces with sustainable transitions are connected mainly to three main areas: environmental challenges – related to the ways supply chains and communities impact the environment; social challenges – related to poverty, social exclusion, human rights, war, and immigration; network-/ecosystem-related challenges – related to the ability of ecosystem actors to collaborate, produce innovations and diffuse them (Adams et al., 2013; Silvestre & Tîrca, 2019; Goworek et al., 2018).

Such growing challenges, over time, have raised the attention of different groups of policymakers in the United Nations, who, in the past twenty years, started to work more intensely on multiple developmental agendas, to define a framework to be followed globally and that should have led to a global commitment towards sustainable development.

Nevertheless, it was only until defining their 2015 Sustainable Development Goals agenda, to be reached by 2030 (Sachs, 2012), that they have been much closer to that goal: they developed an evidence-based framework for national, regional, and global sustainable development planning and programming, building on the success of other target and indicator-based frameworks from their past agendas, and containing better coverage of, and balance between, the economic, social and environmental dimensions of sustainable development and provide an opportunity to trigger systemic change towards a sustainable future (Costanza et al., 2016).

A framework like this, especially, according to Sachs et al. (2019), needs six types of transformations in order to be operationalized under an economic, environmental, and social point of view: “(1) *education, gender, and inequality*; (2) *health, well-being, and demography*; (3) *energy decarbonization and sustainable industry*; (4) *sustainable food, land, water, and oceans*; (5) *sustainable cities and communities*; and (6) *digital revolution for sustainable development*” (Sachs et al., 2019).

Indeed, since sustainable transitions are complex, multi-level, and dynamic processes, they must be approached on multiple levels simultaneously, and in this context, innovation and digitalization can become the protagonists.

2.2 On digital technologies and sustainability

Considering the need for revolutionary changes capable of accelerating sustainable transitions and the linked pressure on sustainable development goals, digital technologies, and digitalization

appear to be among the most appropriate solutions to overcome such challenges.

Digitalization refers to using digital technologies to transform business processes, models, and customer experiences, impacting societies, the economy, and the environment. This paradigm is leading the innovation landscape worldwide, causing significant changes in organizations and society by disrupting current business models and helping entrepreneurs respond to urgent economic, environmental, and social challenges (Calderon-Monge & Ribeiro-Soriano, 2023).

If used to overcome sustainability challenges, the digital technologies typical of the Industry 4.0 paradigm can have a positive impact on both macro and micro aspects of manufacturing, such as business models, value creation networks, equipment, products, processes, organization, and also humans (Stock & Seliger, 2016). Digital technologies can help save resources efficiently and decrease the operational costs involved in production activities (Ching et al., 2022) but can also positively impact the adoption of clean technologies and accelerate the resource flow (Townsend and Coroama, 2018).

However, despite the positive correlation between digitalization and sustainability (Isensee et al., 2020; Gomez-Trujillo & Gonzalez-Perez, 2021; Ching et al., 2022; Irajifar et al., 2023), achieving digitalization for sustainable development purposes, is an arduous task. It is, in fact, a challenging process that requires any organization that pursues it to take into consideration both the characteristics of sustainable development and sustainability transitions (Parida et al., 2019) and all the challenges related to them and innovation development (Guandalini, 2022).

Despite, however, the rising interest in the topic and the growing need for solutions to overcome the challenges mentioned above, the literature that links digitalization to sustainability is not effective in giving a comprehensive view of the relationship between the two paradigms and paving the way for studies that can shed light on the issues of the operationalization process.

That is why, in order to close this gap and to give a more transparent and better view of the phenomenon, this paper aims to dive deeper into the topic of digitalization for sustainability by profoundly analyzing scientific production in this regard and to answer the following research questions:

- RQ 1. What are the trends of publications on digitalization for sustainability?
- RQ 2. Are there any clusters of topics regarding digitalization for sustainability?
- RQ 3. What are the motor themes, in the literature, on digitalization for sustainability?

3. Data and Methodology

In this work, a bibliometric analysis was conducted. Bibliometric analysis can provide a systematic, transparent, and reproducible review process based on the statistical measurement of science, scientists, or scientific activity (Broadus 1987, Diodato 1994, Pritchard 1969, Crane 1972). The sample of publications was analyzed with the statistical software R-Studio and the Bibliometrix package (Aria & Cuccurullo 2017), which allows scientific analysis of the results obtained through the multi-disciplinary database.

Bibliometrix was chosen as it is more suitable for practitioners. In this sense, it enables researchers to investigate a more considerable amount of data from different sources (Scopus, Web of Science), providing support for robustness and reliability in science mapping (Dada 2018, Rey-Martí et al. 2016, Moral-Munoz et al. 2020).

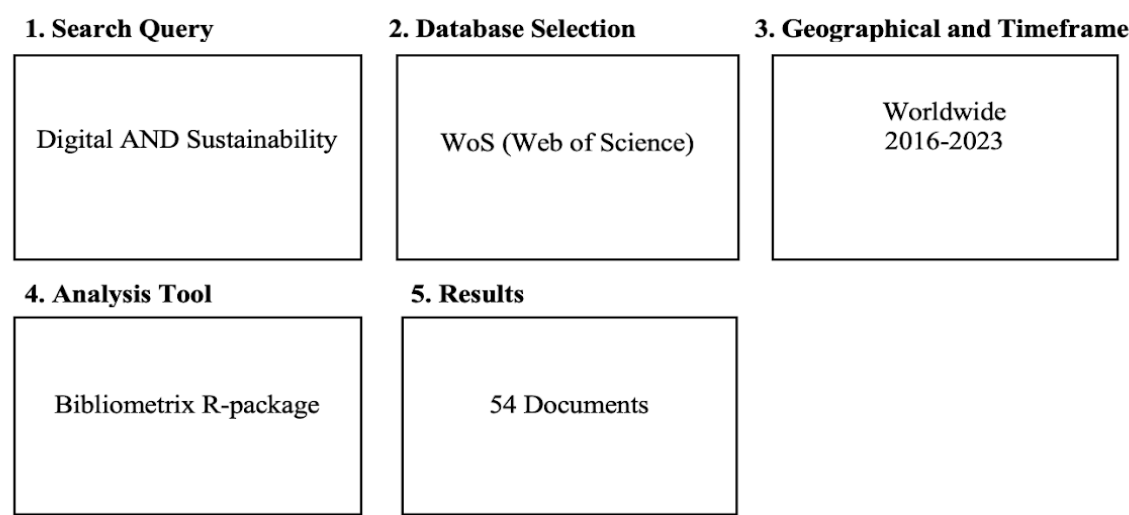
The sample of publications for analysis was obtained using the Web of Science (WoS) database. We selected the WoS database for data collection because it contains the highest number of high-impact factor journals and articles in our research field (Hicks & Wang, 2011; Ball & Tunger, 2006) and required fewer data-cleaning procedures (Zupic & Cater, 2015).

The scoping analysis focused on the two keywords “Digital” and “Sustainability” in the topic field (abstract, title, and keyword). Data collection was then refined: by including Web of Science

categories: (Management, Business, and Sustainability), including languages: (English). A total of 54 publications were retrieved from this search query, published since 2016; Bibliometrix generated the starting date, defined by the first published article dealing with the analyzed topic.

Figure 1 summarizes the research steps.

Figure 1: The methodological framework of bibliometric analysis



The final sample was examined through bibliometric analysis. The main results analyzed in line with the research questions are: the type of document, annual scientific production, the multiple correspondence analysis (MCA), and the thematic map.

4. Results

We start introducing the primary information about data. A total of 54 documents produced from a period ranging from 2016 to 2022 were analyzed; 2023 is not representative as it is ongoing.

Figure 2 illustrates the annual scientific production regarding the investigated topic, which starts from 2016, rising in rapidity from 2019 until today, and showing an increase in interest in the topic over the last four years. Especially in recent years, there has been a growing awareness of the importance of the strategic use of digital technologies to drive sustainable practices, processes, and solutions.

Figure 2: Annual Scientific Production

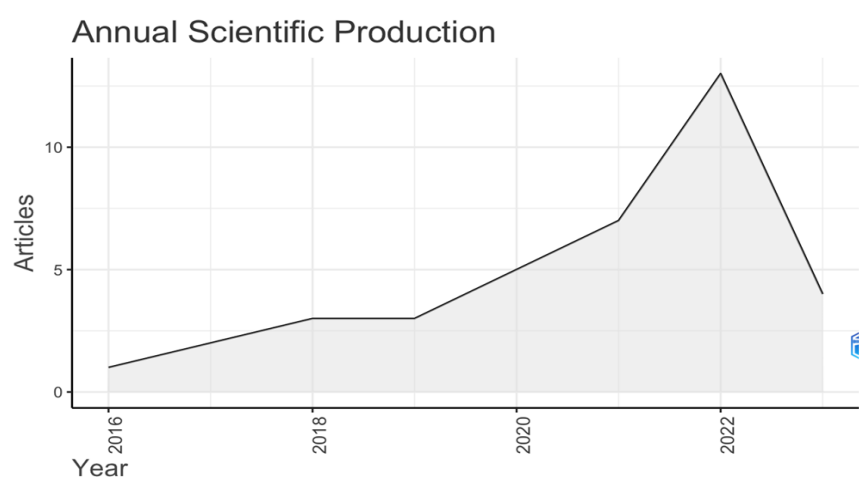


Figure 3 reports the Conceptual Structure Map based on MCA. It reports the presence of two clusters: the red and the blue ones.

Figure 3: Conceptual Structure Map – Method: MCA

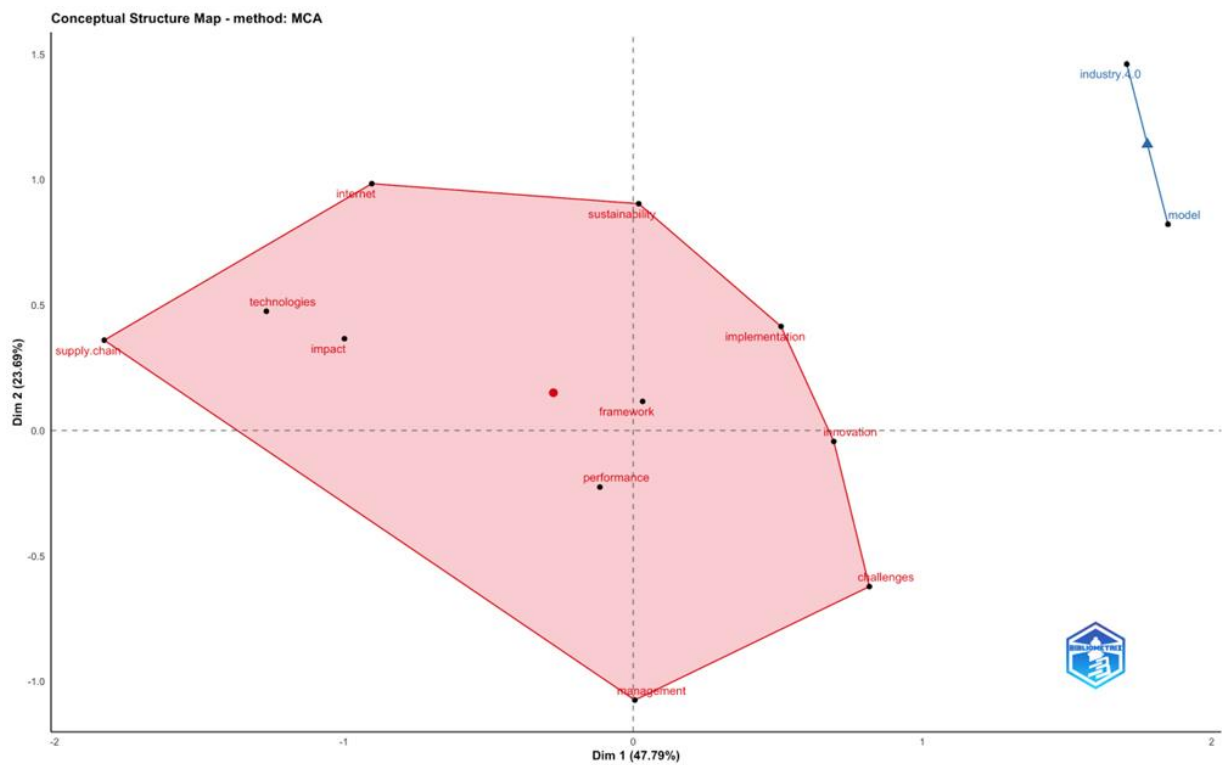
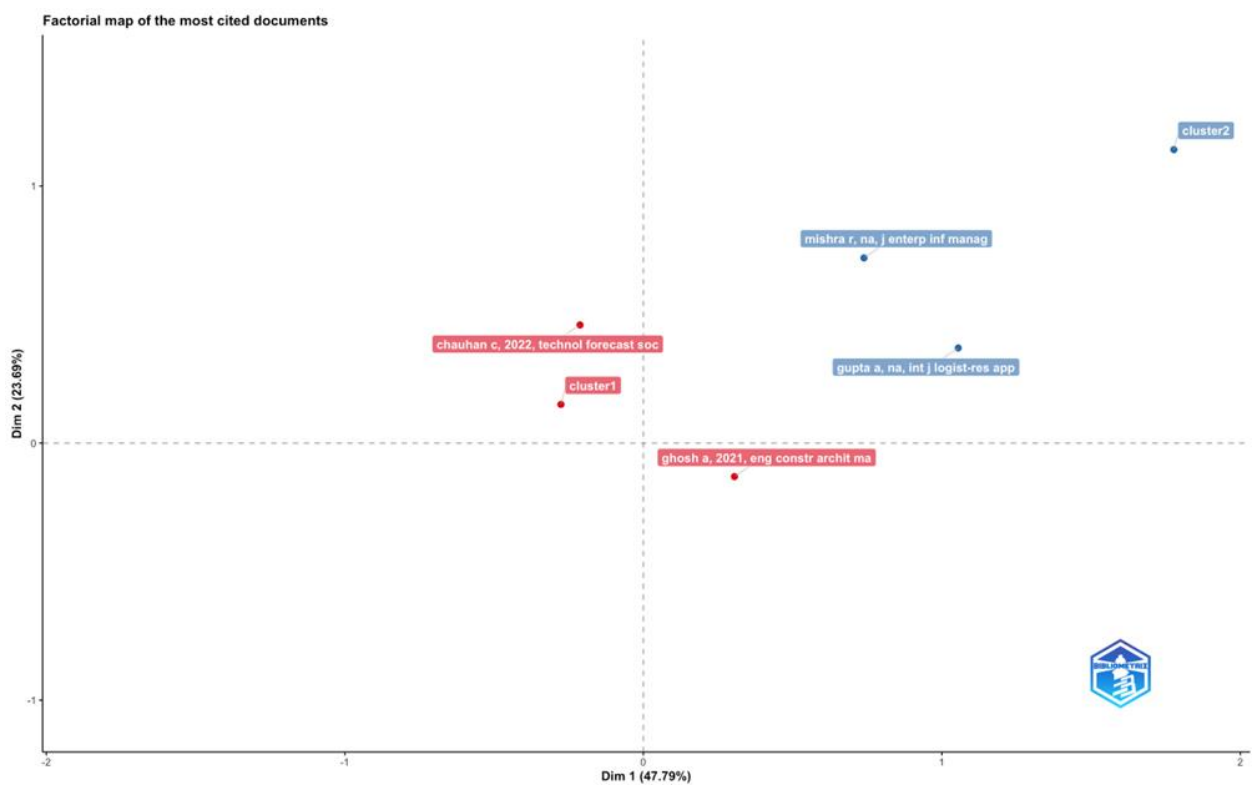


Figure 4: Factorial Map of the most cited documents



Red cluster

The red cluster is characterized by the following keywords: supply chain, internet, technologies, impact, sustainability, implementation, framework, innovation, performance, challenges, and management.

The importance of new technologies and innovative tools such as the Internet of Things (IoT), blockchain, artificial intelligence (AI), and data analytics is emphasized by the most cited article in the cluster by Chauhan et al. (2022) – fig. 4 – with the article “Linking circular economy and digitalization technologies: A systematic literature review of past achievements and future promises.”

According to the authors, the application of various digital technologies (such as AI, big data, and blockchain) drives the transition toward the circular economy as they can disrupt linear business models, enabling mass customization of products and services and allowing companies to select sustainable inputs based on customer needs. These technologies also support product life extension by developing predictive maintenance requirements, thereby further improving customer experience and waste reduction. In addition, they state that companies moving toward digitalization can improve overall opportunities in manufacturing, processing, logistics, and waste recovery through improved visibility into all stages of the supply chain.

The paper shows how big data plays a significant role in acquiring relevant information and facilitating effective decision-making by consolidating different datasets. Companies are actively involved in generating new databases by integrating various types of data, such as weather conditions and trends in economic factors, which are accessed through third-party vendors and used to create customized decision-making models for companies. For example, in the manufacturing industry within a big data-driven supply chain, the relationship between resource management and business performance improves from the perspective of a CE.

AI and machine learning also offers several benefits to the transition to a CE, such as reduced costs, identification of hidden patterns, improved quality, and greater responsiveness. Implementing AI increases productivity through better optimization, real-time data analysis, and improved design, all enabling circularity. Machine learning algorithms can predict the uncertain performance of various processes, monitor those processes in real-time, and detect defects.

Finally, the paper highlights obstacles to the digitalization-driven circular economy transition and highlights policy issues, lack of predictability, psychological issues, and vulnerability of information. A significant barrier is the absence of structured data management processes and the difficulty of implementing IoT-enabled product development. In addition, the absence of appropriate regulations, scarcity of environmental education, lack of a culture of environmental conservation, and lack of market demand pressure are among other challenges facing the digitalization-driven CE transition. At the same time, the paper emphasizes the negative consequences of disruptive technologies, such as the absence of predictability, psychological problems, and information vulnerability that hinder the adoption of digitalization-enabling CE technologies.

The second paper highlighted as the most cited of the cluster is the one by Ghosh et al. (2021), titled “Patterns and trends in IoT research: future applications in the construction industry,” which focuses the discussion on the awareness of the latest developments and potential applicability of the IoT in the construction industry.

The paper highlights IoT’s common themes and applications in the construction sector, such as real-time monitoring of construction sites, equipment, and materials, remote sensing and control, predictive maintenance, energy management, and safety enhancement. It discusses these applications’ benefits and potential challenges and the emerging trends and innovations in IoT technologies.

The findings of the study indicated that the field of study is still in its early stages, with only a few experts working somewhat independently and offering individual solutions instead of adopting a comprehensive and integrated approach. The study identified the primary publication outlets and

observed that the research primarily focused on technical aspects such as smart buildings, smart construction objects, and environmental sustainability. For the construction industry to address the contemporary technological demands of Industry 4.0, shifting from traditional and outdated practices to digitalized automated systems is crucial. This transformation represents a significant milestone, as it not only enhances productivity and efficiency but also facilitates environmentally sustainable planning and transaction management. Moreover, the study outlined the key factors driving the adoption of the IoT, which include interoperability, data privacy and security, flexible governance structures, and proper business planning and models.

Blue cluster

The blue cluster is characterized by the following words: industry 4.0 and model.

The most cited study in the cluster (fig. 4) is the paper from Mishra et al. (2022), “Managing tensions in resilience development: a paradox theory perspective on the role of digital transformation,” it discusses how digital technologies and processes can enable organizations to respond to disruptions, improve agility and increase their ability to recover from shocks or crises. The paper can also address the potential challenges and dilemmas associated with digital transformation in the context of resilience development.

The first point underlined is how digital technologies (such as IoT, big data analytics, and cloud computing) affect environmental and economic performance. The literature review highlights how manufacturing companies should rely on internal information processing capabilities and use digital supply chain platforms to access information externally in a dynamic environment. In addition, it highlights how Industry 4.0 can help unlock the full potential of environmentally sustainable processes and services through digitalization, providing more accurate and higher-quality data and solutions for real-time tracking and management.

The second aspect the authors focus on is the trade-off between sustainability and resilience. In traditional industries concept, achieving both sustainability and resilience appears to be challenging as they often appear to be contradictory. Sustainability is influenced by climate change, environmental degradation, and geopolitical instability, necessitating a fresh perspective to prioritize resource conservation and environmental governance. On the contrary, resilience is driven by unforeseen events, shocks, and disruptions. While sustainability aims to effectively manage the complete value chain of each product and minimize waste, a resilient supply chain is built on the foundation of the agile management concept. The work highlights the increasing recognition of the interconnectedness between sustainability and resilience in recent years, showing that both aspects are essential and should be considered together.

The study identifies two primary tensions: exploitation versus exploration and control versus flexibility. Firstly, the tension between exploitation and exploration refers to the challenge of balancing the optimization of existing resources and capabilities (exploitation) with the exploration of new opportunities and innovation (exploration). The results emphasize that organizations must strike a delicate balance between these two dimensions to foster resilience.

Secondly, the tension between control and flexibility revolves around the trade-off between maintaining centralized control and flexibility to adapt to changing circumstances. The findings suggest that organizations should adopt a dynamic approach that combines centralized control mechanisms with decentralized decision-making and flexibility to enhance resilience.

The paper argues that digital transformation is both an enabler and a source of tension in resilience development. While digital technologies provide new opportunities for organizations to enhance their resilience, they also introduce complexities and challenges that must be effectively managed. The authors propose several strategies to manage these tensions, including embracing paradoxical thinking, developing ambidextrous capabilities, fostering collaboration and communication, and implementing adaptive governance structures. These strategies aim to support organizations in

leveraging digital transformation to develop resilience while addressing the inherent tensions that arise.

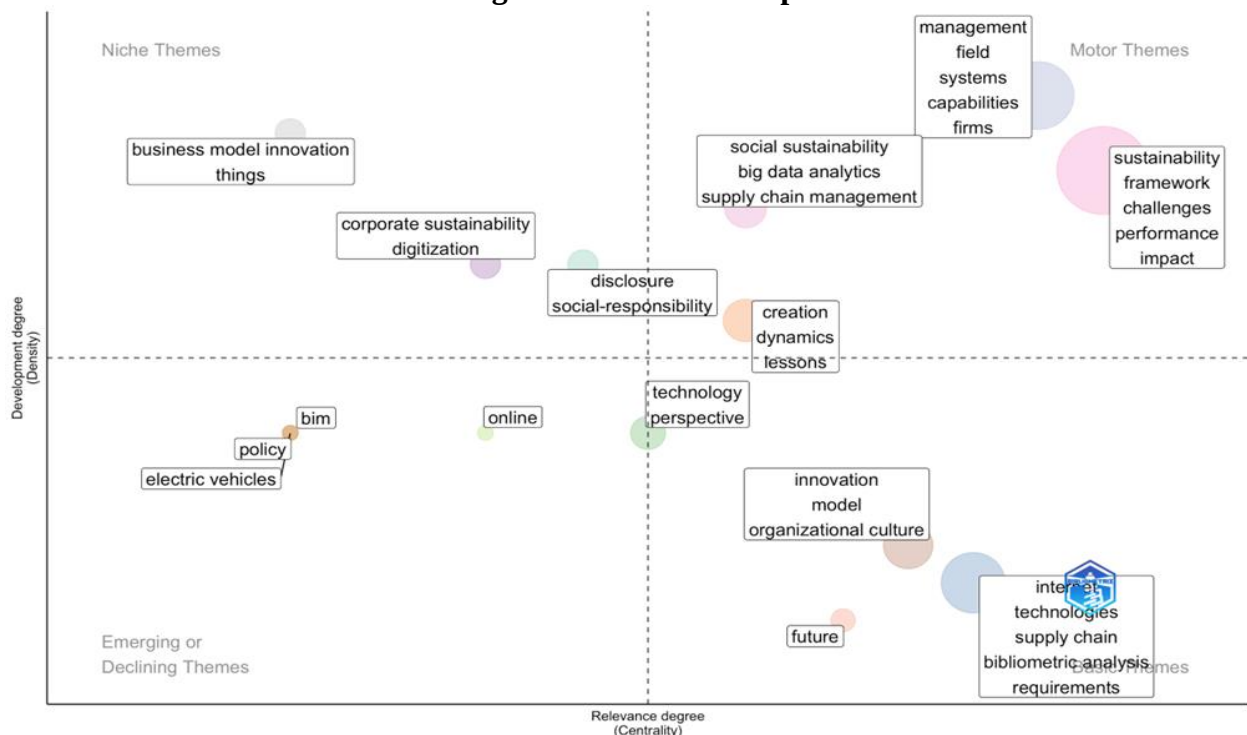
The second most cited paper in the blue cluster is “Applications of emerging technologies in the logistics sector for achieving circular economy goals during COVID-19 pandemic: analysis of critical success factors” by Gupta et al. (2021). The paper explores the critical success factors associated with implementing these technologies, such as technology readiness and IT infrastructure, data management, stakeholder collaboration, regulatory frameworks, financial investment, workforce skills, and management commitment. The authors discuss the importance of addressing these factors to ensure the effective integration of emerging technologies and achieve circular economy goals during the pandemic. Accurate and comprehensive communication facilitated by technological advancements and sustainable developments can enhance collaboration among all supply chain partners in the logistics sector.

Figure 5 helps us better understand the topics covered in the literature, showing us a map of the field’s Niche, Emerging or Declining, Motor, and Basic themes.

The motor themes is characterized by the following words: management, field, systems, capabilities, and firms. The correlation between these words lies in how management practices and capabilities in specific fields enable firms to integrate digital systems and technologies into their operations, supply chains, and overall strategies. Integrating digital systems within firms and across systems in a given field can facilitate sustainability objectives and outcomes.

While the pink bubble with the keywords ‘sustainability’, ‘framework’, ‘challenges’, ‘performance’, and ‘impact’ express how a digitalization for sustainability aims to integrate digital technologies and systems to promote environmental, social, and economic sustainability. This goal requires a framework that provides a strategic structure for integrating digital technologies into sustainable practices, guiding the challenges faced during implementation, and which serves as a benchmark for evaluating performance outcomes and the broader impact of digitalization initiatives on sustainability. Addressing these issues is essential to leverage digital technologies to drive sustainable practices and achieve positive results.

Figure 5: Thematic Map



5. Discussion

This bibliometric research allows us to analyze the main issues related to digitalization as a tool to foster sustainability. The approach used in this study compares information derived from the dataset used in Bibliometrix software with an analysis of some documents found in the dataset.

The exploration was conducted on 54 documents, including articles, conference proceedings, and preprints. The analysis of the trend of scientific production showed that in the past five years, research on the topic of digitalization for sustainability has grown and focused heavily on topics related to the circular economy, digitalization of the supply chain with a view to sustainability, and the use of technologies such as artificial intelligence and the Internet of Things.

Due to the intense global debate on the need for a transition toward sustainability, this trend has been more evident since 2018. This phase of increased attention on sustainability-related practices is linked to the events – and the subsequent European and global policies – that have highlighted the importance of addressing environmental, social, and economic challenges.

The reasons for such a growing interest in the topics under analysis is due to various reasons. First, the European Commission aims to achieve a zero-carbon economy by 2050 to meet the climate goals of the Paris Agreement. While the 2009 Renewable Energy Directive (RED) required renewable energy sources to provide 20 percent of the Union's total energy demand by 2020, the 2018 edition of the RED sets an even more ambitious target: to achieve 32 percent renewable energy by 2030. The new policy framework recognizes the significant role that digitalization can play in achieving these goals. Digital technologies and solutions can contribute to sustainability goals by facilitating the monitoring, reporting, and verification of renewable energy generation and consumption. At the same time, the directive emphasizes the importance of cross-sector integration and the role of individuals, communities, and public and private sectors in the transition to a low-carbon economy to promote innovation and accelerate the development and deployment of new sustainable technologies. As a result of this policy, there has been a growing interest in this topic since 2018.

In line with this growing interest, Del Río Castro et al. (2021) conducted a literature review examining the role of digital technologies in achieving the United Nations Sustainable Development Goals (SDGs). The authors highlight growing expectations regarding the potential of digitalization in contributing to the SDGs, including better access to new data sources, increased analytical capabilities, and collaboration within digital ecosystems.

Moreover, in November 2019, the European Parliament declared a climate emergency, asking the Commission to ensure that all proposals align with the goal of limiting global warming to below 1.5° C and significantly reducing greenhouse gas emissions. The European Commission consequently unveiled the European Green Deal, a roadmap to achieve climate neutrality in Europe by 2050, under which a new circular economy action plan is identified to build a cleaner and more competitive EU that fully contributes to climate neutrality.

Therefore, organizations, policymakers, and scholars worldwide increasingly emphasize the transition to a CE as a critical strategic priority. The CE can leverage new digital technologies like big data, artificial intelligence (AI), blockchain, and the Internet of Things (IoT), among others, to address various challenges and drive economic transformation. Combining these digital technologies and innovative business models is a promising solution for a wide range of global problems. Given the importance of CE and digitalization, there has been a significant increase in academic research in these areas in recent years.

Previous literature review studies have given valuable contributions, explicitly exploring the connections between CE and digitalization. For example, Awan et al. (2021) focus mainly on digitalization tools that can support the implementation of CE; other authors examine the interaction between the CE and information and communication technologies or provide insights on the challenges that firms face in achieving the digitalization required for CE (Demestichas and Daskalakis, 2020; Bag and Pretorius, 2022).

Finally, a further event that explains the growing interest in recent years in the topic of

digitalization to foster a transition toward sustainability can be ascribed to the shock caused by the recent COVID-19 pandemic. Following the emergence of the COVID-19 pandemic, scholars and practitioners have shown a significant increase in interest in cultivating resilience through digital transformation. Leveraging the capabilities of digital technologies enables organizations to proactively address immediate challenges and adapt to uncertain circumstances, including sustainable transition-related ones.

The analysis conducted on the various papers shows a shared focus on the intersection of digital technologies, sustainability, and their applications in various sectors, highlighting the potential benefits, challenges, and associated strategies.

The similarities and common themes of the analyzed papers include: exploring the potential of technologies such as the Internet of Things (IoT), big data, artificial intelligence (AI), and other emerging technologies to drive innovation, improve sustainability, and address environmental challenges; the potential of digitalization and emerging technologies to support circular economy goals by improving resource efficiency, enabling resource sharing, enhancing transparency, and optimizing processes; and the critical success factors associated with the adoption and implementation of digital technologies for sustainability.

The potential of digital technologies to disrupt linear business models, enable mass customization, and improve sustainability in various sectors is recognized. Emphasis is placed on the role of digital technologies in improving supply chain sustainability and opportunities to optimize manufacturing, logistics, and waste recovery.

Specific applications of emerging technologies in logistics are examined, such as real-time tracking, inventory management and waste reduction, demand forecasting, and product life extension. It also emerges the role of information technologies in finding green solutions, improving workforce and infrastructure utilization, and increasing productivity.

Emphasis is also placed on the critical success factors for implementing emerging technologies to achieve circular economy goals. Here, the importance of addressing technology readiness, equipping organizations with adequate IT infrastructure, data management, stakeholder collaboration, workforce skills, and management commitment emerges.

6. Conclusion

Digitalization for sustainable development processes is an increasingly significant area of research involving researchers, policymakers, and practitioners.

Nevertheless, academic research today is not yet sufficiently complete and ready to give guidance in this regard. There are still many “open issues” regarding the role of digitalization in promoting sustainability (e.g., how new technologies contribute to developing digital solutions that can help industries toward the adoption of CE practices; how management scholars contribute to the support of companies by defining pathways for training competent human resources and supervise transition toward sustainability).

Our study provides a comprehensive overview of the current literature and thematic trends on digitalization for sustainability. The purpose is to provide a comprehensive picture of the topic under consideration, highlighting established, emerging, motor, and niche themes.

The results show that, since 2018, scholarly attention has focused predominantly on integrating digital technologies to enable sustainable industrial models and practices, with an emphasis on CE principles. The year 2018, indeed, has marked a shift to more challenging SDGs than the previous version of the RED, and the analysis shows how some contributions are oriented toward demonstrating how the use of new digital technologies provides support for businesses toward the transition from a traditional linear economy to a circular economy.

Some authors also emphasize the importance of using big data to foster the adoption and monitoring

of sustainable practices or the importance of collaboration between different stakeholders to achieve sustainability goals.

Other authors point out that continuous monitoring and real-time tracking of supply chains are needed to help organizations identify and address problems quickly and to foster transparent reporting of sustainability performance, which can help reduce waste and optimize logistic processes.

The main studies concerning the link between digitalization and sustainability focus on the tools facilitating a transaction toward a circular economy and the critical success factors.

However, there has been a lack of insights related to: 1) what is the role of policymakers in fostering the adoption of new technologies for sustainability with targeted policies; 2) how does the role of digitalization vary in achieving sustainability across sectors; and 3) how can challenges in adopting technologies that contribute to sustainability goals be mitigated.

Our systematic literature review offers valuable insights for both academics and practitioners. On the one hand, in particular, it contributes to advancing the literature regarding the use of digitalization tools for sustainability purposes and rapidly aligning academic research with the needs of management practice.

It provides an up-to-date and detailed picture of the themes and the discourses that circle the topic in question and also informs the challenges regarding how digitalization can help address sustainability transitions. These insights can promote, at the same time, a better comprehension of the phenomenon and a better academic response to the issues of practice.

On the other hand, the paper has several important practical implications for managers, logistics directors, product developers and innovators, public administrators, consultants, and regulators. Indeed, this work responds to the call for practical support in understanding how to use digitization to achieve sustainability goals. For example, the study highlighted the main tools used for this purpose and the primary benefits to organizations.

In addition, the main obstacles to this process are also highlighted, such as the trade-off between resilience and sustainability, the absence of structured data management processes and lack of appropriate regulations, the scarcity of environmental education within organizations, and some negative consequences of disruptive technologies (unpredictability and vulnerability of information).

Naturally, this study also presents some limitations, which are described below.

First, the study's main weakness concerns the tools used in the data collection process. The sample in this study, indeed, was collected from the WoS database. Researchers may conduct further analysis using other academic and independent databases such as Scopus and Google Scholar.

Second, the keywords used in querying the database could be a barrier to exploring other related themes to the topic. Furthermore, some exclusion criteria were imposed during the sample collection as language and research fields.

In the future, additional studies could extend our protocol for much better results by including articles written in different languages and integrating other keywords. Future analyses could also try to understand the causes of such geographical concentration and the motivation behind the choice not to conduct studies on this topic in some regions of the world.

It would be helpful to conduct a comparative analysis between countries active in this research field and countries not currently involved. Finally, the study also highlights unexplored topics that researchers can study further from policymaking and managerial perspectives.

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