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The relationship of digital transformation and corporate sustainability: Synergies and tensions

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ABSTRACT

Scholars within management disciplines have shown a growing interest in digital transformation and sustainability phenomena to address global societal challenges. Indeed, previous studies have investigated the initial analysis of the intersection between these two emerging and intertwined topics. However, there has been no comprehensive or critical analysis of the relationships among these concepts. Nevertheless, a clear understanding of this phenomenon is key to developing rigorous and meaningful knowledge and enabling future research. Our critical review analyses 91 articles on digital transformation and sustainability research to address this issue. The findings propose a synthesis of the definition types of digital transformation and sustainability in four categories, from which only 16 articles show a relationship between both concepts. This study theoretically contributes to management research by uncovering issues and assumptions around the conceptualizations of digital transformation and sustainability at the corporate level. By doing so, we present a consolidation of conceived knowledge and clarify these interrelated concepts. Moreover, understanding and assessing these relationships will lead to a future research agenda and implications for practitioners.

1. Introduction

Sustainability has become a fundamental global challenge, necessitating immediate attention from organizations and society at large (Aguilera et al., 2022). As a strategic priority (Hengst et al., 2020), sustainability encompasses environmental integrity, social equity, and economic prosperity, significantly influencing organizational practices and societal expectations (Bansal, 2005; Scherer et al., 2013). In response to this imperative, scholars have turned their interest toward the opportunities provided by digital technologies for a cleaner industry (e.g., Birkel and Müller, 2021) to reduce waste in the industry (e.g., Sepasgozar et al., 2021) or in agriculture (Benyam et al., 2021) and to promote social equity (e.g., Skare and Porada-Rochoń, 2022). This positive view of digital technologies is balanced by studies focusing on their negative consequences and threats, such as digital waste (e.g., Alieva and Powell, 2023), digital inequality (Zheng and Walsham, 2021), and social risks caused by digital disinformation (e.g., Serrano-Puche, 2021). The problem of digital waste has been investigated for decades in the Green IT (e.g., Dedrick, 2010; Melville, 2010) and Green IS (Seidel et al., 2017; Tim et al., 2018) streams.

Management research has investigated digital technology opportunities through the lens of digital transformation (DT). The interest in this

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phenomenon manifests through several special issues in high-ranked journals (specifically, in the California Management Review in 2020, the Journal of Information Technologies in 2022, the European Journal of Information Systems in 2022, the Journal of the Association for Information Systems in 2022, the Information Systems Journal in 2022, and the Journal of Business Research in 2022) and several literature reviews (e.g., Vial, 2019; Feliciano-Cestero et al., 2023; Hanelt et al., 2021).

While scholars have focused on various aspects and levels of DT, such as organizations (Wessel et al., 2021), business strategies (Singh and Hess, 2017; Hanelt et al., 2021; Vial, 2019), work practices (Ologeanu-Taddei et al., 2023), entrepreneurship (Nambisan et al., 2019), or sales (Guenzi and Habel, 2020), there is a consensus that DT leads to changes in business strategy, thus delivering value creation as the outcome (Vial, 2019; Wessel et al., 2021; Nambisan et al., 2019; Warner and Wäger, 2019). With the growing concern for sustainability, scholars have started to investigate different goals of DT, such as sustainability (e.g., Pappas et al., 2018; Pan et al., 2022; Guandalini, 2022).

Current studies envision sustainability either as a driver of DT (e.g., Ghobakhloo et al., 2021; Guandalini, 2022) or its outcome (e.g., Soltani Delgosha et al., 2020). These differences may result from different definitions and assumptions related to both concepts and their relationships. In addition, scholars have suggested that DT and sustainability should be interrelated. Lichtenthaler (2021) combined DT and sustainability with digitainability, highlighting potential synergies between DT and sustainability in line with organizational initiatives. Other scholars have suggested a broader merging concept, digital sustainability (Pan et al., 2022; George et al., 2021; Pan and Zhang, 2020), to address the issue of how digital technologies can be used to foster sustainable development, such as solving climate change challenges.

While several literature reviews on DT have been published (Vial, 2019; Hanelt et al., 2021; Feliciano-Cestero et al., 2023), the relationship between DT and sustainability has been explored only three times (Feroz et al., 2021; Guandalini, 2022; Pauliuk et al., 2022). Feroz et al. (2021), for example, reviewed the impacts of DT on environmental sustainability. In this case, this study discussed DT as a specific digital technology usage, such as AI, big data, IoT, social media, and the cloud, and how they have transformed the environmental sustainability spectrums. Similarly, Guandalini (2022) focused on how DT improve sustainability. However, they used the terms digitalization, digital (technologies), and digital innovation as proxies for DT. Pauliuk et al. (2022) took a systemic perspective and argued that DT and sustainability coevolve. The authors identified major DT strategies and sustainable development goals (SDGs). They argued that while most DT strategies focus on the product, process, and process cluster levels, the SDGs predominantly target the economy-wide level. This conclusion raises concerns about the concepts used, for instance, DT and sustainability, and their definitions and relationships.

Therefore, despite the relevance of these reviews for understanding how digital technology can participate in sustainable goals, which complements recent literature on the topic (e.g., Mendez-Picazo et al., 2024), the need to assess the relationship between DT and sustainability remains. For example, the Academy of Management Perspectives recently launched a call for papers on digital sustainability (Höllerer et al., 2023). At the same time, an editorial in the Journal of the Association for Information Systems (Kotlarsky et al. 2023) has highlighted the importance of bridging digital technologies, digital transformation, and sustainability. While this relationship has rarely been explored in the current literature, the academic community is still encouraged to study this topic. The focus on DT instead of digital technologies allows for a consistent understanding of organizations' digital initiatives, processes, and strategies instead of a broad heterogeneous vision of opportunities that mix different levels (e.g., society, industry, and organization), types of typologies and technologies, and various stages of implementation and adoption. Moreover, explicit definitions and assumptions of DT and sustainability research are crucial to create cumulative research on DT (Baiyere et al., 2023) and provide rigorous and actionable knowledge for scholars and practitioners seeking to use DT to address sustainability issues.

Thus, our research questions are as follows: *What is the relationship between DT and sustainability? What is the nature and extent of this relationship, and what are the underlying assumptions there?*

Therefore, we propose a critical review (Steininger et al., 2022; Paré et al., 2015) to analyse and problematize the research on DT and sustainability. This critical review reveals weaknesses, contradictions, controversies, and inconsistencies in the current literature (Paré et al., 2015), especially with respect to the relationship between DT and sustainability, as well as emerging issues and underlying assumptions (Alvesson and Sandberg, 2011). We propose a synthesis of what is known about these relationships at the corporate level, and generate new avenues for future research (Steininger et al., 2022; Alvesson and Sandberg, 2020).

The structure of this paper is as follows: the next section presents and delineates related work regarding DT and corporate sustainability. In the third section, we outline our research approach. Our results offer insights into the definitions and the conceptualized relationships between the two phenomena in the literature in section four. We then critically discuss the results and provide a research agenda.

2. Conceptual background

2.1. Digital transformation

DT is a rapidly evolving topic. Scholars have conceptualized DT as the strategic disruption enabled by digital technology (Vial, 2019; Baiyere et al., 2023; Markus and Rowe, 2023; Warner and Wäger, 2019; Nambisan et al., 2019) or the organizational change driven by digital technology adoption (Wessel et al., 2021; Nadkarni and Prügl, 2021; Hanelt et al., 2021). Authors have distinguished DT from IT-enabled organizational transformation, highlighting that DT is a process of value creation, whereas IT-enabled organizational transformation enhances the existing business strategy and identity (Wessel et al., 2021).

Several literature reviews focus on DT. Vial (2019) conducted an integrative literature analysis of existing DT definitions and proposed a framework envisioning DT "as a process where digital technologies create disruptions triggering strategic responses from organizations that seek to alter their value creation paths while managing the structural changes and organizational barriers that affect the positive and negative outcomes of this process." The author proposed a research agenda including the role of dynamic capabilities and ethical issues. Vial's framework has been adopted as a definition for DT for many studies (e.g., Iivari et al., 2020), whereas Markus and Rowe (2021) highlighted the circularity and unclarity of this statement used as a definition.

In addition, Hanelt et al. (2021) conducted a systematic literature review investigating DT from the organizational change perspective. They identified two patterns: first, DT moves firms to malleable organizational designs that enable continuous adaptation; second, this move is embedded in and driven by digital business ecosystems. The malleability required to achieve DT has been highlighted by various studies, with an emphasis on digital agility (Sambamurthy et al., 2003; Grover, 2022; Salmela et al., 2022; AlNuaimi et al., 2022).

Extant work has also explored the role of leadership and culture in accomplishing DT (AlNuaimi et al., 2022; Kane and Euchner, 2021; Tabrizi et al., 2019), organizational capabilities (e.g., Warner and Wäger, 2019), organizational paradoxes (Danneels and Viaene, 2022; Noesgaard et al., 2023) and how DT raises ethical issues (Vial, 2019). DT research has suggested that DT depends on various factors and that the same DT initiative can lead to different outcomes (Noesgaard et al., 2023).

The breadth of this literature highlighting different levels and various factors affecting DT has been complemented by the depth of new theoretical lenses, such as institutional theory (Gegenhuber et al., 2022),

collective social action (Tana et al., 2023) and evolutionary theory (Ologeanu-Taddei et al., 2023).

2.2. Corporate sustainability

Corporate sustainability has been addressed primarily through the lens of the Triple Bottom Line (TBL) framework (Elkington, 1994; Böttcher et al., 2023; Ahuja et al., 2023). Bansal and Roth (2000) seminally examined companies' motivation to go green within the corporate ecological response, namely, competitive advantage, legitimation, and ecological responsibility that stems from social obligations.

Specifically, the three principles underpinning sustainability at the firm level, or 'corporate sustainability,' are environmental integrity through corporate environmental management, social equity through corporate social responsibility (CSR), and economic prosperity through value cocreation (Bansal, 2005; Scherer et al., 2013). The sustainability concept thus becomes closer to CSR, which has provided a rich research stream in management (e.g., Rodriguez-Gomez et al., 2020). Nevertheless, the concepts of corporate sustainability and CSR have been envisioned as complex problems rather than solutions (Hahn et al., 2024; Howard-Grenville et al., 2014; Wang et al., 2016, 2020). The TBL approach highlights the tensions and tradeoffs among these different aspects, which need to be addressed simultaneously (Kleine and Hauff, 2009; Elkington, 1997). Scholars have argued that tensions and paradoxes arise from the interdependence between economic, environmental and social concerns related to sustainability (McWilliams and Siegel, 2011; Wittneben et al., 2012; Gao and Bansal, 2013; Hahn et al., 2015; Hahn et al., 2018; Hahn et al., 2024). Therefore, these paradoxes need to be addressed as such rather than as a win–win paradigm according to which economic, environmental and social sustainability aspects can be achieved simultaneously (Hahn et al., 2018). The multifaceted and complex nature of sustainable development entails conflicts and requires trade-offs that occur at different levels or among levels (individual, organizational, industry, societal) and with varying temporal and spatial horizons (Hahn et al., 2015, 2018). In addition, conflicts arise over goals (as related to the different domains of sustainability) and means (Hahn et al., 2018; Hahn et al., 2015; Hahn et al., 2024; McWilliams and Siegel, 2011). Because a solution to one issue could be detrimental to that of another (Newton, 2002), this may lead to unintended consequences (Hahn et al., 2015). Tensions also arise from changes in the current patterns of activity, which are required by sustainability issues (Hahn et al., 2015). However, TBL-driven frameworks have rarely been investigated from a theoretical perspective (Wang et al., 2020).

2.3. Digital transformation and corporate sustainability

A growing number of studies have highlighted the use of digital technologies for sustainability (e.g., Birkel and Müller, 2021; Sepasgozar et al., 2021; Benyam et al., 2021; Skare and Porada-Rochoń, 2022). This emerging stream extends the research on Green IT/Green IS, with the difference between both concepts distinguished by Pan et al. (2022). Green IT is about reducing the direct environmental impacts of IT use (Dedrick, 2010) and focuses primarily on environmental sustainability at an organizational level (Pan et al., 2022), whereas Green IS involves using IS to promote eco-sustainability in businesses and society (Melville, 2010), consequently addressing a wider range of issues pertaining to environmental sustainability across the micro-, meso-, and macrolevels (Seidel et al., 2017; Tim et al., 2018). More specifically, Melville (2010, p. 1) defines IS for environmental sustainability as "IS-enabled organizational practices and processes that improve environmental and economic performance". Nevertheless, this view contrasts with DT and sustainability-driven DT, as DT focuses on changes in business strategy and value creation (Vial, 2019; Wessel et al., 2021), beyond changes in practices and processes.

Other scholars have focused explicitly on DT and sustainability. For instance, Hilali et al. (2021) test a model in which customers, data, and innovation drive DT to reach sustainability. Taking a different lens, Pauliuk et al. (2022) address the alignment between DT strategies and sustainability, considered under the SDG label, which blurs the meaning of sustainability, between corporate sustainability, mainly the TBL and CSR, and sustainability, understood as sustainable development. Moreover, several authors have proposed merging DT and sustainability into the same concept, thus envisioning a common process. For instance, Lichtenthaler (2021) introduced the term digitainability, emphasizing the synergies between DT and sustainability within organizational efforts. This was motivated by the need to address the potential negative impacts of digital technologies to enable sustainable DT (Lichtenthaler, 2021).

Other scholars suggest a similar concept, digital sustainability (George et al., 2021; Pan and Zhang, 2020; Pan et al., 2022). This is defined as the "opportunities and challenges facing the convergence of digital and sustainability imperatives" (Pan and Zhang, 2020) to "advance environmental sustainability goals by creatively deploying technologies that create, use, or transmit electronic source data" (George et al., 2021). In other words, digital sustainability addresses the issue of how digital technologies can be used to foster sustainable development, such as solving climate change challenges. It addresses the "organizational activities which create socioecological value as a core part of an economic proposition" and "long-term public value creation" (George et al., 2021).

To summarize, prior works considering both topics (i.e., DT and sustainability) are considered according to different definitions, and previous studies have assessed their relationships in a broad manner.

3. Methodology

To address our research questions, we followed prior management (e.g., Köllen, 2021) and IS studies (e.g., Steininger et al., 2022) that aimed to critically analyse the literature on a broad topic. We chose a critical review approach (Paré et al., 2015) to synthesize and critically assess the relationship between DT and sustainability. Since we are attempting to bring together two bodies of knowledge, examine their relationships, and elaborate on potentially contrasting underlying assumptions, we followed the process of Paré et al. (2016) and combined it with the grounded theory approach of Wolfswinkel et al. (2013). These approaches have already been used in other critical reviews to explore alternative conceptual assumptions of different strands of knowledge (Moeini and Rivard, 2019) or to understand the underlying assumptions of existing concepts in various research fields (Steininger et al., 2022). Consequently, in the first step (Section 4.1), we adopted Wolfswinkel's method to identify relevant literature and extract pertinent data to analyse and synthesize existing research on DT and sustainability critically (Section 4.2). The method is divided into five phases: **define, search, select, analyse,** and **present**.

3.1. Literature identification and initial data extraction

In the **define** stage, we selected peer-reviewed journals to ensure scientific rigor and quality. We used the Academic Journal Guide (ABS/AJG List) as a starting point and chose all the journals from all the fields, most of which were available in the abstract and citation database

SCOPUS,[1] which was chosen because of its greater coverage in comparison with the Web of Science (Falagas et al., 2008). We formulated an initial research query on the basis of the concepts of DT and sustainability. However, we preferred to keep our search open and include ICT or IT-enabled transformation, as the conceptualization of their difference is very recent (e.g., Wessel et al., 2021). From the same perspective, we preferred to not exclude a priori all the literature on Green IT and even included broader views such as societal and environmental impacts.

Our goal was to create a comprehensive corpus, which we would narrow down through analysis rather than restricting it from the outset with strict search terms. Thus, we iterated it through several rounds of trial searches and discussions to include different synonyms and closely related concepts:

ABS(((“digital transformation”) OR (“digital disrupt*”) OR (“IT enabl*” AND “transformation”) OR (“ICT enabl*” AND “transformation”)) AND ((“sustainab*”) OR (“societal” AND “impact”) OR (“environmental” AND “impact”) OR (“green IT”) OR (“responsib*”))).[2]

After the search results were analysed briefly, the main AIS conference proceedings from the AIS eLibrary were included: ICIS, AMCIS, PACIS, ECIS, and HICSS. In doing so, we ensure that we include up-to-date research to obtain a broad view of both topics and their interactions.

During the **search** stage, which was conducted between December 2022 and March 2023, we applied the search query to the abstracts to ensure that the identified publications focused on both research topics. The initial search resulted in a total of 270 publications (69 conference papers +201 journal articles). Five conference papers were found to be duplicates, so we excluded them. The longlist comprises 265 publications for first-round abstract coding (64 conference papers +201 journal articles) (see Fig. 1, DT = Digital Transformation, SB=Sustainability, OF=Other Factors).

In the **select** stage, we divided the publications and assigned their abstracts to eight authors, who then denoted whether the publication focused on both concepts and should be included and whether the topics of DT and sustainability were used as context, driver, outcome, or factor. This approach aligns with the guidelines for critical reviews that recommend not solely comparing the identified papers but also verifying each work against a criterion (Paré et al., 2015).

Each author's coding was reviewed by one of the other authors. Thus, we first formed teams of two and distributed the list of papers between them equally (all the papers per team were coded by two coders at this stage). We reviewed and discussed all cases of dissent in a first coding workshop with all eight coders until an agreement was reached. The search resulted in many false-positives, as the term *sustainable* is often combined with nouns such as *business.* The combined term *sustainable business* refers to a financially viable business rather than having, for instance, an environmentally sustainable business. Hence, many publications that used the term sustainable were excluded. This led to a first shortlist of 91 publications.

In the **analyse** stage, we engaged in an exhaustive 2nd round of coding on the basis of the full text to validate the role of DT and sustainability and to reassess their final inclusion. We meticulously extracted definitions of digital transformation and sustainability from each paper. Subsequently, we scanned their definitions (Suddaby, 2010) and then analysed the relationship between the two topics in two categories: the role of the concept (i.e., DT; sustainability) in this relationship, namely, context, driver, outcome, mediator/moderator, factor, codependency, and second, the assessment of this relationship (positive, negative, or neutral).

We further scrutinized our sample of 91 papers to capture how the concepts of DT and sustainability were defined by the authors, their relationships, and underlying theories and models. We also classified the papers as either empirical or conceptual and identified their respective research methods. We categorized the context in which the DT and sustainability concepts were applied and their theoretical foundations employed or developed. We consequently extended our initial coding framework iteratively to incorporate subsequent important criteria, as recommended by Steininger et al. (2022). The coding workflow proceeded similarly to that in the first phase. Thus, eight authors individually coded the papers assigned to them. Finally, two authors reviewed the results of each individual coding and prepared a table for the second coding workshop in which, again, all eight coders discussed any discrepancies.

3.2. Critical analysis

On the basis of the extracted data, we engaged in backwards- and forwards-oriented knowledge-building activities, following the recommendations of Schryen et al. (2020). Thus, in the first step, three authors summarized the results of the coding sessions and subsequently synthesized and critically described the extant literature on DT and sustainability in terms of their definitions and relationships to reveal weaknesses, contradictions, controversies, and inconsistencies. More specifically, we investigated how the definitions and the relationship between DT and sustainability were conceptualized and what issues emerged from these conceptualizations. Since a relationship can be described properly only if both concepts are defined, we considered only 16 papers for the 3rd round of analysis, in which we specifically examined the relationships between the concepts.

Following the problematization approach of Alvesson and Sandberg (2011), we compared the issues with existing trends and general developments in management research. This allowed us to categorize the identified issues and underlying assumptions into three main themes (i.e., conceptualizations of DT and sustainability, understanding the relationship between DT and sustainability, and assessing the relationship between DT and sustainability), propose corresponding solutions and derive research strategies.

4. Results

In this section, we shed light on the definitions of DT and sustainability. We begin by describing different types of definitions, including undefined, conceptual proxies, plain definitions, and contextualized definitions. Therefore, we also consider rules for conceptual clarity (Suddaby, 2010). We further elaborate on the relationship between the two concepts. Our primary focus is on how DT is portrayed as driver of sustainability, highlighting its potential impact in promoting sustainable practices and outcomes. Additionally, the section delves into less common relationships between DT and sustainability.

4.1. Definitions of digital transformation and sustainability

Table 1 presents the definition type distribution. The DT definition type is displayed in rows on the left side, whereas sustainability is presented in columns. For example, the row and column labelled Undefined include papers where no definitions for DT and sustainability are provided. The cells indicate the number of papers for the corresponding definition types. At the right and bottom edge of the table are the sums

[1] The following nine journals were missing. They were thus retrieved manually from their publishers' databases: AIS Transactions on Human-Computer Interaction, e-Service Journal, Journal of Information Technology Theory and Applications, Journal of Information, Information Technology, and Organizations, South African Journal of Information Management, Online Journal of Applied Knowledge Management, Communications of the ICISA, International Journal of Cases on Electronic Commerce, and International Journal of Digital Strategy, Governance, and Business Transformation.

[2] The asterisk (*) denotes that all articles with words containing the common stem will be found during the search, e.g., sustainab* will apply to both sustainab*le and sustainab*ility.

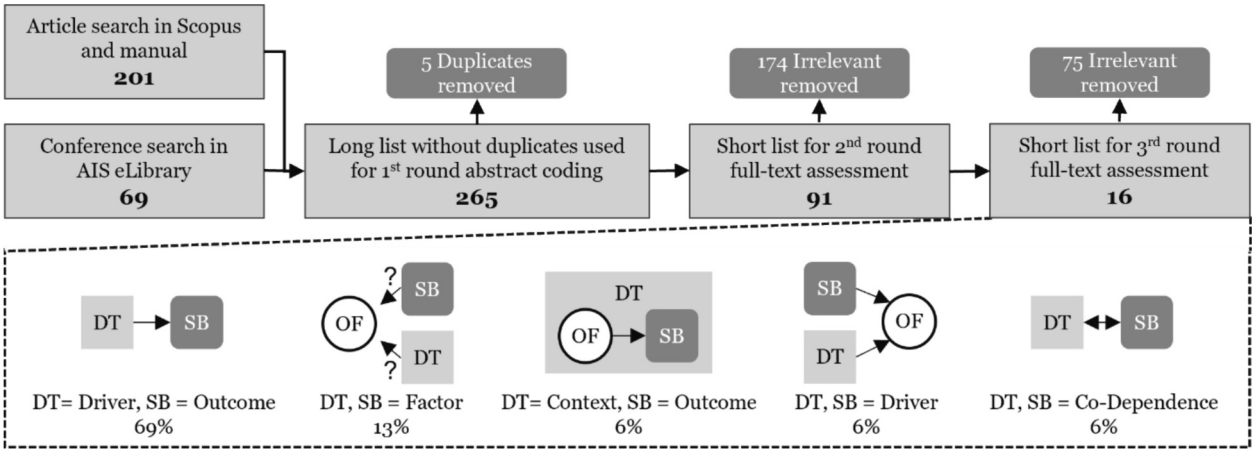

Fig. 1. Overview of the literature review process.

Table 1
Definition type distribution.

			Sustainability				
			Definition Types				Σ
			Contextualization	Plain	Proxy	Undefined	**Sum**
Digital Transformation	Definition Types	Contextualization				3	**3**
		Plain	7	9	9	12	**37**
		Proxy	6	8	14	3	**31**
		Undefined	5	3	2	10	**20**
	Σ	**Sum**	**18**	**20**	**25**	**28**	**Σ 91**

per definition type displayed. The grey cells indicate the 16 articles that show a relationship between both concepts.

In the following subsections, we discuss the definition types used: 1) undefined concepts, 2) conceptual proxies, 3) plain definitions, and 4) contextualized definitions.

4.1.1. Undefined concepts

The undefined concept refers to articles in which the concepts DT or sustainability were explicitly mentioned, but the term and its underlying notion were not clarified or explicated in the article.

Among the 91 articles, 28 define only DT or sustainability, not both. In ten articles, neither of the concepts is defined (e.g., Begnum et al., 2019; Chen et al., 2021; Mir et al., 2020; Gunduz et al., 2021), which makes it difficult to assess the relationships among the concepts. In general, sustainability is more frequently used as a vague and undefined concept than is DT: 28 papers do not specify the concept of sustainability (e.g., Reuschl et al., 2022; Li, 2022, 2020; Rijswijk et al., 2021; Dal Mas et al., 2023), whereas 20 do not define DT (e.g., Kurniawan et al., 2022; Ambos and Tatarinov, 2022; Nudurupati et al., 2022). For example, Ambos and Tatarinov (2022) showed that digital solutions create transparency and enable responsible innovation in socially oriented organizations but leave DT undefined.

4.1.2. Conceptual proxies

Many articles use conceptual proxies for DT and sustainability. A proxy is a surrogate or substitute for the actual concept.

Fourteen articles use a conceptual proxy for DT and a plain or contextualized definition for sustainability (e.g., Verma et al., 2022; Kurniawan et al., 2023), and another 14 use proxies for both concepts (e.g., Chen, 2022; Felsberger et al., 2022; Guo et al., 2022; Niehoff et al., 2022; Denicolai et al., 2021). Nine articles use a proxy for sustainability while providing a plain definition for DT (e.g., Zhong and Ren, 2023; Pauliuk et al., 2022; Cappelli et al., 2023). In two articles, the conceptual sustainability proxy is used in combination with undefined DT; similarly, in three other articles, conceptual DT proxies are combined with undefined sustainability (e.g., Wamba and Chatfield, 2009; Zhao et al., 2023). In sum, 31 articles use a conceptual proxy for DT, and 25 use a conceptual proxy for sustainability.

In Table 2, we list the conceptual proxies in our sample. The most frequently used proxy for DT is Industry 4.0 (e.g., Verma et al., 2022; Ghobakhloo et al., 2021), which is used 13 times, and for sustainability, the proxy SDG (e.g., Shenkoya, 2023; Pauliuk et al., 2022), which is used five times. For instance, Ching et al. (2022) and Niehoff et al. (2022) established a definitional connection between DT and Industry 4.0, considering Industry 4.0 as a representative manifestation of DT. They left sustainability undefined but circumscribed it with the SDGs and TBL without explaining this conceptual connection. Other commonly used proxies for DT are the digital economy, Green IT/IS, and digitalization. For sustainability, other recurring proxies were the circular economy, CSR, and digital/precision agriculture.

In total, 15 different conceptual proxies are used for DT and 16 for sustainability (cf. Table 2 for the full list of proxies). Thus, DT is often considered broadly, such as the use of digital technology, or loosely related to and substituted by related concepts such as digitalization or DT readiness. Park et al. (2022), for example, investigated how digital technology (and more specifically the IoT) enables social impact for

Table 2
List of conceptual proxies.

Digital transformation		Sustainability	
Proxy	Source	Proxy	Source
Industry 4.0	Trivelli et al., 2019; Ghobakhloo et al., 2021; Pencarelli, 2020; Dukić Mijatović et al., 2020; Kurniawan et al., 2023; Niehoff et al., 2022; Verma et al., 2022; Ching et al., 2022; Dionisio et al., 2023; Xin et al., 2022; Felsberger et al., 2022; Ali and Govindan, 2021; Nwaila et al., 2022	Sustainable Development Goal	Aleshkovski et al., 2020; Niehoff et al., 2022; Pauliuk et al., 2022; Ufua et al., 2021; Shenkoya, 2023
Digital Economy	Chen, 2022; Melnyk et al., 2022; Aleshkovski et al., 2020; Ufua et al., 2021	Circular Economy	Del Giudice et al., 2021; Kristoffersen et al., 2021; Godsiff and Wood, 2021
Green IT/Green IS	Kazim, 2021; Schmermbeck, 2019; Schmermbeck et al., 2020	Corporate Social Responsibility	Jelovac et al., 2022; Zhong and Ren, 2023; Esposito et al., 2023
Digitalization	Lichtenthaler, 2021; Denicolai et al., 2021	Digital/Precision Agriculture, Agricultural Management	Trivelli et al., 2019; Bento et al., 2019
Agriculture 4.0	Bento et al., 2019	Low-carbon Development	Chen, 2022; Shilton, 2021
AI Readiness	Denicolai et al., 2021	Sustainable Development	Melnyk et al., 2022; Pauliuk et al., 2022
Digital Innovation	Zhao et al., 2023	Absence of corruption	Cappelli et al., 2023
Digital Nation	Penmetsa and Bruque-Camara, 2021	Climate Change	Shilton, 2021
Digital Technology Adoption	Li, 2022	Environmental Innovation	Guo et al., 2022
Digital Transformation Readiness	Hoa and Tuyen, 2021	Environmental Sustainability	Denicolai et al., 2021
Digital Twin	Shilton, 2021	Green IT/Green IS	Schmermbeck, 2019
Emerging Digital Technologies	Chen, 2022	Smart City	Anthony Jnr et al., 2021
Green Digitalization	Guo et al., 2022	Smart Tourism	Pencarelli, 2020
IoT Technology Usage/Capabilities	Park et al., 2022	Social Innovation	Dionisio et al., 2023
RFID Technologies	Wamba and Chatfield, 2009	Sustainable Business Model Innovation	Hajiheydari et al., 2023
		Triple Bottom Line	Felsberger et al., 2022

people living at the bottom of the pyramid (the largest group at the lowest/poorest level in the wealth pyramid of our society). Similarly, Kristoffersen et al. (2021) showed that business analytics capacity (DT) positively affects the implementation of circular economy strategies.

4.1.3. Plain definitions

Out of 48 articles coded as plain, 37 articles offer such a definition of DT, whereas 20 explain sustainability in a plain way. Nine articles offer both terms with plain definitions. For the coding process, plain definitions refer to a very general and noncontextualized meaning. Those types mainly consist of the core and basic characteristics of the phenomenon. For example, three articles offered a plain definition of sustainability but did not define DT (Nudurupati et al., 2022; Ambos and Tatarinov, 2022; Broo and Schooling, 2023) or saw DT as a proxy (8 papers). Seven papers had simple definitions of DT and contextualized definitions of sustainability (e.g., Nayal et al., 2022; Forcadell et al., 2020. Among the other papers with plain DT descriptions, nine offered a general understanding of sustainability with a conceptual proxy. Finally, 12 articles provided a simplified explanation for DT while having no explanation for sustainability. Table 3 shows the definitions of DT and sustainability for all 16 articles that define both concepts either plainly or contextually. As shown, some papers use definitions from 2015 by Matt et al. or Loebbecke and Picot (Forcadell et al., 2020; Nayal et al., 2022). In addition, several papers use the definition of Vial (2019) to define DT for their study purposes (e.g., Lokuge et al., 2021; Rahimi et al., 2022; Nguyen and Thanh Hoai, 2022), in which this process is seen as a disruption based on technologies and thereby requires organizational changes. Other papers include definitions from Verhoef et al. (2021) or Hanelt et al. (2021), which also highlight a trigger through technologies.

Similar to a prominent literature review by Vial (2019), during the analysis, we considered the guidelines for conceptual clarity by Suddaby (2010). These guidelines refer to (1) offering definitions of key terms and constructs, (2) capturing the essential properties and characteristics of the concept or phenomenon under consideration, (3) avoiding tautology or circularity, and (4) being parsimonious (Suddaby, 2010). Given the context of our study, these guideline rules collectively might enhance the precision, clarity, and consistency of definitions of DT and sustainability. Ultimately, when the extant definitions are scanned on the basis of guidelines and rules, the analysis reveals several challenges, including circularity, unclear terminology, and the conflation of the concept and its impacts, which hinder the conceptual clarity of DT and sustainability for plain definitions.

4.1.4. Contextualized definitions

Twenty-one articles contextualized definitions for either DT or sustainability. Therefore, the definitions are applicable to different circumstances and are relatively specific for the actual conditions in the paper. These types of definitions are not universally considered in other contexts.

First, three articles contextualized DT but did not define sustainability (Dorfleitner et al., 2022; Silva and Bonetti, 2021; Kazim, 2021). These definitions refer to specific DT-related contexts but do not offer information about the definition of sustainability in this context. In contrast, five articles offer some contextualization in terms of frameworks or theoretical foundations related to the definition of sustainability but without any definition of DT (Ângelo and Barata, 2022; Kurniawan et al., 2022; Zhu and Li, 2023; Thai et al., 2022; Lopes et al., 2022). Therefore, contextualized definitions such as ‘greening of enterprises’ (Zhu and Li, 2023) or ‘sustainable construction’ (Ângelo and Barata, 2022) are used. Seven articles entail a contextualization of sustainability and a plain definition of DT (e.g., Hamalainen and Salmi, 2023; Nayal et al., 2022; Forcadell et al., 2020). These contexts were ‘sustainable construction’, ‘sustainable development strategy’ or ‘corporate sustainability’. Moreover, the contextualization of sustainability was referred to as a ‘sustainable production system’ (Frau et al., 2022) or ‘financial sustainability’ (Rahimi et al., 2022). Finally, we identified six papers with a contextualization of sustainability and a conceptual proxy definition of DT (e.g., Nwaila et al., 2022; Kurniawan et al., 2023; Park et al., 2022).

Table 3
Digital transformation and sustainability definitions.

Definition of digital transformation	Definition of sustainability
Lokuge et al. (2021) "Vial (2019, p. 118) defines digital transformation as "a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies"." (p. 618)	"The World Commission on Environment Development (1987) defines sustainability as "development that meets the needs of the present without compromising the ability of future generations to meet their needs"." (p. 618)
Guandalini (2022) "Hanelt et al.'s (2021) definition of 'digital transformation' as the organizational change that is triggered and shaped by the widespread diffusion of digital technologies." (pp. 457–458)	"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" (Stuermer et al., 2017; Gartner, 2019)." (p. 457)
Hamalainen and Salmi (2023) "To explicate the extensive effects of novel digital technologies and innovations, the concept of digital transformation has been applied to describe "the changes that the digital technology causes or influences in all aspects of human life" (Stolterman and Fors, 2004, p. 689)." (p. 1251)	"Expertise on sustainable construction is also very much in the making, as it is a relatively new area in which different actors (e.g. regulators and companies) are facing new information and demands (Salmi et al., 2022)." (2023, p. 1253) "([…] [cross-laminated timber], which is an environmentally friendly way of constructing) and the adoption of digital Construction 4.0 solutions (which creates efficiency in operations)." (p. 1252)
Nayal et al., 2022 "Fundamental business processes that involve digitalizing everything that can be digitalized (Hagberg et al., 2016) for stronger collaboration and coordination among business processes and activities (Matt et al., 2015)." (p. 847)	"[Sustainable development strategy] is defined as a group of business programs that try to fulfill the needs of firm's stakeholders without compromising the resources and betterment of local people (Dyllick and Hockerts, 2002)." (p. 847)
Forcadell et al., 2020 "Digitalization allows companies to optimize their production costs while minimizing distribution costs, thus increasing their efficiency (Loebbecke and Picot, 2015)." (p. 2182)	"Corporate sustainability (CS) refers to a firm's orientation toward sustainable development; it is based on three pillars: economic, ecological, and social (Baumgartner and Ebner, 2010; Hubbard, 2009; Ozbekler and Ozturkoglu, 2020)." (p. 2181)
Nguyen and Thanh Hoai, 2022 "Digital transformation has been defined as the process by which a firm uses digital technologies to create appropriate new digital business models (Verhoef et al., 2021). By aggregating information, computing, communication, and connectivity technologies, digital transformation can improve an organization's environmental performance by facilitating significant environmental initiatives (Vial, 2019)." (pp. 3–4)	Items for Environmental performance (p. 10): • Complying with environmental regulations • Preventing and mitigating environmental crises • Limiting environmental impact beyond regulatory compliance • Educating employees and the public about the environment
Hein-Pensel et al., 2023 Digital transformation goes beyond pure digitalization and affects the entire company and its employees by reorganizing processes, business models and organizational structures (Verhoef et al., 2021). This transformation was given increased attention by the German government's initiative launched in 2011, called Industrie 4.0 (Industry 4.0), which emphasized the importance of cyber–physical systems especially in the manufacturing domain (Rojko, 2017).	In the elements of Industry 5.0, sustainability (Fig. 1) (p. 202): Implementation of environmental solutions, business models with sustainable aspects, involvement in strategic planning, monitoring of sustainability indicators
Ziadlou, 2021 "Practically, digitalization refers to the implementation of digital technologies and digital transformation refers to the effect of digitalization on human-related factors (Schallmo and Williams, 2018)." (p. 377)	"Sustainability points out the smart organizations must be active for not only gaining financial return, but also transforming people's mindset toward promoting community outcome, health outcome and environmental return (Albers Mohrman and Edward, 2014)." (p. 376)
Rahimi et al., 2022 "Digital transformation was described by Vial (2019) as a process through which DTLs cause some disruptions triggering strategic responses from the companies seeking to adjust their paths for value creation and, at the same time, managing the structural changes and organizational obstacles influencing both positive and negative concerns of such transformational process." (p. 2)	"In this context [financial], "sustainability" is generally described as a development that satisfies the present generation's requirements without compromising the future generations' requirements (Brundtland, 1987). Sustainability is characterized not only by this intergenerational aspect but also by intra-generational equity between north and south (Barkemeyer et al., 2014) and by taking into account both societal and environmental aspects of development (Vifell and Soneryd, 2012)." (p. 7)
Kumar et al., 2022 "Digital transformation leveraging Industry 4.0 is referred to as a strategic solution to handle the challenges given by growing competition and unpredictable customer demands in today's highly competitive business environment. […] The term Industry 4.0 refers to the fourth industrial revolution, which describes the recent technological changes that the manufacturing industry is experiencing in terms of the emergence of new business models and digitalized value chains based on enabling digital technologies (Büchi et al., 2020)." (p. 453)	"With a better understanding of sustainability issues, practitioners are more concerned about making industrial practices sustainable for people's social well-being (social), environmental prosperity (environment), and company's economic development (economic) (Sikdar et al., 2017). The term sustainability refers to meeting the needs of current generations without jeopardizing future generations' ability to meet their own needs (Belaud et al., 2019)." (p. 456)

(*continued on next page*)

Table 3 (*continued*)

Definition of digital transformation	Definition of sustainability
Sivarajah et al., 2020 "Digital transformation generally refers to the globally accelerated process of technical adaptation by individuals, organizations, communities and nations resulting from digitalisation (Westerman et al., 2014)." (p. 163)	"Sustainability, according to the World Commission on Environment Development (1987, p. 41), is a strategy that helps a business "to meet its current requirements without compromising its ability to meet future needs"." (p. 164)
Zekhnini et al., 2022 "More clearly, organizations' digital transformations entail essential changes in business processes, like digitising anything that could be digitalised (Zekhnini et al., 2020), gathering massive amounts of data from various sources and building a strong network for the value chain end-to-end (E2E), using digital technologies." (p. 6531)	"Thus, sustainability can be defined as the degree of the impact of existing actions of organizations on the potential situation of the natural environment, business viability, and culture (Krysiak, 2009)." (p. 6532)
Bordeleau et al., 2021 "We define DT as the process by which innovative solutions based on digital technologies transform all areas of organizations to reach a new form in which the technological and social aspects are integrated, ultimately driving digital value creation." (2021, p. 2) "Moreover, an exploration of the literature revealed a lack of consensus on the definition of DT. Some authors decide to focus on the integration and the interconnection of cyber-physical systems (Lee et al., 2015), (Chien et al., 2017), while others focus on the technological opportunities to answer changes in the market (Berman, 2012), (Bortolini et al., 2017)." (p. 1)	"Sustainability is the intersection of economic, environmental and societal viability (Weichhart et al., 2016)." (2021, p. 5) "[DT] It also leads to a better utilisation of resources, helping organizations reach their sustainability goals (Kamble et al., 2018)." (p. 1)
Frau et al., 2022 "Digital Transformation (DT)—defined as "a fundamental change process enabled by digital technologies that aim to bring radical improvement and innovation to an entity to create value for its stakeholders" (Gong and Ribiere, 2021, p. 10)" (p. 1)	"A sustainable production system is "protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources (FAO, 2012)." (p. 2)
Mohammadian et al., 2022 "In recent decades, due to the widespread development of technology, a new concept called the concept of "digital transformation" has become common (Kotarba, 2018). Digital transformation is defined as: "the use of new digital technologies for important advances in business, including improved customer experience, operational improvement, and innovation in business models." (p. 25)	"Hence, sustainable business model innovation refers to value creation for customers and companies by addressing social and environmental needs through business improvement. In the face of the need to achieve sustainability, business models need basic design." (p. 25)

4.2. Relationships between digital transformation and sustainability

Following the logic that a relationship can be described properly only if both concepts are defined, we include only papers containing explicit definitions in the 3rd round, resulting in a second shortlist. Thus, we exclude all papers where at least one of the concepts is undefined, as well as all papers using a conceptual proxy (total exclusion $n = 75$).

Table 4 presents the coding outcomes for the relationship between DT and sustainability. Following the logic of Table 1, on the left side, the role of DT is displayed in rows, whereas the role of sustainability is presented in columns. The cells indicate the number of papers coded for the corresponding role combination.

4.2.1. Digital transformation as driver for sustainability

The analysis of the role of DT and sustainability in the final 16 papers reveals that most articles see DT facilitating sustainability. More precisely, 11 papers see DT as the driver and sustainability as the outcome (e.g., Frau et al., 2022; Guandalini, 2022; Lokuge et al., 2021). In the context of this study, a driver represents a factor that actively influences a specific variable. At the same time, an outcome refers to the result or consequence of a potential variable and emerges from another element. Within the sample of the final articles, the link between DT and sustainability was mainly positive, as identified for 13 papers. For the remaining articles, there was one coexisting relationship between the two concepts (Hamalainen and Salmi, 2023), one negative connection (Rahimi et al., 2022), and one paper that was coded with both a negative and a positive relationship in parts (Lokuge et al., 2021). Overall, most of the studies were empirical papers, with either case studies or quantitative survey data. Nevertheless, four literature reviews were also part of the final sample. Table 5 shows the detailed coded characteristics per

Table 4
Relationship type distribution.

			Sustainability				
			Roles				∑
			codepend.	driver	factor	outcome	**Included**
Digital Transformation	Roles	codepend.	1				**1**
		context				1	**1**
		driver		1		11	**12**
		factor			2		**2**
	∑	**Included**	**1**	**1**	**2**	**12**	**∑ 16**

Table 5
Detailed relationships and paper types.

Coded characteristics	Coded characteristics per paper
Lokuge et al., 2021	
Role of Digital Transformation and Sustainability:	Driver–Outcome
Assessments of the causality link:	Positive & negative
Paper type:	Conceptual (panel discussion)
Research method:	Conceptualization
Context of application:	Environmentally sustainable digital transformation
Guandalini, 2022	
Role of Digital Transformation and Sustainability:	Driver–Outcome
Assessments of the causality link:	Positive
Paper type:	Conceptual
Research method:	Systematic literature review
Context of application:	Sustainability through digital transformation
Hamalainen and Salmi, 2023	
Role of Digital Transformation and Sustainability:	Driver–Driver
Assessments of the causality link:	Coexisting
Paper type:	Empirical
Research method:	Qualitative inductive research approach and semistructured interviews
Context of application:	Cross-laminated timber business network in Finland
Nayal et al., 2022	
Role of Digital Transformation and Sustainability:	Codependence–Codependence
Assessments of the causality link:	Positive
Paper type:	empirical
Research method:	Structural equation modelling
Context of application:	Sustainable supply chain firm performance
Forcadell et al., 2020	
Role of Digital Transformation and Sustainability:	Factor–Factor
Assessments of the causality link:	Positive
Paper type:	Empirical
Research method:	Panel data analysis
Context of application:	Banking
Nguyen and Thanh Hoai, 2022	
Role of Digital Transformation and Sustainability:	Driver–Outcome
Assessments of the causality link:	Positive
Paper type:	Empirical
Research method:	Structural equation modelling
Context of application:	Vietnamese manufacturing firms
Hein-Pensel et al., 2023	
Role of Digital Transformation and Sustainability:	Driver–Outcome
Assessments of the causality link:	Positive
Paper type:	Conceptual
Research method:	Systematic literature review
Context of application:	Maturity models for the digital transformation process in SMEs in the context of Industry 5.0
Ziadlou, 2021	
Role of Digital Transformation and Sustainability:	Driver–Outcome
Assessments of the causality link:	Positive
Paper type:	Empirical
Research method:	Exploratory qualitative approach with a semistructured, open-ended questionnaire
Context of application:	Health care industry
Rahimi et al., 2022	
Role of Digital Transformation and Sustainability:	Context–Outcome
Assessments of the causality link:	Negative
Paper type:	Empirical
Research method:	Interval-valued Pythagorean fuzzy sets
Context of application:	Financial services
Kumar et al., 2022	
Role of Digital Transformation and Sustainability:	Driver–Outcome
Assessments of the causality link:	Positive
Paper type:	Empirical
Research method:	Survey with partial least squares structural equation modelling (PLS-SEM)
Context of application:	Industry 4.0

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Table 5 (*continued*)

Coded characteristics	Coded characteristics per paper
Sivarajah et al., 2020	
Role of Digital Transformation and Sustainability:	Driver–Outcome
Assessments of the causality link:	Positive
Paper type:	Mixed method
Research method:	Taxonomy development by inductive qualitative research (focused literature review and interviews)
Context of application:	Web-based technology (participatory web) and sustainability in a B2B environment
Zekhnini et al., 2022	
Role of Digital Transformation and Sustainability:	Factor–Factor
Assessments of the causality link:	Positive
Paper type:	Conceptual
Research method:	Literature review & bibliometric analysis
Context of application:	Supply chain management
Bordeleau et al., 2021	
Role of Digital Transformation and Sustainability:	Driver–Outcome
Assessments of the causality link:	Positive
Paper type:	Conceptual
Research method:	Literature review and framework building
Context of application:	Industry 4.0
Frau et al., 2022	
Role of Digital Transformation and Sustainability:	Driver–Outcome
Assessments of the causality link:	Positive
Paper type:	Empirical
Research method:	Case studies
Context of application:	Food production
Mohammadian et al., 2022	
Role of Digital Transformation and Sustainability:	Driver–Outcome
Assessments of the causality link:	Positive
Paper type:	Empirical
Research method:	Meta-synthesis and interpretive structural modelling
Context of application:	Food industry

paper.

4.2.2. Further relationships

In addition, in one article, DT was a context in which to study sustainability outcomes (Rahimi et al., 2022). This paper explores how DT contributes to sustainability. In comparison, a few papers envisioned DT and sustainability both as drivers (Hamalainen and Salmi, 2023) and as factors (Forcadell et al., 2020). In the case where both concepts act as drivers, both are jointly aiming for a transformation. When both concepts are factors, they coexist in the context of DT and sustainability. Finally, DT and sustainability were assessed as codependent in one article (Nayal et al., 2022). With this coding, we assess the interrelationship and mutual influence between the two concepts.

5. Discussion

Next, we shift our focus from synthesizing the existing knowledge about DT and sustainability to interrogating and scrutinizing scholars' thinking and investigations of the topic (Alvesson and Sandberg, 2011; Steininger et al., 2022). The critical approach involves identifying methodological, logical, or conceptual concerns and reassessing the prevailing comprehension of this relationship. This helps us to question established assumptions and limitations. For the first theme, we highlight and extend the concept of digital sustainability. Additionally, for all three themes, we propose new research avenues and research questions.

5.1. Theme 1: uncovered issues and assumptions: conceptualizations of DT & sustainability

5.1.1. Uncovered issues and assumptions

Although there is a proliferating body of literature conceptualizing DT, it is rarely defined in the context of sustainability. Instead, various concepts, such as digital technologies, are used as proxies for DT without explaining the switch. For instance, Aleshkovski et al. (2020) use digital economy, Frau et al. (2022) digital technology adoption, and Verma et al. (2022) digital manufacturing and its synonym Industry 4.0 as proxies for DT. Similarly, Dukić Mijatović et al. (2020) noted that Industry 4.0 includes DT for sustainable development. Broo and Schooling (2023) use the proxy of a digital twin but state that digital twins are both an outcome and a prerequisite of DT.

Additionally, sustainability is often broadly defined (Suddaby, 2010). For example, Lokuge et al. (2021) adopt an atheoretical and general definition: "The World Commission on Environment Development (1987) defines sustainability as 'development that meets the needs of the present without compromising the ability of future generations to meet their needs'" (2021, p. 618). On the other hand, sometimes a contextualized concept in a specific industry is used. For example, Nwaila et al. (2022) address sustainability as "energy-efficient and environmentally conscious extraction and processing of minerals." Contextualized definitions make it difficult to assess their conceptual clarity and application to other contexts (Suddaby, 2010).

There seems to be a tendency to approach DT and sustainability theoretically and take practitioner-driven definitions, such as the TBL or the SDGs, for granted. However, these concepts need a theoretical anchor (Suddaby, 2010) and an analysis of their paradigmatic assumptions. This is because 1) sustainability is a multilevel concept, including individual, organizational, political-economic, social-cultural, and

ecological levels (Starik and Rands, 1995), where tensions may arise between the levels or different goals; 2) short-term and long-term goals can conflict; and 3) the generic goals in TBL or SDG frameworks can be interpreted and operationalized in various ways. Milne and Gray (2013) argue that the concept of a TBL that fully integrates and balances the economic, social, and environmental dimensions is likely unattainable, calling it 'an implausible pursuit' (p.17).

5.1.2. Solution for conceptualizing DT and sustainability

The conceptualization issues raise a major challenge: How can we conceptualize a consistent understanding of the multifaceted concepts of DT and sustainability? The related research question can then be formulated as follows: How can we conceptualize DT and sustainability?

We call upon scholars to conceptualize both concepts together. These can be operationalized and used in empirical research. Recent research has conceptualized DT (e.g., Baiyere et al., 2020; Wessel et al., 2021; Verhoef et al., 2021). Corporate sustainability lacks such an accuracy and conceptualization path. We propose a minimum working definition of their fusion concept by building on concepts of digitainability (Lichtenthaler, 2021) and digital sustainability (George et al., 2021; Pan and Zhang, 2020; Pan et al., 2022). We refer to this concept as *sustainability-driven DT (SDT)*. Furthermore, we propose that this minimum definition (Steininger et al., 2022) should build on prior literature on DT as well as on Green IT/Green IS.

Despite different theoretical lenses and levels of analysis, there seems to be a consensus that DT refers to a disruptive change process in business strategy driven by the possibilities of digital technologies (Hanelt et al., 2021; Singh and Hess, 2017; Vial, 2019; Wessel et al., 2021; Ologeanu-Taddei et al., 2023). Specifically, it has been argued that, in contrast to IT-enabled transformation, DT transforms an organization's value propositions (Ologeanu-Taddei et al., 2023; Wessel et al., 2021). While this literature accounts for new value creation as an outcome of DT, the nature of value is not questioned. Therefore, we argue that value can also be extended to digital sustainability, envisioned as SDT. This leads to our initial SDT definition: *SDT is the disruptive change process of business strategy, driven by the possibilities offered by digital technologies and leading to new value propositions that address value from the prism of corporate sustainability-related goals*.

DT requires changes in operations, business processes, and practices (e.g., Ologeanu-Taddei et al., 2023; Tana et al., 2023; Wessel et al., 2021). This means that SDT also necessitates changes at the operational level. Work practices and processes using digital technologies need to be sustainable. However, digital technologies have been criticized for their negative environmental impacts, especially because of their product lifespans, electricity costs, and associated greenhouse gas emissions (Jenkin et al., 2011). SDT, at the operational level, thus requires the consideration of the contributions of Green IT/Green IS research, which aims to improve energy consumption and reduce waste associated with the use of hardware and software (Jenkin et al., 2011). We thus finalize our SDT definition as follows: *SDT is the process of disruptive change in business strategy, driven by the possibilities offered by green digital technologies and leading to new value propositions that address value from the prism of corporate sustainability-related goals and translated into corporate sustainability-based operational processes.*

The social outcomes of using digital technologies can be included in the SDT definition, as they can be the SDT goals at the strategic or operational level. For example, responsible AI (e.g., Zimmer et al., 2022) can support new value propositions related to environmental or social values, such as improving people's health and well-being.

5.1.3. Research agenda

Our SDT definition emphasizes environmental aspects, but a definition of sustainability still needs better conceptualization, as highlighted by prior literature (e.g., Wang et al., 2020). This need for clarification has been addressed in various management fields.

The current literature has addressed the positive and negative social impacts of specific digital technologies in particular contexts. For example, the effects of using AI, such as algorithmic control of work on online labour platforms (e.g., Kellogg et al., 2020; Möhlmannn et al., 2021), discrimination during employees' recruitment and selection (Tambe et al., 2019) or discrimination for customer prioritization on the basis of demographic and economic factors, may lead to social inequality (e.g., Libai et al., 2020). Additionally, social media has raised concerns, such as cyberbullying and hate campaigns (e.g., Lowry et al., 2016) and filtering bubbles and echo chambers (e.g., Flaxman et al., 2016), leading to opinion polarization (e.g., Wade et al., 2020). On the other hand, AI may have positive outcomes, such as reducing human bias in the recruiting process (e.g., Chamorro-Premuzic and Akhtar, 2019), identifying risk factors for different types of grafting asthma (e.g., Zhang and Ram, 2020), and overall, allowing humans to flourish (Stahl et al., 2021). Hermann (2022) argued that AI should promote social good and prevent harm. Similarly, social media can be leveraged to detect early adverse events (Abbasi et al., 2019) and, therefore, to improve people's health, and mobile apps can foster digital entrepreneurship and well-being in low-income countries (e.g., Soluk et al., 2021). Both positive and negative social outcomes of digital technologies have emerged around ethical approaches (e.g., Hunkenschroer and Luetge, 2022). Unfortunately, these studies have not converged into coherent and concise definitions. We thus urge definitions (Suddaby, 2010), typologies (i.e., Negoita et al., 2018; Tana et al., 2023), and frameworks that can lead to rigorous and relevant empirical research.

In this route, the literature on Green IT/Green IS can be exploited more in depth. Similar to CSR, critical analysis of underlying assumptions on Green IS is needed to make this lens useful. This motivates the following research question: How can Green IT/IS contribute to a better understanding of SDT?

5.2. Theme 2: understanding the relationship between DT and sustainability

5.2.1. Uncovered issues and assumptions

When the relationship between DT and sustainability is considered, the role of DT (and its proxies) is not always clear. For instance, Verma et al. (2022) state that sustainability impedes the digitalization of manufacturing (Industry 4.0) but that digitalization also helps or harms sustainability. Similarly, Pauliuk et al. (2022) emphasized synergies between DT and sustainable development, but how these synergies are envisioned remains unclear.

This relationship has indeed been assessed. All but one paper in our final list envisioned DT as a driver and sustainability as an outcome. The exception is Rahimi et al. (2022), who argue that the digitalization of finance creates challenges and opportunities for new entrants. As all the studies use different definitions, it is difficult to comprehensively understand the relationship between DT and sustainability. How can we conceptualize the relationship between DT and sustainability?

5.2.2. Research agenda

We encourage scholars to be explicit with their assumption of the type of theory they choose. For example, variance theories (van de Ven and Poole, 2005) operationalizing and measuring the link between DT and sustainability constructs and process theories (van de Ven and Poole, 2005) describing temporal sequences, critical events, contextual influence, and formative patterns of change related to both DT and sustainability are fundamentally different. Zhong and Ren (2023) propose a variance theory where CSR moderates DT effectiveness. They argue that CSR weakens the negative impact of DT on transition economy firms' short-term performance but enhances the positive impact of DT on their long-term value by increasing stakeholder recognition and support for DT initiatives.

Therefore we propose the following research questions: How can DT and sustainability be operationalized? How does DT impact sustainability (or vice versa)? What are the antecedents, consequences,

mediators, and moderators of their relationships? What are the antecedents, consequences, mediators, and moderators of SDT? How do DT and sustainability interplay? How does SDT unfold over time?

5.3. Theme 3: assessing the relationship between DT and sustainability

5.3.1. Uncovered issues and assumptions

In combination with the previous theme, it is unclear how the relationship between DT and sustainability is assessed. The current literature shows that it is static. When sustainability definitions, such as the TBL or the SDGs, are taken for granted, sustainability is addressed positivistically as a "thing" (Langley and Tsoukas, 2010), while DT is assumed to be more processual. This further increases the ambiguity and fuzziness of their relationship.

5.3.2. Research agenda

To address this challenge, we make two suggestions. First, we call for the problematization of the existing CSR literature. CSR assumes that corporations and their shareholders are accountable for society and the environment (Lamm et al., 2015). This view remains atheoretical. The term has evolved from maximizing the stakeholders' profit to satisfying and balancing the stakeholders', especially the employees', interests (Rodriguez-Gomez et al., 2020). A recent perspective on how CSR is integrated into strategy and can generate long-term stakeholder value (Rodriguez-Gomez et al., 2020) blurs its frontiers with sustainability. Theoretical analysis to disentangle these concepts and to understand whether CSR relies on an illusion (Gomez-Carrasco et al., 2016) is thus needed.

The sustainability term (and closely related terms CSR, TBL, and SDGs) should be disentangled to understand whether there are conflicting constraints and tensions. For example, does sustainability, particularly SDT, motivate stakeholders to pursue the same direction, or is it a wicked multistakeholder problem (i.e., Hales and Jennings, 2017; Diriker et al., 2023)? In contrast, does DT help in "taming" or solving tensions and finding a solution to a sustainability problem? Would SDT create a wicked problem because of the broadness of an idea/concept? If the concept is qualified as a hembig, meaning as hegemonic, ambiguous, and big (Alvesson and Blom, 2022), would it obscure the scholarship discussions and facilitate poor relevance for empirical studies and practical impacts? Prior studies have shown that environmental issues

Table 6
Issues, proposed solutions, and research path for digital transformation and sustainability.

Theme	Issues	Challenge & research question	Proposed solution and research path
Conceptualizations of DT & sustainability	Ambiguity and fuzziness of at least one of the concepts Misconceptualization of DT (use of a proxy) Use of nonconceptualized definitions of sustainability (TBL, SDGs) while the ambiguity and complexity of these definitions are neglected.	Challenge How can we conceptualize a consistent understanding of the multifaceted concepts of DT and sustainability? Research questions How can we conceptualize DT and sustainability taking into account that sustainability is a multifaceted concept? How can Green IT/IS contribute to a better understanding of SDT?	Definition and consistent conceptualization of both concepts and their interplay Minimum construct definition: digitainability or "digital sustainability" as SDT Research path The strategic level: DT and sustainability (Green IT/Green IS; social goals) leading to the new value proposition and business models; The operational level: DT and sustainability (Green IT/Green IS; social goals) as practices.
Understanding the relationship between DT and sustainability	Lack of conceptualization of the relationship between DT and sustainability	This issue poses another challenge: How can we conceptualize the relationship between DT and sustainability? How can DT and sustainability be operationalized in measurable variables? How does DT impact sustainability (or vice versa)? What are the antecedents, consequences, mediators, and moderators of their relationship? What are the antecedents, consequences, mediators, and moderators of SDT? How do DT and sustainability interplay? How does SDT unfold over time?	Research path Choose and explicate the assumptions of the relationship: variance or process perspective (van de Ven and Poole, 1995). *Variance theories*: operationalize and measure the link between constructs related to DT and sustainability *Process theories*: describing temporal sequences; critical events and turning points, contextual influence, and formative patterns of the change related to both DT and sustainability
Assessing the relationship between DT on sustainability	Ambiguity and fuzziness of the relationship between DT and sustainability	Research questions: How do external factors (i.e., regulation, legitimacy) foster SDT? Is sustainability, and in extension SDT, an incentive or motivation for the stakeholders to pursue the same direction, or, in contrast, is it a wicked multistakeholder problem? Does DT help in "taming" or solving tensions and finding a solution, even nonoptimal, to the sustainability problem? Would SDT create a wicked problem because it evokes an overly broad idea/concept that can be qualified as a "hembig"? What are the tensions existing in the relationship between DT and sustainability? How is SDT constructed (e.g., as a synthetic reality of sustainability or synthetic sustainability)?	Choose and explicate the assumptions of the type of process theory chosen: evolution, dialectic, life cycle, teleology (van de Ven and Poole, 1995). Suggested theories *Evolution:* "Innovation offset": Environmental regulation pushes organizations to foster digital transformation (Chen, 2022). *Dialectic*: Tensions and paradoxes of SDT or the interplay between DT and sustainability. *Life cycle*: The life cycle of green digital technologies and their influence on sustainable operational processes and business models. *Teleology*: Alignment of DT and sustainability (Lokuge et al., 2021).

are complex (Carmine and Marchi, 2023; Alexander et al., 2022; Karakulak and Stadtler, 2022) and have investigated the tensions between the social, economic and environmental dimensions of the TBL (Hahn et al., 2018, 2015; Carmine and Marchi, 2023). For instance, Hahn et al. (2015) highlighted that tensions in corporate sustainability occur between different levels, in change processes and within temporal and spatial contexts.

Second, we call for investigations of various types of process theories: evolution, dialectic, life cycle, or teleology (van de Ven and Poole, 1995). For example, an evolutionary perspective can be adopted to study how external factors drive an organization's evolution. Chen et al. (2022) argue that institutional regulation may enhance innovation and that environmental regulations have the compensatory effect of stimulating DT. Thus, how do external factors (i.e., normative pressure related to regulation and legitimacy) foster SDT?

Interestingly, no paper has addressed the tensions in the relationship between DT and sustainability. Are the tensions absent because sustainability-related goals align all the stakeholders and give them a common trigger and motivation? Or are those tensions a blind spot in DT and sustainability research, while organizations struggle with conflicting institutional logics (Gümüsay et al., 2020; Besharov and Smith, 2014) and competing demands, contradictions, and paradoxes (Smith and Lewis, 2011; Smith et al., 2017; Bledow et al., 2009), which underlie various goals embedded in the TBL and SDG definitions?

These questions can be approached, for example, from the perspective of DT as a collective social action (Tana et al., 2023, p. 2). Tana et al. (2023), using the criterion of openness of both boundaries of social actors and their objectives, propose four distinct types of DT: prescribed, with predeterminate boundaries and rigid objectives; constructive, with rigid boundaries and open objectives; connective, with fluid boundaries and predetermined objectives; and systemic, with fluid boundaries and open objectives. Their lens can envision digital sustainability in settings where sustainability-related goals are predetermined or open. The potential contradiction between the understanding of sustainability and DT can hinder a consensus on shared goals. The collective action can then be trapped in a paradoxical dilemma and conflicting constraints (e.g., Alexander et al., 2022; Carmine and Marchi, 2023; Karakulak and Stadtler, 2022). From this perspective, adaptive governance in a complex system (Dietz et al., 2003) and the evolution of this social-ecological-digital system (e.g., Ologeanu-Taddei et al., 2023) offer other lenses for further research.

In addition, future research may investigate the role of reflexivity (Mutch, 2007) and employees' values (i.e., Bertland, 2009) when they become more active change agents (Benson, 1977) initiating and engaging in SDT. For instance, Lamm et al. (2015) investigated employees' organizational citizenship behaviours toward the environment. The agency, reflexivity, and values of consumers and their role in fostering SDT can provide a promising area of investigation.

Scholars may also investigate how the life cycle of green digital technologies influences operational processes and business models to make them more sustainable. A teleological path can be pursued, for example, in line with Lokuge et al. (2021), who suggested that aligning DT and sustainability initiatives provides a new theoretical lens for IT-business alignment. Further research can integrate this lens with social alignment, i.e., alignment with stakeholders' goals (Burton-Jones et al., 2020).

In current research, there is a prevailing implicit positivist lens of sustainability, beyond which the construction of the relationship between DT and sustainability should be studied. Future research can explore how DT leads to data provision, creating a synthetic reality of sustainability (Cetina, 2009). Consequently, the following research question can be formulated: How is SDT constructed (e.g., as a synthetic reality of sustainability or synthetic sustainability)?

Table 6 summarizes the issues, challenges, and solutions and recommendations for DT and sustainability from our critical review.

This review contributes to the literature in four main ways. First, we highlight the conceptual ambiguity surrounding DT and sustainability and, consequently, the need for conceptual clarification of this link. Second, by calling for a more consistent, theoretically grounded understanding of both concepts, it offers a refined definition of SDT. This advances the literature by integrating digital and sustainability goals more coherently rather than treating them as separate or proxy concepts. Third, this paper critically assesses the assumptions made in prior research, for example the overreliance on practical frameworks such as the TBL and SDGs. By questioning these frameworks and their theoretical underpinnings, scholars are encouraged to reexamine the paradigmatic assumptions that drive research in this field. Fourth, the identification of methodological, logical, and conceptual gaps provides new research directions, such as exploring how digital transformation and sustainability interact at different levels (individual, organizational, and ecological) and time frames (short-term vs. long-term). This generates new questions, including how Green IT/IS can be integrated into the broader connection between digital transformation and the sustainability agenda.

Our study can help managers design and assess a digital transformation strategy driven by sustainability goals. Such a strategy needs clarity to engage internal and external stakeholders (employees, customers, regulators, and investors) in the company's sustainability-driven digital transformation journey.

6. Concluding remarks

We provided a critical review of the relationship between DT and sustainability. We identified 91 articles that exhibited a growing interest in DT and sustainability. Our critical review revealed that most of them have no definition, use a proxy for the specific phenomenon, or include plain or contextualized definitions. Only 16 articles explicitly highlighted the relationship between both concepts.

Organizations and researchers should move beyond broad, practitioner-driven definitions of DT and sustainability, such as TBL or SDGs, and develop more nuanced and theoretically grounded conceptualizations. This shift would enable more accurate assessments of the relationship between DT and corporate sustainability, ensuring that the transformative potential of digital technologies is leveraged to create sustainable business strategies.

CRediT authorship contribution statement

Roxana Ologeanu-Taddei: Conceptualization, Formal analysis, Investigation, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. **Sarah Hönigsberg:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Visualization, Writing – original draft, Writing – review & editing. **Pauline Weritz:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Writing – original draft, Writing – review & editing. **Hendrik Wache:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Validation, Writing – original draft, Writing – review & editing. **Ferdinand Mittermeier:** Conceptualization, Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. **Silviana Tana:** Conceptualization, Data curation, Formal analysis, Investigation, Validation, Writing – original draft, Writing – review & editing. **Duong Dang:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Writing – original draft, Writing – review & editing. **Tuire Hautala-Kankaanpää:** Conceptualization, Data curation, Formal analysis, Investigation, Validation, Writing – original draft, Writing – review & editing. **Samuli Pekkola:** Supervision, Writing – original draft, Writing – review & editing.

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Data availability

No data was used for the research described in the article.

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