



Sustainability through digital transformation: A systematic literature review for research guidance

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ABSTRACT

Motivated by the rising attention of businesses and regulators towards how digital transformation can assist sustainability improvement, this paper sheds light on the relationships between these two phenomena. Specifically, this research pioneers the study of ‘digital sustainability’ through a systematic review of 153 academic articles aimed to 1) consolidate the existing research, 2) understand the thematic connections amongst the different studies, and 3) identify research gaps to move forward in the development of the topic. The suggested research agenda has important theoretical and practical implications. Through the identified gaps, this study acknowledges the management scholarship of pitfalls and delays on the research topic, providing detailed guidance to develop this new stream of subject area. The opportunistic approach of this paper responds to the practical call for support in understanding the use of digitalization for sustainability-related goals. This research directly impacts a wide range of practitioners, including managers, consultants, and policymakers.

1. Introduction

Digital technologies are an operant resource to achieve goals (Nambisan et al., 2019). How to exploit and speed the digital and sustainability transformation process is at the centre of the debate of major management consultancies (Accenture Strategy & GeSI, 2016; Deloitte & GeSI, 2019; Gartner, 2019; PWC, 2018) and on top of many governments’ agendas (European Commission, 2020; United Nations, 2020; World Bank, 2020). The exponential advance of artificial intelligence and machine learning is evident (Di Vaio et al., 2020), and as noted by Merrill et al. (2019), both businesses and governments are competing to exploit their potential. In this accruing competitive landscape, the unavoidable transition to digitalization is acknowledged through the term ‘digital imperative’ (George et al., 2020).

In 2002, Alakeson and Wilsdon were already urging policy development to take advantage of the ability of digital technology to strengthen economic growth whilst putting less pressure on the environment. Such potential spans a wide range of applicable arenas, among which are knowledge development and sharing, information transparency, management and assessment, communication, coordination, trust, as well as access and reach (Di Vaio et al., 2021). This applies not only to businesses, but to the wider concept of institutions (George et al., 2020).

However, while sustainability is undisputedly one of the most growing phenomena, it is still an insufficiently discussed field of application for digital technology (George et al., 2020; Merrill et al., 2019). This is a peculiarity in the management literature, as it is widely known that leading organizations are increasingly using such technologies to transform their business models with the purpose of better tackling societal challenges (Di Vaio et al., 2021; Ferreira et al., 2019; Gartner, 2020; George et al., 2020; Nill & Kempf, 2009; Smith et al., 2005).

Skepticism on the actual positive effects of digitalization on sustainability may subsist in absence of clear evidence. However, if the digital transformation process cannot be stopped, how can we adopt a conscious ethical willing in the use we do of it? The lack of academic guidance on the topic requires attention as it has direct implications on regulators and practitioners in terms of policy development and effective strategy building. Here the question is what contribution the management scholars are providing in support of companies and business regulatory bodies. At stake is how science fulfils its promise as the innovation driver for both the economy and society (Perkmann et al., 2021).

The proposed research joins the current conversation on sustainable innovation, and more specifically on the reconciliation between sustainability challenges and innovation practices (Cillo et al., 2019; Orlando et al., 2020; Shahzad et al., 2020), further advancing it with a

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critical focus on digital transformation. A recent review on the use of digital technologies towards the achievement of the UN Sustainable Development Goals (SDG) is by [Del Río Castro et al. \(2021\)](#). Their paper shows rising expectations on the contribution of digitalization in pursuing the SDGs, particularly due to access to new data sources, improvement of analytical capacities, and cooperation among digital ecosystems. Yet, the authors largely ground their study on extra-academic literature, with explicit focus on the SDGs. Therefore, there remains a call for the understanding and gauging of scholars' contribution towards the topic, which highly motivates the development of this paper. Looking to clarify the comprehensive use of digital transformation for sustainability purposes, this work analyzes the extant academic literature on the relationship between digitalization and sustainability, guided by the following research question:

RQ: "How can sustainability improve through digital transformation?"

To advance the enquiry, a systematic literature review is carried out with three research objectives: 1) consolidate the existing research, 2) understand the thematic connections among the different studies, and 3) identify research gaps to move forward in the development of the subject. These are achieved by giving equal emphasis to both research profiling and content analysis (e.g. [Dhir et al., 2020](#); [Khan et al., 2021](#); [Sahu et al., 2020](#); [Tandon et al., 2020](#)).

As noted by [Kushwah et al. \(2019\)](#), systematic reviews have the ability to provide useful insights to both academics and practitioners. In particular, this review contributes to accelerate the alignment of academic research with management practice agendas, by understanding and potentially catching up with this phenomenon. On the theoretical side, this study responds to the pertinent need of informing the scholarly community on the pitfalls of the extant literature on how digital transformation can help addressing sustainability, which implies the development of better academic responses to practical issues.

The implications of this research are likewise important to practitioners and regulators, who are confronted by both the sustainability and digital transformation processes and strive to exploit the synergies existing between the two phenomena. This does not mean that the study of digitalization for sustainability purposes should be in the exclusive management domain. However, the significant extension of the management production on both topics independently suggests the need for a joint consideration of the phenomena as a next, natural stream of research.

Given the explicit intent to solve practical issues, the scope of this research requires an opportunistic approach to settle the basis for moving the subject forward. A deductive rather than inductive approach ([Trochim & Donnelly, 2007](#)) is adopted here with the intent of allowing the immediate identification of papers focusing on the digitalization/sustainability relationship. As a result, this study investigates and maps the existing literature at the broadest level. Gauging and investigating the actual impact of one phenomenon on the other is just one of the possible research developments which may originate from this study. As a corollary of this, it is excluded from the scope of this research to enforce a message of univocal, positive relationship between digital transformation and the improvement of sustainability.

Given the above premises, this research is structured as follows: [Section 2](#) provides a brief clarification of the relationship between sustainability and digitalization, which is at the core of this study. [Section 3](#) explains the chosen research methodology. [Section 4](#) and [Section 5](#) present the research profile and the thematic foci of the extant literature. [Section 6](#) discusses the results, highlighting research gaps, future academic research development (synthesized in a research agenda), theoretical and practical implications of this paper, as well as its limitations. Finally, [Section 8](#) presents concluding remarks.

2. On the relationship between sustainability and digitalization

As mentioned by [Río Castro et al. \(2021\)](#) and [Brenner and Hartl \(2021\)](#), sustainability and digitalization stand as megatrends shaping

the economy and society, thus urging major transitions. However, at a first glance, 'sustainability' and 'digital technologies' appear as disparate terms ([George et al., 2020](#)). Authors such as [Gebhardt \(2017\)](#) mention that as conflicting concepts they lead to a paradigm shift in social and ecological systems. Still, [Osburg \(2017\)](#) remarks that those terms are game changers and strategic imperatives able to trigger major transformations.

The holistic character of the two concepts makes it very difficult to define them. The most accepted definition of 'sustainability' across academics, practitioners and policy makers, was developed by the [UN Brundtland Commission in 1987](#) as the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" ([Sturmer et al., 2017](#); [Gartner, 2019](#)). According to [Banerjee \(2003\)](#), this definition is often used interchangeably with 'sustainable development', but it is just one of the several definitions that have been developed throughout the years. Authors such as [Moldavska and Welo \(2017\)](#) and [Del Río Castro et al. \(2021\)](#) claim that the concept of sustainability has often been misused, incorporating different views which weakened the actual meaning and undermined its realization. As a matter of fact, the domain of 'sustainability' is difficult to define, because the term is multi- and trans-disciplinary, influencing socio-economic organizations at all levels, through actions, decisions and behaviors ([Caputo et al., 2021](#)). For instance, the decision-making with regards to sustainability often presents cultural biases and reveals contrasting approaches with regards to open-mindedness, investment attitude, and risk perception. This applies to multiple stakeholders such as owner-managers, governments as well as customers ([Cegarra-Navarro et al., 2019](#); [Del Giudice et al., 2017](#); [Orlando et al., 2020](#)). Last, but not the least, sustainability highly depends on stakeholders' engagement in the co-creation of shared value ([Chaurasia et al., 2020](#)). As a result, the debate on definitions is far from being closed and the need for a unified definition of sustainability is questioned in the first place ([Banerjee, 2003](#); [Ramsey, 2015](#)). The existence of different perspectives on sustainability can enrich the debate ([Ruggerio, 2021](#)), potentially making it more applicable to specific sectors or stakeholders. Specifications in different contexts include, for instance, 'urban sustainability' ([Turcu, 2013](#)), or 'sustainable manufacturing' ([Moldavska & Welo, 2017](#)). Also, professional bodies such as the Chartered Institute of Procurement and Supply (CIPS) have developed their own definitions, such as 'sustainable procurement' as "the act of adopting social, economic and environmental factors alongside the typical price and quality considerations into the organizations' handling of procurement processes and procedures" ([CIPS, 2021](#)). In addition, the diverse range of stakeholders, including governments, non-governmental organizations, consumers, and corporations, all have a different perception of what sustainability encompasses ([Pepe et al., 2018](#); [Souza et al., 2015](#)). In this regard, it is important to note that Western definitions of sustainability and 'sustainable development' have also been criticized for severe consequences on minorities such as indigenous communities ([Banerjee, 2003](#)). It is argued that considering minority perspectives may instead lead not only to a major integration, but also to new conceptions of the socio-technical change, characterized by a fairer and more natural understanding of sustainability ([Pyhälä, 2020](#); [Velasco-Herrejón et al., 2022](#)). Still, the existence of different stakeholders' perspectives is one of the major gaps in the implementation of sustainability ([Souza et al., 2015](#)) and any attempt to further develop a universal concept may prolong the controversial debate ([Del Río Castro et al., 2021](#); [White, 2013](#)).

Of similar complexity is the agreement on a terminology for 'digitalization' and its derivatives, such as 'digital technology' and 'digital transformation'. Often literature uses 'digitization', 'digitalization', or 'digital transformation' as inter-changeable terms ([Gong & Ribiere, 2020](#); [Mergel et al., 2019](#)). For instance, according to [Gartner \(2021\)](#), 'digitalization' is the use of digital technologies to provide new value-producing opportunities as well as the process of moving to a digital business. This is not too far from [Hanelt et al.'s \(2020\)](#) definition of

‘digital transformation’ as the organizational change that is triggered and shaped by the widespread diffusion of digital technologies. Independently of terminology, digitization is currently the most important driver of entrepreneurship and innovation (Berger et al., 2021).

Acknowledging the existence of strengthening relationship and increasing convergence between the ‘sustainability’ and ‘digitalization’, the professional environment has coined the term ‘digital sustainability’. In this regard, both practice and academics put the emphasis on the achievement of sustainability development goals. In fact, for the Cybercom Group (2021), digital sustainability is “the means by which digitalisation, as a key part of the fourth industrial revolution, can deliver on the global sustainability goals”. Likewise, George et al. (2020) defines digital sustainability as “the organizational activities that seek to advance the sustainable development goals through creative deployment of technologies that create, use, transmit, or source electronic data”. As mentioned by Markman et al. (2016), sustainability is often perceived as being in conflict with other goals or missions. In this case, ‘digital sustainability’ has the power of unifying the two strategic objectives of sustainability and digital transformation to drive positive societal and environmental changes rather than just focusing on reducing them.

Widely recognized in literature is the potential of specific forms of digitalization towards the development of sustainability (Di Vaio et al., 2020; Gebler et al., 2014; Rai et al., 2006; Saberi et al., 2019, among the others). For example, Information and Communication Technologies (ICT) and the Internet of Things (IoT) play fundamental roles in advancing sustainability, improving transparency or assessment abilities thanks to the contribution of big data analysis and management (Del Río Castro et al., 2021; Paiola et al., 2021). In addition, innovation as a whole is recognized as a vehicle for sustainability (Fagerberg, 2018; Smith et al., 2010), for instance through the shared value created by knowledge management systems, openness of access, and organizational structure (Chaurasia et al., 2020).

However, it is important to note that a positive correlation between the two elements of sustainability and digitalization as suggested or implied by the definition of ‘digital sustainability’ is not a given. As mentioned by Smith et al. (2010), innovation challenges not only concern the economic potential, but also the societal challenges that the innovation activity may cause, along with their consequences on the social and environmental aspects of sustainability. For this reason,

Table 1
Literature Search and Selection.

Source-Type Restriction			
Academic Articles (2000-August 2021)			
Keyword Search	Database		
	EBSCO Business Source Premier	Science Direct	Web of Science
“digital*” and “sustainab*” (topic/topic)	1933 First source found in 2001	1981 First source found in 2001	5594 First source found in 2000
“digital*” and “sustainab*” (title/title)	118	70	372
“digital*” and “social responsib*” (title/title)	7	2	14
“digital*” and “business ethic*” (title/title)	2	0	2
“digital sustainab*” (topic but not title)	9	2	16
Quality Restriction SJR Q1 TOT. 153 (Selected Sample)			

sustainable development explicitly requires normative development concerning innovation. Caputo et al. (2020) note that sustainable innovation is only possible if all the levels of the socio-economic organizations are engaged. As mentioned by Ardito et al. (2021), there is no evidence that combining digitalization and sustainability benefits a firm’s performance. While there is an overall optimistic view about the opportunities that digitalization offers to sustainability, it is important to keep high the awareness that digitalization can be a disruptive force which if unintended, uncontrolled or underestimated, may negatively affect sustainability and its development (Andriushchenko et al., 2020; Carnerud et al., 2020; Flyverbom et al., 2019; Ghobakhloo, 2020). For this reason, Aksin-Sivrikaya and Bhattacharya (2017) call for the development of sustainable governance models able to reduce digitalization vs sustainability frictions and boost opportunities. To shed some light on the issue, Brenner and Hartl (2021) analyse how digitalization is differently perceived in relation to the ecological, economic and social components of sustainability. Still, the question of legitimacy of technology and innovation for transformative changes in the first place remains answered (Weber & Rohrer, 2012; Genus & Coles, 2008).

3. Methodology

Reviews are the foundation of new research (Webster & Watson, 2002). The choice of the most appropriate review methodology depends on the research question or the specific purpose of the review (Snyder, 2019). As other researchers in the business management field (e.g. Crossan & Apaydin, 2010; Hanelt et al., 2020), the systematic review in this study follows the organized 3-steps framework suggested by Tranfield et al. (2003) and consisting of: 1) data collection, 2) data analysis, and 3) synthesis.

4. Research design

Similar to Reis et al. (2018), to approach the research topic in a comprehensive and unbiased way, the analysis is conducted through two complementary approaches: a quantitative characterization of the selected publications (see ‘Research Profile’ in Sec. 4), and a qualitative characterization based on content analysis (see ‘Thematic Foci’ in Sec. 5). The quantitative characterization is based on papers’ grouping according to: 1) Date of publication (‘Historical development’ in Sec.4.1); 2) Academic source and citations (‘Journal of publication and citations’ in Sec.4.2); 3) Articles methodology (‘Sample Research Design’ in Sec.4.3), and 4) Keywords in the title of the articles (‘Terminology’ in Sec. 4.4). The qualitative characterization follows Mayring’s (2000, 2014) five steps for content analysis: (1) develop a category system according to the research purpose, (2) code relevant passages in the text according to the category system, (3) revise the previously developed classification framework, (4) code the text according to the revised category system, and (5) interpret and discuss the final results. More specifically the initial codes, based on the keywords in the title of the articles (Sec.4.4), were grouped into categories to facilitate the content analysis (Appendix A, Tables A.1 and A.2). This process allowed to verify and highlight the connection of the selected articles with the topic addressed in this study, leading to the detection of four main themes: digitalization strategies for sustainability purposes (Sec. 5.1), applicability to industries or sectors (Sec. 5.2), applicability by organizational and stakeholder type (Sec. 5.3), and sustainability through specific digital technologies or functionalities (Sec. 5.4).

4.1. Database search

Sources were limited to peer-reviewed journals, to access trustful sources and in line with the objective of understanding the status-quo of scholars’ contributions on the topic. The initial search was performed through the EBSCO Business Source Premier database, which is one of the main references for sources in business studies (Hanelt et al., 2020).

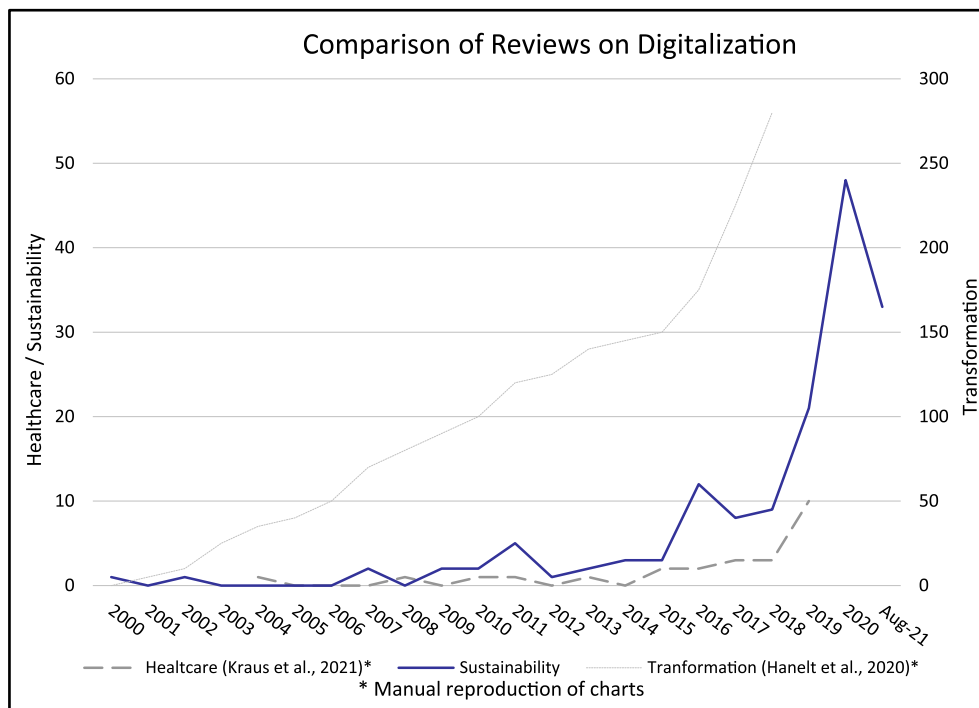


Fig. 1. Development of academic publication by year.

However, to ensure a complete coverage, results were compared and, if needed, integrated with Web of Science and ScienceDirect search engines without any specific field restriction. As this review tackles an uprising field, similar to Di Vaio et al. (2021), no time restrictions were imposed with the purpose of collecting all relevant literature available on the examined databases. As a result, this study covers the academic outputs between 2000 (first article found on the topic) and August 2021.

4.2. Selection criteria: steps, keywords, and restrictions

As previously mentioned, the topic of this paper is the combination of two main subject areas, ‘digital transformation’ and ‘sustainability’. Recognizing that this focused selection potentially excluded relevant papers, a stepwise iterative search approach was implemented. This approach is particularly important not only to select content, but also to highlight synthesis of topics in continue development (Cook & West, 2012).

To ensure a comprehensive cohort of relevant papers, the search looked at 1) derivatives of the word ‘digital’ and ‘sustainability’ as well as 2) words that are content related to the two terms. As Kraus et al. (2021), the asterisk after ‘digital’ allows to access a wider cohort of research, derived from the word ‘digital’ (e.g. digitalized, digitally) and including both English and American spelling (e.g. digitalisation or digitalization).

The literature selection process is described in Table 1. Specifically, the selection started with ‘digital*’ and ‘sustainab*’ as topic. This search initially cast a net of over 4,000 academic articles. Therefore, as a first screening to grab the most focused literature on the topic, the search was limited to ‘digital*’ and ‘sustainab*’ words in the title. For completeness, the search was integrated with ‘digital*’ and ‘social responsib*’ as well as ‘digital*’ and ‘business ethic*’ as keywords in the ‘title’. The expression ‘digital sustainab*’ was also searched as ‘topic but not title’, given its relevance for the investigated topic.

Two types of restrictions were applied: source-type and quality. With regards to the source type, we felt the need to restrict the search to academic articles in line with our interest in exploring the state of development of academic research on the topic. In addition, we limited the

search to peer-reviewed journals. The quality restriction applied was at least half of subject areas in the first quartile (Q1) of the Scimago Journal Review (SJR) ranking. Furthermore, despite the intention of not restricting academic production exclusively to managerial journals, some findings were manually removed because referring to contexts or meanings different from the sought ones, such as ‘financial sustainability’ in Gofran Faroqi (2015) or ‘sustainability of competitive advantages’ in Knudsen et al. (2021). This approach resulted in a total sample of 153 papers.

It is important to note that the undertaken approach as per Table 1 voluntarily excludes few highly cited papers related to the topic, because of too specified a scope and the lack of reference towards the sought digitalization/sustainability relationship. Some examples are the works on digitally enabled supply chain integration (Rai et al., 2006), on sustainable urbanization (de Jong et al., 2015), on 3D printing (Gebler et al., 2014), or on blockchain in supply chain (Saber et al., 2019).

5. Research profile

5.1. Historical development

The analysis of the historical development of the topic is based on the date of publications. The graph in Fig. 1 identifies the first publication in 2000 and shows the development of the topic up to August 2021. The analysis of the academic articles per year reveals that there were only isolated publications until 2010. It is only in 2020 that the number of articles reached peak levels (a total of 48). This demonstrates that the academic environment has drastically worked in picking up on the relationship between digitalization and sustainability. This result itself is very significant as the greatest number in academic publications coincided with the first year of the COVID pandemic. The number of published articles is continuing to rise (already 33 articles up to August 2021). The increase in outputs is in line with those authors such as Allam and Jones (2021) and Hanelt et al. (2020). Among the benefits of digitalization, they remark on the ability of allowing better reactions to hard times. In doing so, these authors leave aside discussions about the negative effects of digitalization in favor of a more pragmatic, reactive

Table 2
Distribution of published papers, ABS 2021 ranking, and citations by journal up to August 2021.

Academic Journal & Field	N. Papers per Journal ≥ 3
Journal of Cleaner Production - <i>Ethics, CSR, Management</i> (Isensee et al., 2020; Ricci et al., 2020)	17
International Journal of Digital Earth - <i>Earth & Computer Sciences</i> (Guo et al., 2020, 2018; Hernandez, 2017)	4
Sustainability Science - <i>Environmental & Social Science</i> (Cutts et al., 2020)	4
Entrepreneurship and Sustainability Issues - <i>Ethics, CSR, Management</i> (Andriushchenko et al., 2020)	3
Government Information Quarterly - <i>Social Sciences</i> (Janowski et al., 2018)	3
International Journal of Agricultural Sustainability - <i>Agricultural & Biological Sciences, Economics & Econometrics</i> (Cook et al., 2021; Silvestri et al., 2020; Ortiz-Crespo et al., 2020)	3
Journal of Medical Internet Research - <i>Health Informatics</i> (Jagesar et al., 2021)	3
Technological Forecasting & Social Change - <i>Business, Management, Accounting, Psychology</i> (Denicolai et al., 2021)	3
Academic Journals & Fields	≥ 3 ABS 2021 ranking
Business Strategy & the Environment - <i>Business, Management and Accounting, Environmental Sciences</i> (Forcadell et al., 2020; Evans et al., 2017)	3
Ecological Economics - <i>Economics and Econometrics, Environmental Sciences</i> (ElMassah and Mohieldin, 2020)	3
Entrepreneurship Theory and Practice - <i>Business, Management, Accounting, Economics & Econometrics</i> (George et al., 2020)	4
Environmental Science & Policy - <i>Environmental Science, Social Sciences</i> (Kunkel and Matthes, 2020)	3
Government Information Quarterly - <i>Social Sciences</i> (Janowski, 2016)	3
Industrial Marketing Management - <i>Marketing</i> (Sivarajah et al., 2020)	3
Information Systems Frontiers - <i>Computer Sciences & Mathematics</i> (Delgosha et al., 2020)	3
Information Systems Journal - <i>Computer Sciences</i> (Tim et al., 2021)	4
International Journal of Research in Marketing - <i>Marketing</i> (Kull and Heath, 2016)	4
Journal of Business Ethics - <i>Arts & Humanities, Business, Management, Accounting, Law, Economics & Econometrics</i> (López Jiménez et al., 2021)	3
Journal of Business Research - <i>Business, Management and Accounting</i> (Okazaki et al., 2020)	3
Journal of Rural Studies - <i>Agricultural & Biological Sciences, Social Sciences</i> (Pant and Hambly Odame, 2017)	3
Journal of the Association for Information Science and Technology - <i>Computer Sciences, Decision & Social Sciences</i> (Chowdhury, 2016)	3
Organization & Environment - <i>Business, Management & Accounting, Environmental Sciences</i> (Hüttel et al., 2020)	3
Technological Forecasting & Social Change - <i>Business, Management, Accounting, Psychology</i> (Hidalgo et al., 2020)	3
Transportation Research Part A-Policy and Practice - <i>Engineering, Decision & Social Sciences</i> (Sgibnev and Rekhviashvili, 2020)	3
Academic Journal, Field & Article	N. Citations ≥ 30
Journal of Cleaner Production - <i>Ethics, CSR, Management</i> (Chen et al., 2015)	177
Journal of Cleaner Production - <i>Ethics, CSR, Management</i> (Bechtsis et al., 2017)	64
International Journal of Precision Engineering and Manufacturing-Green Technology - <i>Engineering and Management</i> (Beier et al., 2017)	53
IEEE Transactions on Power Electronics - <i>Engineering</i> (Chun & Kwasinski, 2011)	49
Journal of Cleaner Production - <i>Ethics, CSR, Management</i> (Holmstrom et al., 2017)	33
Journal of Cleaner Production - <i>Ethics, CSR, Management</i> (Kaewunruen & Lian, 2019)	33

Table 2 (continued)

Academic Journal & Field	N. Papers per Journal ≥ 3
Library Trends - <i>Library and Information Sciences</i> (Bradley, 2007)	32
Information Technology for Development - <i>Computer & Social Sciences</i> (Armenta-Ramade et al., 2011)	32

and opportunistic approach to its employment. It is also important to mention that, despite the samples being selected with different criteria, overall the graph follows the trends outlined by Kraus et al. (2021) with regards to digital transformation in healthcare, but with a higher number of outputs since 2009. Instead, a certain delay exists if compared to the widest topic of digital transformation, which has been constantly growing in the past 20 years, with a noteworthy surge since 2015, as shown by Hanelt et al. (2020).

5.2. Journals of publication and citations

The analysis of the academic journals publishing on the topic focused on 1) revealing the journals publishing on the topic, and 2) detecting where highly cited articles were published. Applying the quality selection criteria ‘SJrq1’, publications are distributed among a wide range of journals, with the Journal of Cleaner Production leading the chart of most published articles on the topic (17 as per Table 2). With the purpose of further highlighting the presence of the topic in relevant journals, the papers were also analyzed according to the Chartered Association of Business Schools latest published journal ranking of ‘major or equal to 3 stars’ (ABS 2021 ≥ 3). Only 17/153 (i.e. 11%) of our sample is ABS ≥ 3 , with only three publications equal to 4 ABS stars (George et al., 2020; Kull & Heath, 2016; Tim et al., 2021). It should be also noted that removing any quality constraint, the number of published articles drastically increase in sustainability journals.

This clearly demonstrates how academic publications are scattered. In addition, it is important to mention that the number of citations in all databases according to the Web of Science, are still quite low, with just one article cited more than 170 times (Chen et al., 2015) and 7 articles over or equal to 30 citations. Again, the highly cited papers belong to the Journal of Cleaner Production (Bechtsis et al., 2017; Chen et al., 2015). Yet, it must be noted that some journals with the most cited papers belong to the engineering, computer science and information fields.

5.3. Sample research design

The analysis of the research design is based on the methodology of the articles in the selected sample. In particular, the 153 papers were firstly divided into literature review, theoretical and empirical works. The empirical works were further distinguished in case studies, surveys/questionnaires, tests/PLS, structural equation modelling, and others. Fig. 2 shows a bias towards empirical works, which represented almost half of our sample.

The chart reveals that scholars have used a variety of methodologies, with most studies involving case study research (14.9% of the whole sample, 32% of empirical studies). In addition, 16.7% of empirical studies were conducted through surveys/questionnaires, followed by structural equation modelling and regressions/test/PLS. Other studies included videos, picture, ethnographic and focused group evidence as well as maps and mixed methods.

5.4. Terminology

Keywords in the title of the articles are gathered in the word cloud in Fig. 3 which reveals what terminology is most used to indicate articles on the topic. Details on the coded words are provided in Appendix A, Table A.1

analysis suggests an academic focus on the phenomenon of digitalization rather than the intention of using it strategically in favor of sustainability. In fact, it was possible to identify only three sources that use ‘digital transformation’ in the title of the selected sample (Andriushchenko et al., 2020; ElMassah & Mohieldin, 2020; Kunkel & Matthes, 2020).

However, even less common is the term ‘sustainable transformation’ in the title (just Goh et al., 2021), as if digitalization did not have a role in the development of sustainability.

6. Thematic Foci

The contents of the selected articles were analyzed to develop insights on how digital transformation can help achieve sustainability, as per the research question. To understand the themes used in academic research, the initial coding based on the keywords in the title of the selected articles were summarized in thematic categories, highlighted in the text and thematically connected (Mayring, 2000; 2014) as shown in the Appendix A (Tables A.1 and A.2). Four main themes were identified to shade light onto the nature of the relationships between sustainability and digitalization: 1) Digitalization strategies for sustainability purposes; 2) Applicability to industries or sectors; 3) Applicability by organizational and stakeholder type; 4) Sustainability through specific digital technologies and functionalities.

6.1. Digitalization strategies for sustainability purposes

When considering the strategic role that digital technology can play to enhance sustainability, one of the most recurrent themes is SDGs. Known as the UN Agenda 2030, the 17 SDGs span over a wide range of issues and build upon the advancements in the subject of sustainable development over the past 30 years (Del Río Castro et al., 2021; ElMassah & Mohieldin, 2020). In this regard, Mondejar et al. (2021) highlight the different opportunities offered by digitalization in the achievement of SDGs. However, our literature sample reveals a bias towards two characteristics. The first is about the focus on policy making (e.g. ElMassah & Mohieldin, 2020; López Jiménez et al., 2021). The second is the localized and sectorial boundaries of the published articles, despite the claim of SDGs having an overarching, global reach (e.g. Asi & Williams, 2018; ElMassah & Mohieldin, 2020). At this regard, the un-discussed role of businesses in contributing through digitalization to SDGs, and sustainability more in general, seems neglected by academic production or touched only at high level (e.g. George et al., 2020).

Yet, a number of articles explicitly address digital opportunities for sustainability as part of a business strategy in a new era of scientific and technological progress (Andriushchenko et al., 2020; Ghobakhloo, 2020). Many articles propose business models to guide strategic application. Even in this case, the majority of articles are sector or function oriented, such as Pignataro et al. (2014) on contemporary architecture, or Carnerud et al. (2020) on quality management. Some involve the embedding digital technologies towards sustainable entrepreneurship. For instance, Gregori and Holzmann (2020) approach the question focusing on the concept of value creation, while Andriushchenko et al. (2020) look at predicting the development and minimizing the risks of digital transformation.

In addition, it is important to note that numerous studies investigating the strategic relationship between sustainability or digitalization focus on restricted geographies. This is sometimes highlighted in the title (e.g. Alakeson & Wilsdon, 2002; Beier et al., 2017; Singh et al., 2021), but in most of cases emerges from the content. For instance, Paiola et al.'s (2021) use case studies from the Italian manufacturing landscape to explain how digital servitization impacts sustainability. Similarly, Ukko et al.'s (2019) study on the role of sustainability strategy on the relationship between digital business strategy and financial performance is based on evidences from Finnish SMEs.

6.2. Applicability to industries or sectors

The analyzed literature also reveals a preference of scholars towards specific industries or sectors. Among those, a frequent theme is the application of digital technology to agriculture (Clapp & Ruder, 2020; Lajoie-O'Malley et al., 2020; Sott et al., 2020, among the others) or to rural communities (Pant & Hambly Odame, 2017; Tim et al., 2021). In particular, the research focus is on understanding the use, the access as well as the environmental, social, and political implications of technologies for agriculture.

Several publications look also at ‘Industry 4.0’, highlighting the meaning and the trends implied by such term in relation to sustainability aspects (e.g. Beier et al., 2020; Ghobakhloo, 2020). Particular attention is put on manufacturing and supply chain (Lafferty, 2019; Nica, 2019; Ozkan-Ozen et al., 2020; Plumpton, 2019, among the others). It is noted that at industry or sector level, articles become much more strategic than descriptive (e.g. Holmström et al., 2017). Among those, Chen et al. (2015) and Lee et al. (2019) explicitly recognize that digital manufacturing is one of the most salient topics in the manufacturing practice and according to the authors, digitalization has a positive effect on sustainability development if challenges of social and technological changes are addressed.

Moreover, the search highlights several publications concerning libraries, particularly with regards to the value of digital information, as well as the effects and the path towards digital learning (e.g. Chowdhury, 2016; Etter & Galt, 2009). Articles also explore the potential of digitalization towards urban sustainable development, particularly in light of trends and reaction to events (Allam & Jones, 2021; Balogun et al., 2020; Bouzguenda et al., 2021; Zheng et al., 2020). Finally, a number of literature outputs discuss the effects of digitalization on sustainability in healthcare (Asi & Williams, 2018; Oderanti et al., 2021; Persson & Rydenfält, 2021; Wadmann & Hoeyer, 2018), and tourism (Go et al., 2020; Martínez-Graña et al., 2016; Tiago et al., 2021).

Recurrent are also the themes of digitalization in relation to both sustainable production and consumption (Fuentes et al., 2021; Kull & Heath, 2016; Nica, 2019; Samsioe & Fuentes, 2021), or in relation to the energy and utility sectors (Chun & Kwasinski, 2011; Ci et al., 2020; Monks et al., 2021; Vlasov et al., 2019).

6.3. Applicability to organizations and stakeholders

Looking at the organizational types discussed on the relation between digitalization and sustainability, a first dramatic line can be drawn between ‘business’ and ‘government’. In fact, hardly studies involve or relate to both types of organizations, despite frequent is the claim of implications to both. Main discussions concern SDGs, touching upon policies to businesses (e.g. Del Río Castro et al., 2021; ElMassah & Mohieldin, 2020; George et al., 2020; Janowski, 2016). Within ‘businesses’, the major theme concerns business models (e.g. Gregori & Holzmann, 2020; Ludbrook et al., 2019; Oderanti et al., 2021). They generally apply only to specificities, such as entrepreneurship (e.g. Gregori & Holzmann, 2020; George et al., 2020), or SMEs (e.g. Paiola et al., 2021). In relation to government, main themes involve policy development (e.g. ElMassah & Mohieldin, 2020), support to specific stakeholders (e.g. Coates Nee, 2014), or administrative sustainable streamlining through digital technologies (Janowski, 2016; Janowski et al., 2018).

Stakeholders involved in the relationship between digitalization and sustainability are explicitly considered in Esposito and Ricci (2021), Lock and Seele (2017), and Velthoven and Cordon (2019). However, the theme is much more discussed through the aspects of networking, participation, and citizenship (e.g. Armenta-Ramade et al., 2011; Bouzguenda et al., 2019; Busch, 2011; Nica, 2019; Paiola et al., 2021). Among stakeholders frequently considered are communities (e.g. Pant & Hambly Odame, 2017; Tim et al., 2021), learners (e.g. Diniz dos Santos et al., 2019; Eitzel et al., 2018; Hidalgo et al., 2020) and consumers (e.g.

Fuentes et al., 2021; Kull & Heath, 2016).

6.4. Sustainability through specific digital technologies or functionalities

A wide compass of digital technologies and functionalities have been discussed among the highly fragmented topics of the selected sample. However, the main ones can be summarized in the following order:

1. ICT

Information is the most discussed theme concerning functionalities. Most articles refer to it separately from ‘communication’, rather than using the combined acronym ICT. Particularly, the topic of information is often related to the library sector and to learning activities (Anthony et al., 2020; Blau et al., 2020; Chowdhury, 2016). Some articles refer to ‘sustainability communication’ in specific fields such as self-adhesive labelling or tourism (Tesařová et al., 2020; Tiago et al., 2021). Social and digital media is also another popular theme (e.g. Liu, 2016; Nulman & Özkula, 2016; Okazaki et al., 2020; Sivarajah et al., 2020). Last but not least, part of the literature touches upon the corporate strategic use of ICT and the social issue of digital divide (Armenta-Ramade et al., 2011; Busch, 2011; Hidalgo et al., 2020).

2. Big data

In the digital era, big data are the ‘new oil’ (ElMassah & Mohieldin, 2020). The selected literature mentions them in relation to two aspects, specifically their contribution to sustainability as well as to sustainable IoT. With regards to the first, according to Seele (2016b), by enhancing communication and transparency, big data can trigger and monitor sustainability on large scale. In addition, big data enable stakeholders to rigorously observe and compare sustainability performance. However, a comprehensive theoretical (and regulatory) framework to control and sanction harmful activities is still missing. Focusing on business to business, Sivarajah et al. (2020) highlights the integrative role of big data and social media analytics to boost sustainability, particularly with specific functions such as marketing and operations. With regards to the second aspect, big data are often discussed in relation to the concept of Industry 4.0 and digital manufacturing (Lafferty, 2019; Plumpton, 2019; Seele, 2016a).

3. Digital twin

Highly discussed as specific technology in relation to sustainability is also the concept of digital twin. For instance, Allam and Jones (2021) discuss the role of digital twin in smart cities and urban development, explaining how such technology helps visualising and preparing for future sustainable cities. He et al. (2021) propose a data processing model for intelligent detection robotics aimed to the achievement of sustainable development goals. Recurrent themes are also the use of digital twin in manufacturing (e.g. Li et al., 2020; Park et al., 2020) and automated vehicles in supply chain (Bechtsis et al., 2017, 2018). Other articles consider the application of digital twin to specific contexts such as sustainable grinding wheels (Kannan & Arunachalam, 2018) or the railway turnout systems (Kaewunruen & Lian, 2019).

7. Discussion of findings

The crucial research question of “How can sustainability improve through digital transformation?” was approached through a rigorous literature review of 153 academic articles with the purpose of shedding light on the information available within the current academic offer. The first objective, to consolidate the existing research, was pursued through a thorough research profiling (Sec. 6.1). The second objective, to understand the thematic connections among the different studies, was developed in the thematic foci section (Sec.6.2). The third objective, to

identify research gaps to move forward in the development of the subject, is discussed in detail in this section, along with the important implications and the limitations of the presented results.

7.1. Research gaps

7.1.1. Management focus

It seems clear from the analyzed historical development in Sec.4.1 that a new, practice-inspired stream of research is in the making and we are likely to assist to a progressive flow of studies on how digital transformation can help achieving sustainability development in the very short term. However, the first gap identified through our research profiling is a lack of management focus on the topic. The analysis of the journals of publication and citations in Sec. 4.2 revealed that the extant literature is extremely fragmented and spread on a vast number of journals. Also highlighted is the oddly reduced number of publications on the relationship between digital transformation and sustainability in well-respected sources, which often specialize in subject areas other than management, such as computer science and information, or engineering. This is in stark contrast to the abundant attention and speculation of the theme among practitioners. It is also atypical, considering the wide range of papers existing on the separate topics of sustainability and digitalization in management publications. Therefore, from this viewpoint, the management literature largely fails to fulfil its role of synthesizing and guiding companies and business regulators in the implementation of programmes related to the topic. As digital transformation in sustainability is expected to become a ‘new normal’, it is also important to remark that the topic should not be considered only by journals specialized in sustainability, as it is currently in most of cases, but by the widest community of management scholars for its strict connection to other important subject areas such as innovation, performance, and development. Thus, there is an urgent need to acknowledge, develop, and publish papers focused on the topic.

7.1.2. Terminology alignment

A second research gap is found in the misalignment of the terminology used in academic research. This is shown by the scarce use of terms such as ‘digital sustainability’ or ‘digital transformation’ in sustainability contexts, as noted in Sec.4.4. For instance, while it is possible to find several sources related to this term on internet, an EBSCOhost search of ‘digital sustainability’ in ‘title’ resulted in only 9 journal articles, of which only two in the field ‘business/economics’ database. This result may conceal a conceptual delay with the practice environment in considering digitalization and sustainability as a unified goal and phenomenon, hence urging management researchers to converge towards a terminology more familiar to practice. By doing this, it would be already possible to reduce the extant literature fragmentation, offering much more focused research on the topic.

7.1.3. Overarching strategic studies

A major concern and still a major opportunity exists in the lack of overarching strategic studies, which represents the third gap identified in this study. The scattered thematic development of publications is perceived as the main issue in understanding the phenomenon of digital transformation for sustainability purposes and therefore a change in the approach to the topic is required in the future research. As revealed by the content analysis, the specificity of the sectors and contexts highly limits the generalizability and transferability of research findings. For the same reason, it is not possible to categorize the empirical research described in Fig. 2 by Thematic Foci to validate statements such as ‘big data and social media analytics boost sustainability’. This is because the sample at specificity level is too modest to drive significant conclusions at aggregate level.

Among the other consequences, there is the difficulty in gauging advantages and disadvantages of the use of digitalization for sustainability. This implies hindrances in understanding and controlling the

Table 3
Research Agenda.

#	Words in the title	Frequency		Categories	#	Words in the title	Frequency (Count ≥3)	Impact (% of Text)	Categories
		(Count ≥3)	Impact (% of Text)						
1	sustainability	120	16.80%	1, 2, 3, 4	41	network	5	0.40%	3, 4
2	digitalization	22	3.10%	1, 2, 3, 4	42	path	5	0.20%	1
3	technology	15	1.50%	1, 2, 3, 4	43	platform	5	0.40%	4
4	sustainable-development	14	3.20%	1	44	production	5	0.50%	2
5	system	14	0.80%	4	45	supply-chain	5	0.60%	2
6	information	12	1.40%	4	46	theory	5	0.30%	1
7	manufacturing	11	1.40%	2	47	twin	5	0.20%	4
8	smart	11	0.60%	4	48	analysis	4	0.30%	1
9	social	11	0.70%	3, 4	49	challenge	4	0.40%	1
10	city	10	0.40%	1, 2	50	citizenship	4	0.40%	3
11	innovation	10	1.00%	1, 2, 3, 4	51	community	4	0.40%	3
12	design	9	0.50%	4	52	digital-technology	4	0.70%	1
13	environment	9	1.00%	1	53	digital-transformation	4	0.90%	1
14	relationship	9	1.10%	1, 2, 3, 4	54	energy	4	0.20%	2
15	research	9	0.70%	1	55	internet-of-things	4	0.70%	4
16	economy	8	0.60%	1	56	responsibility	4	0.60%	1
17	industry-4.0	8	0.80%	2	57	strategy	4	0.30%	1
18	learning	8	0.60%	2	58	tool	4	0.20%	4
19	participation	8	1.00%	4	59	approach	3	0.20%	1
20	development	7	0.80%	3	60	automated	3	0.30%	4
21	digital-sustainability	7	1.50%	1	61	corporate	3	0.30%	3
22	healthcare	7	0.70%	1	62	covid	3	0.20%	1
23	management	7	0.70%	2	63	culture	3	0.20%	3
24	model	7	0.40%	1	64	cyber-physical	3	0.40%	4
25	role	7	0.30%	1	65	digitization	3	0.40%	1
26	agriculture	6	0.70%	2	66	divide	3	0.20%	3
27	big-data	6	0.50%	4	67	educational	3	0.30%	2
28	business-models	6	0.90%	1, 2, 3, 4	68	framework	3	0.30%	1
29	china	6	0.30%	1	69	governance	3	0.30%	1
30	collaboration	6	0.80%	1	70	intelligent	3	0.30%	4
31	media	6	0.30%	4	71	machine	3	0.20%	4
32	organization	6	0.70%	3	72	operational	3	0.30%	4
33	perspective	6	0.70%	1	73	performance	3	0.30%	1
34	practice	6	0.50%	2	74	process	3	0.20%	4
35	data	5	0.20%	4	75	rural	3	0.20%	2
36	food	5	0.20%	2	76	services	3	0.20%	2
37	future	5	0.30%	1	77	shoppers/consumers	3	0.20%	2
38	industry	5	0.40%	2	78	study	3	0.20%	1
39	integration	5	0.60%	4	79	techniques	3	0.30%	1
40	library	5	0.40%	2	80	value-creation	3	0.40%	1

phenomenon. Related to the latter, is also the difficulty to fully support practitioners and business regulators in dealing with sustainable digital transformation processes.

7.1.4. Comparative research

A fourth gap is represented by the scarcity of comparative research. In fact, while evidence-based research is quite widespread as originally noted in Sec. 4.3, content analysis revealed a very limited number of comparative studies. Among the few exceptions are [Beier et al. \(2017\)](#) on industrial production, [Delgosha et al. \(2020\)](#) on the relationship of digitalization and sustainability competitiveness, or [ElMassah and Mohieldin \(2020\)](#) on governments' digital transformation to achieve local SDGs. Comparative research would complement existing empirical studies, providing in-dept understanding on the relationship and possible convergence between digital transformation and sustainability.

This would significantly contribute to solve part of the issues related to the previously mentioned generalizability and transferability of findings.

7.1.5. Studies at organizational level

The fifth major gap detected in this review is the lack of studies conducted at organizational level. It was noted in Sec.5.3 how the relationship between digitalization and sustainability is often approached through specific organizations or stakeholder types, with a first remarkable distinction between governments and businesses. The lack of discussions on how organizations as such, including stakeholders, and functions, can exploit synergies in the digital transformation processes to achieve sustainability objectives, is currently one of the main limitations of the research on the topic. Again, this would help refocusing literature on the management subject, as well as favor

the development of research applicable to a wider variety of contexts.

7.2. Future research directions

Based on the above observations, it is evident that few publications are currently able to provide results which are applicable to different contexts. In addition, there is a priority to address the scarce consideration from the pure management subject towards the relationship between digital transformation and sustainability, which partially explains the misalignment existing between theoretical development and practice on the topic of digital sustainability. Details as discussed in the following sections are summarized in the research agenda below (Table 3).

7.2.1. Themes, terms, and research questions

To better contribute to the investigation on the relationship between digital transformation and sustainability as highlighted in Sec. 6.1.1, a first suggestion for future research involves making explicit thematic choices through clear and wide research questions. To acknowledge the importance of the topic for the pure management subject, digitalization for sustainability can be studied along with other mainstream management themes, such as innovation, value creation or financial/sustainability trade-off, as well as sustainability transformation. As noted in Sec. 6.1.5, raising the topic at organizational level allows refocus on the management subject, and consideration of approaches independently of specific contexts. In doing so, it is important to use terms more aligned to the practice environment, among which ‘digital sustainability’ first and foremost, but also ‘digital innovation’ in sustainability and corporate social responsibility contexts. Some examples of research questions include, but are not limited to:

- How can digital and sustainability transformations be combined?
- What are the positive and negative effects of digitalization on sustainability?
- Can digitalization help the convergence of sustainability and financial objectives?
- What are the limitations and the drawbacks of digitalization in a sustainability development process?
- What factors influence the relationship between sustainability and digitalization?
- How can organizations boost innovation in digital sustainability?
- What contribution can digitalization offer in different stages of a sustainability strategy (planning, implementation, assessment, improvement)?
- How to address sustainability challenges through a digital transformation process?

In addition, more inductive research approaches could provide complementary insights. For instance, aggregating specificity level questions such as “Do big data (or social media analytics, artificial intelligence, internet-of-things, etc.) boost sustainability?” would provide additional contributions to our motivating research question on how to improve sustainability through digital transformation. However to do so, different search criteria for each review at specificity levels (for instance the thematic foci found here) should be considered. Some examples of specificity-level reviews are from Bouzguenda et al. (2019) and Zheng et al. (2020) on the role digitalization in advancing sustainable smart cities. In this regard, further studies could be approached through meta-analysis.

7.2.2. Digitalization in sustainability business models

This study recognizes the effort that management scholars are putting to provide pragmatic research, as shown by the large amount of empirical literature and in particular, by the case studies and surveys in the sample (Sec. 4.3). This reflects the prevalence of an inductive rather than a deductive approach to knowledge building (Trochim & Donnelly, 2007). However, as discussed in Sec. 6.1.3, the analysis reveals a current theoretical weakness in the lack of overarching strategic frameworks, which prevents comprehensive understanding of the phenomenon beyond specific technologies or functionalities. Moreover, considering the wide range of publications on the business case for sustainability (e.g. Barnett, 2019; Carroll & Shabana, 2010; Kaplan, 2019) and sustainability business models (e.g. Bocken et al., 2014; Dembek & York, 2020; Ludeke-Freund & Dembek, 2017; Stilgoe et al., 2013; Yang et al., 2017), there is a strong need of modernization of such literature by including the crucial role of digitalization and its transformation process within these business cases and models.

7.2.3. Cross-sectors and cross-geographies comparisons

The highly fragmented literature, and therefore the too restricted scope and applicability of current studies on digitalization and sustainability, represents a significant limitation to the full understanding of the phenomenon. For this reason, the development of studies able to compare those specificities, particularly cross-sector and cross-geographies. This would add immense value to the existing research, allowing to access information on factors, dynamics and approaches encouraging or hindering the exploitation of synergies between sustainability and digital transformations.

7.3. Implications

7.3.1. Theoretical implications

The findings of this study offer significant contributions to management researchers for the advancement of the current knowledge on the relationship between digitalization and sustainability. Three primary theoretical implications may be distinguished.

Firstly, this study pioneers the research on digitalization and sustainability as a unified objective. By conducting a thorough systematic literature review, this study profiles the existing literature and identifies the thematic foci on 1) digitalization strategies for sustainability purposes, 2) applicability to industries or sectors, 3) applicability to organizations and stakeholders, and 4) sustainability through specific digital technologies and functionalities. The result is a comprehensive analysis of the status quo of academic outputs, which serves as a basis for the development of a new stream of research, which connects different macro-topics within the management field and that is more aligned with the practice environment. Macro-topics related to the theme of ‘digital sustainability’ or ‘digitalization for sustainability purposes’ include, but are not limited to: Philosophy and ethics, organization behavior, organizational structure, strategic management and decision making, development studies, innovation, economics and finance, marketing, corporate governance, policy development, research methods, sustainability, and business models.

Secondly, the undertaken study provides a clear research agenda aimed specifically to management scholars, suggesting avenues for future research. More specifically, five gaps have been identified, with regards to the focus of studies, the used terminology, the lack of overarching strategic and comparative research, as well as the missing organizational perspective. Examples of research questions and thematic fields have also been provided.

Last, but not the least, this study has the merit of acknowledging, valuing, and claiming the ownership of the topic of digitalization for sustainability purposes within the management community. Having the literature review highlighted a delay in the theme development as well as the odd under-consideration from highly ranked journals, we hope this study serves to re-establish research equilibria and adequate consideration on the topic.

7.3.2. Practical implications

The systematic literature review conducted in this study has several important implications also for the practice environment. Primarily, this work responds to the practice call for support in understanding how to use of digitalization to achieve sustainability-related goals. For instance, this study revealed a disconnection on the terms used by academics and practice, which prevents a stronger mutual collaboration on the topic.

More importantly, the major issue encountered in the extant literature is that the available information is often not transferable and generalizable. Thus, the encouragement to develop the topic as advocated in this study directly benefits a larger number of practice stakeholders, including but not limited to managers and head of functions, marketers, buyers, product developers and innovators, public administrators, consultants, and regulators.

Moreover, it is important to note that the findings of this study not only enrich practitioners' knowledge on the topic, but also inform and potentially give them access to the specificities of the existing academic production, which has been profiled and analyzed for the first time in this review. At the same time, the provided research agenda and the proposed thematic areas of research largely contribute to better respond to practitioners' needs, particularly with regards to digitalization for strategic objectives.

7.4. Limitations

This study presents some limitations, which need to be put into context and acknowledged to further address them in future research. First of all, the choices made in a systematic literature review can be disputed in multiple ways. For instance, the selected sample highly depends on the search keywords and the applied restrictions. Said that, a robustness test of randomly chosen articles containing keywords in 'abstracts' did not suggest findings substantially different from the ones claimed in this paper. A different but related matter exists in the applied quality criteria, which may exclude important studies despite the intent of guaranteeing high academic standards of findings. Similarly, the sample is naturally limited to the offer available, the reason for which papers were selected from three different renowned academic databases. Even so, potentially the process used may have excluded relevant or more cited papers.

Related to this point, the guiding research question "How can sustainability improve through digital transformation?" could be tackled differently. While the approach undertaken in this research is motivated by the lack of a very much needed literature review on the relationship between sustainability and digital transformation, equally valuable would be a study aggregating specificity-level studies as suggested for future research in Sec. 6.2.1.

Finally, it is important to mention that there may exist unintentional biases implied by the interpretivist nature of qualitative content

analysis, particularly in the coding and analytical phase. Hopefully the use of a reiterative methodical research approach helped reducing such biases.

8. Conclusions

This paper aimed to investigate the relationship between sustainability and digitalization in the academic literature, motivated by the question "How can sustainability improve through digital transformation?", which is of so much interest to practitioners and policy-makers. The study was opportunistically approached through a comprehensive systematization of 153 published articles, which allowed to identify the existing literature gaps and turn them into research opportunities through an informed research agenda.

In particular, the findings showed that the original question requires major attention from academic researchers. In fact, the analysis revealed that despite the raising popularity of the topic among practitioners and regulators, there is a delay of academic production and a discrepancy between literature and practice on terminologies, which makes it difficult to identify, gather and interpret extant literature. Moreover, research on the relation between digital transformation and sustainability emerged as extremely fragmented into sectors, functions and even methodologies, thus calling for unified perspectives and overarching theoretical frameworks in the future developments of the topic.

The findings of this study provide a theoretical and practical contribution towards the development of a new stream of literature dubbed as 'digital sustainability'. The identified research gaps are expected to foster future investigations with more focused outputs from the management scholars to the practical community. Suggestions in this paper aim to advance and complement the existing range of articles on the topic, as well as to closer align the management scholarship to the wider societal calls, be that businesses, governments, or international organizations.

CRedit authorship contribution statement

Ilaria Guandalini: Writing – original draft, Project administration, Investigation, Formal analysis, Data curation, Conceptualization.

Declaration of Competing Interest

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

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Appendix A. Coding process

[Tables A.1 and A.2.](#)

Table A1

#	Words in the title	Frequency (Count ≥ 3)	Impact (% of Text)	Categories	#	Words in the title	Frequency (Count ≥ 3)	Impact (% of Text)	Categories
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5	system	14	0.80%	4	45	supply-chain	5	0.60%	2
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8	smart	11	0.60%	4	48	analysis	4	0.30%	1
9	social	11	0.70%	3, 4	49	challenge	4	0.40%	1
10	city	10	0.40%	1, 2	50	citizenship	4	0.40%	3
11	innovation	10	1.00%	1, 2, 3, 4	51	community	4	0.40%	3
12	design	9	0.50%	4	52	digital-technology	4	0.70%	1
13	environment	9	1.00%	1	53	digital-transformation	4	0.90%	1
14	relationship	9	1.10%	1, 2, 3, 4	54	energy	4	0.20%	2
15	research	9	0.70%	1	55	internet-of-things	4	0.70%	4
16	economy	8	0.60%	1	56	responsibility	4	0.60%	1
17	industry-4.0	8	0.80%	2	57	strategy	4	0.30%	1
18	learning	8	0.60%	2	58	tool	4	0.20%	4
19	participation	8	1.00%	4	59	approach	3	0.20%	1
20	development	7	0.80%	3	60	automated	3	0.30%	4
21	digital-sustainability	7	1.50%	1	61	corporate	3	0.30%	3
22	healthcare	7	0.70%	1	62	covid	3	0.20%	1
23	management	7	0.70%	2	63	culture	3	0.20%	3
24	model	7	0.40%	1	64	cyber-physical	3	0.40%	4
25	role	7	0.30%	1	65	digitization	3	0.40%	1
26	agriculture	6	0.70%	2	66	divide	3	0.20%	3
27	big-data	6	0.50%	4	67	educational	3	0.30%	2
28	business-models	6	0.90%	1, 2, 3, 4	68	framework	3	0.30%	1
29	china	6	0.30%	1	69	governance	3	0.30%	1
30	collaboration	6	0.80%	1	70	intelligent	3	0.30%	4
31	media	6	0.30%	4	71	machine	3	0.20%	4
32	organization	6	0.70%	3	72	operational	3	0.30%	4
33	perspective	6	0.70%	1	73	performance	3	0.30%	1
34	practice	6	0.50%	2	74	process	3	0.20%	4
35	data	5	0.20%	4	75	rural	3	0.20%	2
36	food	5	0.20%	2	76	services	3	0.20%	2
37	future	5	0.30%	1	77	shoppers/consumers	3	0.20%	2
38	industry	5	0.40%	2	78	study	3	0.20%	1
39	integration	5	0.60%	4	79	techniques	3	0.30%	1
40	library	5	0.40%	2	80	value-creation	3	0.40%	1

Table A2

From Categories to Thematic Foci			
1	2	3	4
Digitalization strategies for sustainability	Applicability to industries and sectors	Applicability to organizations and stakeholders	Sustainability through digital technologies or functionalities
Illustrative coding			
Digital transformation favoring the achievement of digitalization for sustainability	Developing digital farming for sustainable food systems and rural communities' development	Unveiling the sustainability opportunities of digital government	IoT for sustainability purposes
Regulation guiding the strategic development of digitalization for sustainability	Exploiting digitalization opportunities for sustainability in Industry 4.0	Helping governments in improving sustainability through digital initiatives	Exploring ICT in and for social responsibility
Digital transformation models considering strategic geographical outreach (localization versus globalization)	Enhancing sustainability through digital manufacturing	Stakeholders' engagement through digital sustainability	Using big data for detecting, measuring, and tracking records of sustainable development
Digitalization converging business and sustainability purposes (including achieving performance, competitive advantages, value creation, etc.)	Improving sustainability in education or human development through digitalization	Gauging the effect of digital sustainability on communities	Developing smart machines for sustainable energy systems
Digitalization solving sustainability issues or hindering sustainability purposes (e.g. climate change; digital divide, resilience, and learning gaps; hindrances in sustainability processes)	Digitalization for a sustainable healthcare system	Strengthening relationships and networking through digital sustainability	Digital twins applied to sustainability-based lifecycle management
	Digital potential of sustainable urban development	Effects of digital transformation on SMEs' sustainability	Innovating sustainable business models through automated production systems
	Implementing sustainable food shopping through digitalization		

(continued on next page)

Table A2 (continued)

From Categories to Thematic Foci			
1	2	3	4
Digitalization strategies for sustainability	Applicability to industries and sectors	Applicability to organizations and stakeholders	Sustainability through digital technologies or functionalities
Thematic Foci Map			
SDGs	Agriculture & rural communities	Businesses	
Policy making	Industry 4.0	Entrepreneurs	
Localized studies	Manufacturing	Government	
Sectorial studies	Supply chain	(policy development & admin	ICT
Business models	Libraries	streamlining)	Big data
	Smart cities/Urban development	Overall stakeholders (networking,	Digital Twins
	Healthcare	participation, citizenship)	
	Tourism	Communities	
	Production/Consumption	Learners	
	Energy/Utilities	Consumers	

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