



The Twin Transformation Butterfly

Capabilities for an Integrated Digital and Sustainability Transformation

Anne-Sophie Christmann · Carlotta Crome · Valerie Graf-Drasch  ·
Anna Maria Oberländer · Leonie Schmidt

Received: 19 August 2022 / Accepted: 27 October 2023
© The Author(s) 2024

Abstract Complex digitalization and sustainability challenges shape today's management agendas. To date, the dedication of Information Systems research to both challenges has not been equal in terms of effort and reward. Building capabilities to leverage the synergetic potential of digital and sustainability transformation may enhance organizational performance and imply new value creation for the common good. To uncover such synergetic potential, this work conceptualizes the “twin transformation”

construct as a value-adding reinforcing interplay between digital transformation and sustainability transformation efforts that improve an organization by leveraging digital technologies to enable sustainability and to guide digital progress by leveraging sustainability. The twin transformation conceptualization is complemented with a capability framework for twin transformation drawing from dynamic capability theory. This work contributes to descriptive knowledge of the interplay between digital transformation and sustainability transformation, setting a foundation for further theorizing on twin transformation and enabling organizations to twin transform.

Accepted after three revisions by Till Winkler.

A.-S. Christmann (✉) · C. Crome · V. Graf-Drasch ·
A. M. Oberländer
FIM Research Center for Information Management, Augsburg,
Germany
e-mail: as.christmann@gmx.de

C. Crome
e-mail: carlotta.crome@fit.fraunhofer.de

V. Graf-Drasch
e-mail: valerie.graf-drasch@uni-hohenheim.de

A. M. Oberländer
e-mail: anna.oberlaender@fim-rc.de

A.-S. Christmann · V. Graf-Drasch · L. Schmidt
University of Hohenheim, Stuttgart, Germany
e-mail: leolorenschmidt@gmail.com

A.-S. Christmann · C. Crome · V. Graf-Drasch ·
A. M. Oberländer
Branch Business and Information Systems Engineering of the
Fraunhofer FIT, Augsburg, Germany

C. Crome
University of Applied Sciences Augsburg, Augsburg, Germany

A. M. Oberländer
University of Bayreuth, Bayreuth, Germany

Keywords Twin transformation · Digital transformation · Sustainability transformation · Dynamic capabilities

1 Introduction

“Digital transformation [...] can be likened to the metamorphosis of a larva into a butterfly.” (Baiyere et al. 2020, p. 253)

We live in a world in which organizational environments are prone to constant change and crises (Ellström et al. 2022). Two global crises have produced powerful transformational forces: the pandemic has fueled digital transformation at all societal levels, and the worsening climate change has fueled sustainability transformation discussions (Boh et al. 2020). Organizations that adapt to these transformational forces and deal with both transformations in a synergetic approach appear to be more successful (Ollagnier et al. 2021, p. 11) than their counterparts focused on single transformation. However, integrating digital transformation and sustainability transformation,

recently labeled “twin transformation” (Balta et al. 2022; Crome et al. 2023b; Ollagnier et al. 2021), is challenging and demands specific capabilities. Many organizations lack the knowledge and guidance needed to develop these essential twin transformation capabilities.

To date, research on the required capabilities of digital and sustainability transformation has evolved almost independently due to being anchored in different domains (Acciarini et al. 2022; Del Río Castro et al. 2021; Forcadell et al. 2020). In specific terms, dedication to the two key transformations in Information Systems (IS) research has not been equal in terms of effort or reward (Zimmer and Järveläinen 2022). While the amount of research on digital transformation has increased significantly over the past decade (e.g., Hanelt et al. 2021; Plekhanov et al. 2022), scant research has been undertaken on sustainability transformation (Lehnhoff et al. 2021). Consequently, when leveraging digitalization and sustainability simultaneously, one transformation has been prioritized over the other (Demartini et al. 2019; Maffei et al. 2019) – or sustainability has been reduced to its ecological aspects rather than integrating its holistic perspective (i.e., accounting for ecological, social, and economic progress). However, the potential of digital solutions to assist in achieving sustainability goals is indisputable, as demonstrated by research streams such as Green IT (Kranz et al. 2015; Lehnhoff et al. 2021; Loeser 2013; Veit and Thatcher 2023) or Green IS (Kranz et al. 2015; Sarkis et al. 2013; Seidel et al. 2017; Watson et al. 2010).

Complex digitalization and sustainability problems demand integrated solutions, as thinking in silos ignores the synergetic potential of the digital and sustainability transformation interplay. Digital transformation can potentially enable insights about sustainability transformation effects, while sustainability transformation may guide the design of digital transformation solutions, realizing value in new ways. To uncover the synergetic interplay between digital and sustainability transformation, IS research has the opportunity and responsibility to create a common understanding of the twin transformation construct. After gaining an understanding of twin transformation and its key elements, it is equally important to understand required capabilities. They refer to repeatable patterns of action in the use of assets to create and/or offer products or services (O’Reilly and Tushman 2008; Teece et al. 1997; Wade and Hulland 2004). Such capabilities are key to trigger and implement twin transformation in research and practice. Against this backdrop, we ask the following research question: *What constitutes twin transformation, and which capabilities are needed for organizations to twin transform?* The research question is sequential, in the sense that the second part builds on the first. As the twin transformation concept is new to IS

research and is yet to be comprehensively conceptualized, we first develop the twin transformation construct as a foundation for deriving dynamic twin transformation capabilities based on empirical insights.

To address our research question, we first align digital and sustainability transformation perspectives, define and establish the twin transformation construct, and delimit related concepts (Podsakoff et al. 2016; Suddaby 2010). Second, we explore relevant capabilities following dynamic capability theory (Teece et al. 1997), resulting in a twin transformation capability framework. To achieve this, we conducted explorative interviews with key informants who exhibited strong leadership and ideas when it came to digital or sustainability transformation and ultimately twin transformation. It should be noted that most organizations have not yet completed an effective twin transformation.

In establishing a general understanding of twin transformation and revealing a range of dynamic twin transformation capabilities that are critical yet overdue, our study presents three overarching implications. First, it provides an opportunity for the IS discipline to take a natural and decisive next step in advancing digital and sustainability transformation knowledge, thus creating a foundation for further theorizing on twin transformation. Second, we arrive at insights relating to the digital transformation realm, emphasizing sustainability in future endeavors. Third, we mobilize sustainability transformation research efforts by emphasizing the need to consider digital transformation as an enabler. In addition, our work highlights the practical value of recognizing and understanding relevant dynamic capabilities to initiate twin transformations in organizations.

2 Theoretical Background

2.1 A Capability Lens for Twin Transformation

Organizations need *ordinary capabilities* to organize recurring processes or to perform efficiently in the market – for example, to manage production processes (Teece 2014). Organizations also require *dynamic capabilities* to build, conjoin, and configure ordinary capabilities and assets when exploring new markets or products – for example, while creating digital innovations (O’Reilly and Tushman 2013; Piccoli and Ives 2005; Teece et al. 1997; Winter 2003). Once identified, dynamic capabilities can unfold benefits, as they enhance an organization’s potential to (1) identify new developments and opportunities, (2) make timely and market-oriented decisions, and (3) systematically solve problems (Barreto 2010; Teece 2007). In essence, dynamic capabilities are essential for effective

organizational transformations, as they initiate change with a view to ensuring competitive advantage (Teece 2007, 2014).

Dynamic capabilities have gained momentum in IS research (e.g., Huber et al. 2022; Steininger et al. 2022; Wade and Hulland 2004). IS scholars have investigated dynamic capabilities in relation to the integration, deployment, and connection of digital technologies combined with other assets, such as human capital (Bharadwaj 2000; Huber et al. 2022; Wade and Hulland 2004). Furthermore, IS research has predominantly applied two complementary perspectives on dynamic capabilities: first regarding their orientation, and second regarding their role in value creation. First, focusing on the orientation of the capabilities, IS research has grouped dynamic capabilities into three different perspectives (Doherty and Terry 2009; Felipe et al. 2019; Wade and Hulland 2004): (1) *inside-out dynamic capabilities*, which are deployed from the inside of an organization in response to market requirements (e.g., IS infrastructure, technical skills), (2) *outside-in dynamic capabilities*, which are externally oriented (e.g., market responsiveness, managing external relationships), and (3) *spanning dynamic capabilities*, which are needed to integrate an organization's inside-out and outside-in dynamic capabilities (e.g., working partnerships, IS management and planning). Second, dynamic capabilities in the context of IS have been subdivided into primary and support capabilities, differentiating the capability's role in value creation (Huber et al. 2022; Porter 1995). *Primary capabilities* focus on delivering new product and service solutions, directly influencing value creation. By contrast, *support capabilities* focus on improving support processes and collaboration, thus indirectly influencing value creation by increasing the effectiveness of primary capabilities.

Following up on existing IS research, this work refers to *dynamic capabilities as the organizational ability to (1) scan the environment regarding opportunities and threats, (2) make decisions based on identified opportunities, and (3) transform ordinary capabilities and assets to realize the identified opportunities withstanding rapidly changing environments* (Steininger et al. 2022; Teece et al. 1997; Teece 2007). In the following section, we examine digital and sustainability transformation as the two building blocks of twin transformation and present related research on associated dynamic capabilities.

2.2 Digital Transformation

Digital transformation has garnered significant interest among IS researchers and practitioners for several years (El Hilali et al. 2020; Konopik et al. 2021; Kraus et al. 2022). Such transformation is associated with changes in the self-understanding of organizations (Wessel et al. 2021), the

nature of strategy (Bharadwaj et al. 2013), and pathways to value creation (Karnebøgen et al. 2021). The new value creation is rooted primarily in emergent digital technologies that trigger digital transformation and often promise to harness novel organizational value (Karnebøgen et al. 2021). As scholars in the IS field, as well as practitioners, have not yet reached full conceptual and empirical clarity in relation to the digital transformation phenomenon (Markus and Rowe 2023), numerous and diverse definitions have been proposed for digital transformation (e.g., Hartl and Hess 2017; Soluk and Kammerlander 2021; Warner and Wäger 2019). For example, Vial (2019, p. 3) defines digital transformation as “a process that aims to improve an entity” by adopting digital technologies. Digital technologies are an umbrella term for information, computing, communication, and connectivity technologies (Bharadwaj et al. 2013). According to Vial (2019), the adoption process usually triggers significant changes to the properties of the entity involved, which may be a process, a business unit, or another organizational element. Other scholars suggest that digital transformation goes even further, as the adoption of digital technologies impacts value creation and capture, enabling completely new digital business models (e.g., AlNuaimi et al. 2022; Kreuzer et al. 2022; Wessel et al. 2021). This has potential consequences and implications for different organizational actors and environments (Chaniyas et al. 2019; Kraus et al. 2022). Furthermore, digital transformation is expected to trigger the development of new organizations. This might involve new market entrants and developments within incumbent organizations that aspire to enhance their competitive advantage (Kraus et al. 2022; Osmundsen et al. 2018).

Scholars have investigated the dynamic capabilities required during a digital transformation, such as those needed to establish digital leadership (Konopik et al. 2021), a digital strategy (Keller et al. 2022), or a digital culture (Weritz et al. 2022). Exemplary dynamic capabilities refer to important initiatives that are part of a digital transformation, such as facilitating data collection and analysis during operational processes – for example, by implementing Industry 4.0 (e.g., Santos and Martinho 2019), or the rollout of process automatization (e.g., Kırmızı and Kocaoglu 2022). Other examples include fostering access to innovative digital infrastructure – for example, to green data centers and thus to green cloud computing (Battleson et al. 2016) – and building a stable funding model for this infrastructure to support the progress of digital transformation (Montealegre et al. 2019). Working with innovative digital infrastructure creates the foundation for the development of other dynamic capabilities such as designing modular processes (Battleson et al. 2016).

Acknowledging and complementing existing valuable insights regarding digital transformation capabilities, this

study aims to develop an overview of relevant dynamic twin transformation capabilities. To establish common ground, we define *digital transformation* in line with Vial (2019), Wessel et al. (2021), and Hanelt et al. (2015) as *an organizational change process that improves an organization through digital technologies and may lead to profound changes in value creation and the organizations' identity*.

2.3 Sustainability Transformation

Like digital transformation, sustainability transformation also refers to an organizational change process that represents a paradigmatic shift in terms of multi-dimensional change (Dao et al. 2011; Dyllick and Muff 2016; Lahtinen and Yrjölä 2019). Efforts to achieve sustainability transformation have increasingly captured the attention of researchers and practitioners (Peters and Simaens 2020). This work builds on the concept of Dyllick and Muff (2016), which defines a truly sustainable organization as one that seeks to have a significant positive impact in critical and relevant areas for society and the planet. We chose to build our work on this concept, as the typology adopted by these authors identifies three maturity levels of business sustainability on the basis of three elements: the what (input), the how (process), and the what for (output; Dyllick and Muff 2016). With this outside-in perspective, serving the common good – defined as benefiting society and the planet as a whole – becomes the main organizational purpose (Dyllick and Muff 2016). Sustainability transformation is undertaken by organizations that review and involve the external environment in which they operate. Moreover, sustainability transformation is present in organizations that ask themselves how to overcome pressing challenges by developing new strategies and business models (Bocken et al. 2014; Geissdoerfer et al. 2018). Consequently, sustainability efforts provide opportunities for innovation and new business models (Bocken et al. 2014; Geissdoerfer et al. 2018). This has resulted in increasing attention being devoted to business model transformation for sustainability in the past few years (Abdelkafi and Täuscher 2016). Today, there are many different forms of sustainable business models. One popular business model centers on the circular economy concept, whose primary objective is to minimize resource input (Ortega-Gras et al. 2021; Zeiss et al. 2021).

Scholars have investigated the dynamic capabilities required during a sustainability transformation, such as those needed to introduce sustainable business practices or market strategies (Gimpel et al. 2020; Mousavi et al. 2018), to foster sustainable process innovation (Chiou et al. 2011), or to initiate sustainability training for employees (Wu et al. 2013). Dynamic sustainability capabilities help

organizations anchor systematic life cycle management and integrate sustainability practices into their routines (Bianchi et al. 2022). This supports organizations in integrating sustainability aspects in product life cycles (e.g., Yazici 2020). In addition, dynamic sustainability capabilities translate into formalizing structural mechanisms to involve important stakeholders (Montealegre et al. 2019). Embedded structural mechanisms enhance the collaboration between specialized sustainability units and product developers or owners (Dangelico et al. 2017).

As a foundation, we understand *sustainability transformation as an organizational change process that is multi-layered, complex, and relates simultaneously to environmental, societal, governmental, regulatory, and individual factors* (Lahtinen and Yrjölä 2019; Oghazi and Mostaghel 2018; Seidel et al. 2014). The integration of sustainability within an organization involves reshaping strategy and operative processes, with the ultimate goal of reducing cost, increasing competitiveness, supporting durable profitability, and becoming a viable, long-term contributor to society and the business market (Cici and D'Isanto 2017; Dao et al. 2011; Peters and Simaens 2020).

3 Method

3.1 Development of the Twin Transformation Construct

Conceptualizing twin transformation makes it possible to organize the complex phenomena with a common language, thus facilitating communication between researchers and practitioners and serving as a fundamental building block of twin transformation theory (Podsakoff et al. 2016). With a view to identifying fundamental characteristics of twin transformation (Podsakoff et al. 2016), we followed four critical steps of construct development based on Suddaby (2010) and Podsakoff et al. (2016). First, we explained the nature of twin transformation based on prior literature and the outlined digital and sustainability transformation constructs in isolation. Drawing on this justificatory knowledge, we elaborated on the synergetic interplay between these constructs and delineated contextual application areas. Second, we abstracted relevant twin transformation elements into a robust conceptual generalization, providing a new definition of twin transformation that demonstrated its relationship to similar, preexisting constructs. Third, we demonstrated logical consistency of the twin transformation construct in relation to our overall theoretical argument. Although presented in a linear manner above, this process of conceptualizing twin transformation was dynamic and iterative and proceeded to unearth a well-crafted construct that captures essential elements

and highlights similarities to and differences from prior research. Throughout the process, we held intense discussions within the author team to ensure a continuous mutual understanding on the progress of conceptualization. Further, we included feedback from external IS researchers, as well as practitioners from organizations that were striving to become twin transformers.

3.2 Development of the Twin Transformation Capability Framework

To explore the dynamic capabilities associated with twin transformation, we followed IS literature's qualitative research genre (Gioia et al. 2013; Sarker et al. 2018) leveraging qualitative empirical data from interviews with practitioners. Qualitative methods are suitable tools for discovering and exploring new research areas (Miles and Huberman 1994). Such methods can be described on the basis of two dimensions (Sarker et al. 2018): (1) the approach to data (data-centric or interpretation-centric) and (2) the process of reasoning (discovery/inductive or confirmation/deductive). Since we treated our interviewees as "knowledgeable agents," we followed a *data-centric* approach (Gioia et al. 2013; Sarker et al. 2018). Consequently, our interviewees are hereafter consistently referred to as "key informants" (Kumar et al. 1993). We gave our key informants a voice in the early stages of data gathering, analysis, and result reporting, thus creating opportunities to discover new concepts and interrelations (Gioia et al. 2013). In addition, our process of reasoning was *inductive* since we treated our data as representative facts and built a framework grounded in data (Bhattacharjee 2012; Sarker et al. 2018).

3.3 Participants and Procedures

We conducted 20 one-on-one, semi-structured interviews with digital, sustainability, and innovation managers from 15 different organizations in various industries from February 2022 to June 2022. We deliberately chose an industry-agnostic sample, as digital, sustainability, and twin transformation are certainly spread across industries. Details of the organizations, industries, and key informants' roles are presented in Supplementary Appendix A. All key informants represent organizations that had conducted a fruitful digital or sustainability transformation and may have considered combining aspects of both single transformations. We argue that digital or sustainability transformations still serve as valuable sources of information and that organizations have gained capabilities from a digital-first or sustainability-first transformation already undertaken. In essence, we observed several organizations that did not consciously aim toward twin transformation,

but implicitly tapped into the advantages of digital and sustainability transformation synergies. Some organizations, for example, understood the importance of digitalization for their sustainability transformation (e.g., establishing data transparency for environmental, social, and governance (ESG) reporting) or of sustainability for their digital transformation (e.g., replacing data centers with green cloud solutions).

Having recruited our initial participants via personal networks, we continued with snowball sampling. In some cases, for example, we received contacts during our interviews as the organizations were partly connected to each other (e.g., through ecosystems, supply chain, or personal relations). This produced a somewhat unrepresentative sample, but is a well-established approach that provides access to key informants who may otherwise be difficult to identify or reach (Heckathorn 1997). We kept including organizations until the point at which few or no new insights could be generated by including more data. The interviews were held in German via video conference. They typically lasted between 30 and 45 min (11,67 h in aggregate). With our key informants' consent, we recorded and transcribed all interviews for subsequent analysis.

Prior to each interview, we provided a clear description of the project and its purpose. Drawing on the dynamic capability literature (Teece et al. 1997), we created an interview guide based on an iterative approach. Although the interviews were conversational, an interview guideline protocol (see Appendix B) covered topics related to our research question, without leading respondents in any direction (Gioia et al. 2013). The first block comprised the general organizational relevance of both digital and sustainability transformation and explained the research topic to our key informants. The second block focused on explicit activities toward twin transformation: Each key informant was asked to name and describe current digital and sustainability initiatives in which they were personally involved. The intention here was to identify organizational factors that stimulated and supported the development of dynamic twin transformation capabilities. The last block was intended to provide space for key informants' final remarks.

3.4 Data Analysis

We performed a pattern-identifying technique to gather empirical qualitative insights from the interview data and to cluster text segments into meaningful concepts, themes, and aggregate dimensions (Gioia et al. 2013). Going back and forth between the literature and data, we consistently compared and contrasted new categories as they emerged and discussed their interconnections. The data were analyzed using the MAXQDA qualitative data analysis

program. During the analysis, we used memoing by writing down ideas on key informants' quotes as they came to our minds while coding (Bhattacharjee 2012). The coding process was divided into three stages: open, axial, and selective coding (Corbin and Strauss 1990). An exemplary coding scheme outlining the coding process is presented in Appendix C. Although presented in a linear manner below, our analysis was dynamic and iterative, with the various aspects being addressed simultaneously. We continued coding new data and refining our findings until the point at which additional interviews did not yield any change in the core categories and relationships. In the following section, we provide details on the coding steps (i.e., open, axial, and selective) and how we derived first-order concepts, second-order themes, and aggregate dimensions.

In the first-order analysis, which relied on informant terms close to the original data, we read the interview transcripts thoroughly and highlighted important text passages. After the first 13 interviews, ~ 210 primary codes emerged. As part of the open coding process, we grouped the primary codes according to equivalent content statements from our key informants. We derived 17 first-order concepts and labeled them, while remaining close to the key informants' actual wording (Gioia et al. 2013). In the course of the coding process, we invariably encountered the issue of different authors interpreting certain informants' terms differently. If agreement could not be reached on certain codes, we revisited the transcripts, engaged in discussions, and developed mutual understanding and consensual decision rules. As the research progressed, we conducted a further seven interviews. While constantly comparing and evaluating similarities and differences, three additional first-order categories emerged. Next, we reviewed whether all identified capabilities matched our understanding of dynamic capabilities. In doing so, we removed four first-order categories as we classified them as ordinary capabilities. Finally, we derived a total of 16 first-order concepts. Following Gioia et al. (2013), we searched for similarities and differences between the codes (similar to Corbin and Strauss's (1990) notion of axial coding) and examined related literature. On the basis of existing literature (e.g., the outside-in/inside-out capability taxonomy of Wade and Hulland (2004)), we interpreted our data by asking whether the emerging themes suggested concepts that might assist us in describing and explaining the phenomena we were observing (Gioia et al. 2013). Moreover, we consistently searched for dynamic interrelations and data-to-theory connections – thus alleviating the usual concern that qualitative research frequently does not demonstrate how data relate to theory. Combining the first-order concepts, we grouped four more abstract second-order themes.

As a last step, we performed selective coding by evaluating all themes with the help of relevant literature (Huber et al. 2022; Steininger et al. 2022; Teece 2014). Consequently, we integrated and refined our second-order themes into larger theoretical schemes and distilled the emergent second-order themes even further into two aggregate dimensions.

4 Results

4.1 Foundation: The Twin Transformation Construct

As the twin transformation construct is new to IS research and is still to be comprehensively conceptualized, we first developed the twin transformation construct as a foundation for deriving twin transformation capabilities. Following Suddaby's (2010) and Podsakoff's (2016) guidelines on construct clarity, we built on two underlying constructs, digital transformation and sustainability transformation, in isolation. Drawing on justificatory knowledge on the digital and sustainability transformation literature, we delimited and elaborated on the synergetic interplay between the two perspectives that constitute twin transformation in the following: digital transformation enabling sustainability transformation and sustainability transformation guiding digital transformation.

Digital transformation as an enabler for sustainability transformation can be divided into two parts. First, "sustainability of digital technology" focuses on making digital technologies more sustainable, using concepts such as Green IT (Veit and Thatcher 2023). It aims to design a sustainable IT infrastructure by, inter alia, implementing IT life cycle management (Loeser 2013) or more sustainable infrastructure such as green data centers and sustainability management systems (Parmiggiani and Monteiro 2018; vom Brocke et al. 2013). Second, "sustainability through digital technologies" comprises the positive impact of using digital technologies to create greater organizational sustainability (El Hilali et al. 2020; Seidel et al. 2017). Digital transformation allows for learning about sustainability effects through transparently generating novel data as a foundation to monitor, for example, sustainability thresholds, to predict sustainability scenarios (Ortega-Gras et al. 2021). The Internet of Things can integrate physical objects into networks via sensors. These networks generate large amounts of environmental data that can be processed by systems based on artificial intelligence (AI). These AI-based systems may identify useful patterns otherwise trapped in massive amounts of unstructured data (Padmanabhan et al. 2022). The patterns, in turn, can inform sustainability transformation design decisions, which, if implemented, generate new data streams (Miranda et al.

2022). Thus, digital technologies enable us to simultaneously address complex economic and environmental concerns. This makes them an essential prerequisite for data-driven decision-making (Ortega-Gras et al. 2021), sustainability investments (Speziale and Klovienè 2014), or new business model opportunities (Chanas et al. 2019; Vial 2019).

Sustainability transformation guides digital transformation in two ways. First, sustainability transformation guides the designing of adequate digital transformation solutions to appropriately address technological, organizational, and cultural aspects (Acciarini et al. 2022). Creating sustainable digital transformation solutions (e.g., innovative business models) may profoundly change an organization's purpose and way of creating value (Hernández-Chea et al. 2021). Rather than remaining self-centered (Bharadwaj et al. 2013; Karnebogen et al. 2021; Vial 2019), sustainability transformation can shift the focus to goals far beyond an organization's boundaries (Hernández-Chea et al. 2021). Value is created for the organization and the common good (Dyllick and Muff 2016). Organizations start to think holistically and focus on the circularity of their products and services. They try to minimize resource input (e.g., through reusing, recycling, etc.) and improve overall sustainable development (Zeiss et al. 2021). Second, sustainability transformation increases the general acceptance of transformations (Daily and Huang 2001). Since it requires organizational flexibility and a new culture, digital transformation fosters continuous change and causes significant tensions between the "old" and the "new" (Svahn et al. 2017). As a result, digital transformation is often not as successful as it could be, and its complex drivers and effects are poorly understood (Gurbaxani and Dunkle 2019) – particularly by employees whose support for an organizational transformation is key. Sustainability transformation may help to motivate employees to support transformational activities.

As illustrated in Fig. 1, the interplay between digital and sustainability transformation is rooted in a holistic, transformational, and deeply synergetic approach, which is disregarded when focusing on digital or sustainability transformation in isolation. Twin transformation is a multi- and interdisciplinary construct that is not only the responsibility of and driven by the entire top management, but also requires the cooperation of all organizational departments (Dyllick and Muff 2016; Wessel et al. 2021). Twin transformation balances the efforts and rewards of both transformations by considering them on an equal footing, with the potential to lead to a reinvention of the organization, thus impacting the organization's identity as well as creating value far greater than the sum of each transformation. Consequently, twin transformation extends prior hybrid constructs at the interplay between digital and

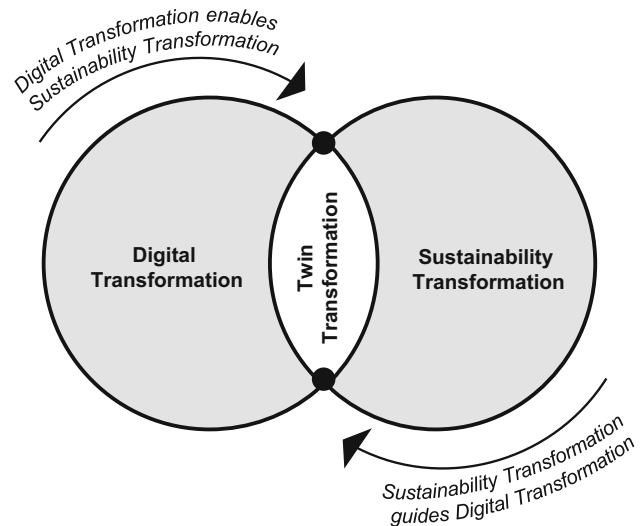


Fig. 1 Twin transformation conjuncts the synergies of digital and sustainability transformation

sustainability transformation, as set out in Appendix D. Serving as a foundation for future twin transformation research in general and the subsequent development of twin transformation capabilities in particular, we present the following definition of the twin transformation construct: *A twin transformation refers to a value-adding interplay between digital and sustainability transformation efforts that improve an organization by leveraging digital technologies for enabling sustainability and leveraging sustainability for guiding digital progress.*

4.2 Twin Transformation Capability Framework

Extending Baiyere et al.'s (2020) symbolic perspective on organizational transformations, the twin transformation process can be likened to the metamorphosis of a larva into a butterfly. Its strong body holds a butterfly together, so that it relies on all four wings to fly. Similarly, organizations can only "take off" into twin transform once relevant dynamic twin transformation capabilities are developed and implemented in all four capability categories. We present the twin transformation capability framework as a butterfly to provide a clear, illustrative structure of dynamic twin transformation capabilities. Our framework captured in Fig. 2 constitutes the butterfly's body, holding together two upper primary wings (i.e., primary capabilities) and two lower supporting wings (i.e., support capabilities). In the following section, we first describe our framework's overarching structure, starting with the butterfly's body (i.e., the aggregate dimensions) and its wings (i.e., the second-order themes). Second, we explain the associated first-order concepts, namely the dynamic twin transformation capabilities.

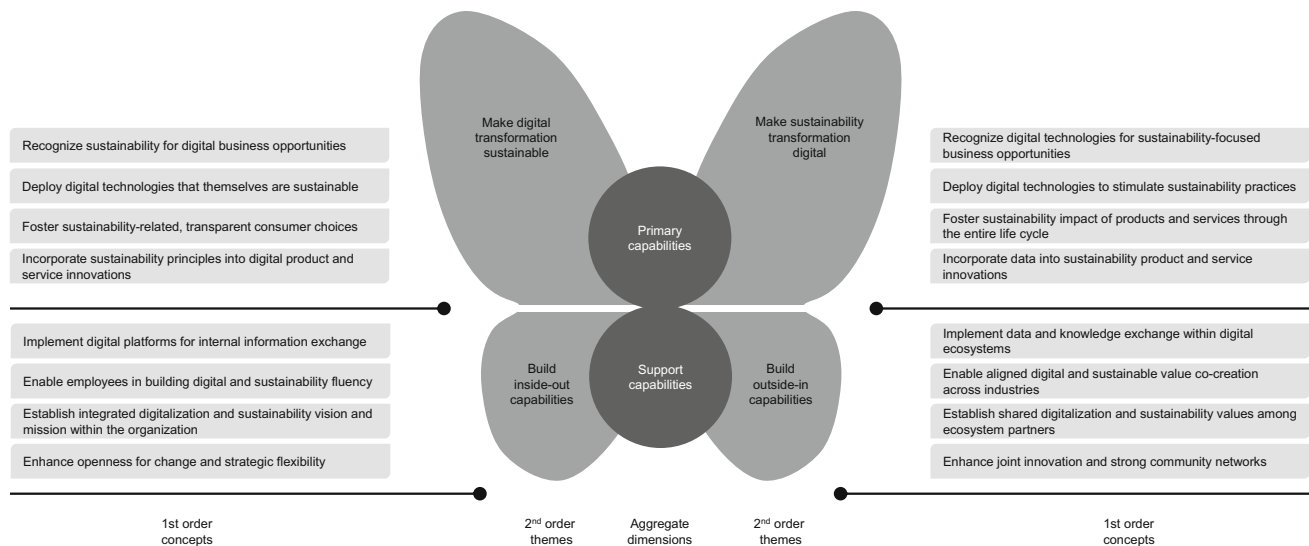


Fig. 2 Twin transformation capability framework

Twin transformation capabilities allow for integrating sustainability and digitalization perspectives into organizations on an equal footing. Our butterfly encompasses dynamic twin transformation capabilities, as they are directed towards organizational change processes (Piccoli and Ives 2005; Teece 2007, 2014) and are therefore needed to initiate the twin transformation. Starting from the butterfly’s body, we distinguish between primary and support capabilities (Huber et al. 2022; Porter 1995). The left and right sides of the butterfly work in conjunction with one another, as both “wings” enable each other. Proceeding with the wings, the first two wings are primary capabilities, which directly influence the organization’s value creation by shaping the supply of new products or services. They encompass spanning capabilities that aim for an integrated approach to digital and sustainability transformation, merging aspects from the inside and outside of the organization. *Making digital transformation sustainable* presents sustainability transformation as a guide to digital transformation. The category captures the dynamic twin transformation capabilities by harnessing digital transformation as a means to attain sustainability targets. By contrast, *making sustainability transformation digital* refers to digital transformation as an enabler of sustainability transformation. The category includes dynamic twin transformation capabilities that accelerate digital technology integration to an end of leveraging sustainability-focused practices.

The other two categories relate to support capabilities that indirectly influence the organization’s value creation by increasing the primary capabilities’ effectiveness. Support capabilities encompass inside-out capabilities, deployed from inside the organization, and outside-in capabilities, which are externally oriented. *Build inside-out*

capabilities therefore describes the ability to respond to market requirements and opportunities. *Build outside-in capabilities* refers to the ability to anticipate market requirements through external partnerships. Support capabilities also encompass relevant change management practices such as “enhance joint innovation and strong community networks.”

To face the challenges of today’s complex and dynamic organizational environment, organizations must develop primary and support capabilities in an integrated manner. Specifically, even though the primary capabilities appear to constitute two separate strategic value creation directions, they intertwine and reveal their full potential through links that should be established in real-world contexts. For example, the first-order dynamic twin transformation capability “deploy digital technologies that themselves are sustainable” is interlinked with its direct counterpart “deploy digital technologies to foster sustainability practices.” While digital technologies can be deployed as sustainability solutions – for example, switching to green cloud computing instead of running large and energy-consuming data centers – they can also be deployed to foster sustainable behavior – for example, making use of an app to encourage employees to travel by public transport instead of driving by car. Another example is the interplay between the dynamic twin transformation capabilities “foster sustainability-related, transparent consumer choices” and “foster sustainability impact of products and services through the entire life cycle.” An organization can enable transparent consumer choices only if data on the life cycle of products and services are available, analyzed, and shared with the public. Our twin transformation capability framework comprises 16 dynamic twin transformation capabilities clustered into four overarching wings. Tables 1

Table 1 Primary capabilities

2nd Order Theme	1st Order Concepts	Description of the Dynamic Twin Transformation Capability	Exemplary Quotes from Key Informants
Make digital transformation sustainable	Recognize sustainability for digital business opportunities	An organization's ability to sense customer needs of the future and recognize sustainability as the essential building block of digital business models	<i>Companies will change in response to customers' preferences for using digital products. We use digitization as an enabler. Sustainability is deeply integrated, and only the combination of both will enable us to address future customer needs. (I3)</i>
	Deploy digital technologies that themselves are sustainable	An organization's ability to continuously experiment with and implement new clean technologies – for example, green cloud computing	<i>We are increasingly relying on the cloud, especially where data centers have been operated so that we can achieve zero emissions in their entirety. (I13)</i>
	Foster sustainability-related, transparent consumer choices	An organization's ability to make sustainability-related information about products and services transparent to the consumer	<i>We see it as our duty to provide customers with data regarding the carbon footprint of our products and services. (I12)</i>
	Incorporate sustainability principles into digital product and service innovations	An organization's ability to integrate sustainability and digital principles right from the beginning of an innovation process	<i>We must include sustainability at the forefront of the innovation process right from the start. The developers must have this on their radar. We try to think sustainable topics through from the idea to the end. (I6)</i>
Make sustainability transformation digital	Recognize digital technologies for sustainability-focused business opportunities	An organization's ability to leverage digital technologies for new sustainability-focused business models	<i>Digital technologies provide great potential for new business models. So, for us, digital [transformation] is the enabler, the key to everything. We see energy, climate change, the environment, and sustainability as the drivers of our time. (I4)</i>
	Deploy digital technologies to stimulate sustainability practices	An organization's ability to realize and exploit the potential of digital technologies for practices and procedures that have a lower level of environmental impact	<i>Digital technologies are used intensively in terms of IT and algorithms, which we deploy to group our delivery tours and to increase efficiency to find the best routes. (I9)</i>
	Foster sustainability impact of products and services through the entire life cycle	An organization's ability to measure and evaluate the sustainability-focused impact of products and services over its lifetime (starting with the extraction of resources until their final disposal)	<i>Obtaining information from your suppliers is very difficult and time consuming, for example [finding answers to the question of] how high the carbon footprint that we already get with natural resources ordered from a specific supplier is. (I14)</i>
	Incorporate data into sustainability product and service innovations	An organization's ability to use data and apply scenario thinking to anticipate demand and innovate toward sustainability solutions	<i>We are using more and more existing data to better understand the consumer and offer more products and service innovations. For example, we have found out through our market research that customers want less packaging waste. That's why we've been working for a long time on a new way to package our frozen pizzas without the extra plastic packaging. (I4)</i>

and 2 outline each dynamic twin transformation capability in more detail, presenting short explanations and examples from interviews with our key informants.

5 Discussion

“Organizations are convinced that digital transformation makes it easier to achieve sustainability goals, but they are not yet considered together. It is

time for IS to realize its role in leveraging the synergies.” (Ahlemann et al. 2021, p. 5, translated into English)

This study was motivated by complex digitalization and sustainability problems that demand integrated solutions. Instead of thinking of digital and sustainability transformation as two separate problem and solution spaces, our objective was to uncover and emphasize the synergetic potential of a twin transformation, namely the holistic

Table 2 Support capabilities

2nd order theme	1st order concepts	Description of the dynamic twin transformation capability	Exemplary quote from Interviews (ID of practitioner)
Build inside-out capabilities	Implement digital platforms for internal information exchange	An organization's ability to establish internal digital information exchange platforms and promote networking within the organization	<i>We have our own [digital] communication platform where you can share knowledge. We learn a lot from and with each other and promote understanding. (I6)</i>
	Enable employees in building digital and sustainability fluency	An organization's ability to build and nurture talent and establish training programs accordingly	<i>The topic of continuous lifelong learning and what that entails is something that we want to develop even more. (I13)</i>
	Establish integrated digitalization and sustainability vision and mission within the organization	An organization's ability to define and establish a vision and mission with integrated digitalization and sustainability values	<i>We have defined the digital and sustainable vision top-down as a CEO [chief executive office] topic, but the whole vision also runs bottom-up through an agile methodology such as the OKR [objectives and key results]. It's nice that it comes from both sides. (I9)</i>
	Enhance openness for change and strategic flexibility	An organization's ability to promote and establish a mindset of continuous change, flexibility, and agility	<i>The only way to keep up with this change is to have a wave of knowledge transfer, from awareness communication to make it tangible and to continue rehearsing iteratively until it becomes flesh and blood with the employees, and then, of course, to learn from the experience and to optimize the whole concept and model over time. (I13)</i>
Build outside-in capabilities	Implement data and knowledge exchange within digital ecosystems	An organization's ability to ease the movement of data among organizations and systems, which, in turn, requires open standards	<i>We are relying more and more on external partners. We've become much more open about partnering and data sharing, which means external exchange within the supply chain is essential. [Doing business] is no longer possible without it. (I4)</i>
	Enable aligned digital and sustainable value co-creation across industries	An organization's ability to convene an ecosystem of partners to create and scale business ideas beyond industries	<i>We have another sub-entity: a company where we are trying to bundle the new business idea of "joint value creation" within the food industry. The vision is to build an ecosystem in the long term. I can't go into too much detail, but we also seek overtaking partners to establish this vision. (I16)</i>
	Establish shared digitalization and sustainability values among ecosystem partners	An organization's ability to actively engage ecosystem partners in their sustainability journey by embedding relevant criteria into the screening	<i>There are defined standards along the value chain, and we are trying to create transparency [as one of the standards] along the value chain first. (I4)</i>
	Enhance joint innovation and strong community networks	An organization's ability to innovate openly and break down internal and external barriers to cooperation where necessary	<i>We have an innovation round table where startups come and present relevant topics and an innovation lab where joint innovation projects are approached. (I5)</i>

alignment of both transformations. Therefore, we first built a common understanding of twin transformation as a foundation on which to present a twin transformation capability framework that outlines relevant dynamic capabilities needed for organizations to twin transform. Our work provides descriptive knowledge on twin transformation and makes a twofold contribution to IS research.

Our primary contribution is the alignment of digital and sustainability transformation perspectives to conceptualize and define the twin transformation construct. Establishing a clear twin transformation construct (1) facilitates effective

communication between scholars by providing a common language and clear terminology (Markus and Rowe 2023), (2) provides the necessary foundation for scholars to explore twin transformation empirically, and (3) leads to greater creativity and innovation in building the foundation of twin transformation theory (Suddaby 2010). Dedicated IS scholars have recognized that the IS discipline could play a central role in fostering more sustainable development, leading to particular issues being raised in prime IS outlets on *Sustainable Development* (Tan and Nielsen 2022), *Social Development*, and *Environmental Action*

(Corbett and Mellouli 2017), *Digital Responsibility* (Mihale-Wilson et al. 2022; Recker et al. 2022) or *Digital Resilience* (Boh and Melville 2022). Despite these issues being raised, the potential of linking IS, digitalization, and sustainability approaches has not been fully explored yet. Against this backdrop, our study will assist the IS discipline direct its research toward solutions to global environmental and social challenges. Drawing on aspects of digital and sustainability transformation itself and on valuable existing hybrid constructs such as digital social innovation (e.g., Bonina et al. 2021), digital responsibility (e.g., Herden et al. 2021), twin transition (e.g., Ortega-Gras et al. 2021), Green IS (e.g., Seidel et al. 2017), Green IT (e.g., Loeser 2013), and circular economy (e.g., Crome et al. 2023a; Geissdoerfer et al. 2017), our work extends current research by integrating digital and sustainability transformation into one double-headed organizational transformation where digital and sustainability transformation stand on an equal footing.

Our secondary contribution is a twin transformation capability framework which uncovers the interplay between dynamic digital and sustainability transformation capabilities. While we have addressed Feroz et al.'s (2021) call for further research on capabilities needed to shift organizations' business model to the environmental sustainability spectrum, we deliberately looked beyond single-transformation-focused capabilities. In doing so, we incorporated valuable prior research regarding dynamic capabilities required for either digital transformation (e.g., Ellström et al. 2022; Konopik et al. 2021; Soluk and Kammerlander 2021) or sustainability transformation (e.g., Buzzao and Rizzi 2021; Wu et al. 2013). As a result, our framework synthesizes both perspectives and expands the known dynamic capabilities with dedicated dynamic twin transformation capabilities. For example, the dynamic capability of "preparing for effective handling of data volume" (Konopik et al. 2021, p. 9) is a prerequisite for this work's proposed dynamic twin transformation capability to "incorporate data into sustainability product and service innovations." Thereby, our work enhances the understanding of dynamic twin transformation capabilities, which support organizations to leverage digital and sustainability measures jointly.

In our framework, we distinguish between dynamic primary and support capabilities. Our support capabilities, divided between "build inside-out capabilities" and "build outside-in capabilities," were influenced by capabilities that Wade and Hulland (2004) identified in relation to collaboration (e.g., "manage external partnerships") and culture and people (e.g., "development of technical skills"). We expanded the dynamic capabilities identified by Soluk and Kammerlander (2021) relating to internal and external triggers of digital transformations by including a

sustainability perspective. Finally, our interviews with key informants supported our findings, linking them to real-world examples and ensuring a close connection between theoretical and practical-oriented research (Huber et al. 2022).

5.1 Theoretical Implications

Our study's theoretical implications are threefold. By establishing the twin transformation construct and developing relevant dynamic twin transformation capabilities, we (1) lay the foundation for further twin transformation theorizing and empirical work. In particular, our results give a strong impetus for (2) digital transformation research to incorporate sustainability transformation's guidance and (3) sustainability transformation research to consider digital transformation as an enabler.

First, we complement existing studies on the interplay between digital and sustainability transformation by considering digitalization and sustainability on an equal footing. By compiling descriptive components of twin transformation, our twin transformation construct and capability framework provide a first step towards a *theory for analyzing* (i.e., type I; Gregor 2006). Our theory addresses the "what is" of this new twin transformation phenomenon, providing knowledge that "*colleagues in other disciplines will acknowledge as belonging to the IS discipline*" (Winter 2003, p. 6). Thus, it may also present a starting point for interdisciplinary research projects examining twin transformation from a holistic perspective. *Theories for analyzing* may then be developed further into other types of theories that provide explanatory or prescriptive knowledge (e.g., type II *theory for explaining* or type V *theory for design and action*; Gregor and Hevner 2013). By building upon our theoretical foundation, future researchers may empirically assess and evaluate the influence of a sustainability transformation-guided purpose on digital transformation or of digital transformation-enabled insights on the effectiveness of sustainability transformation. Moreover, our work calls for more integrated and interdisciplinary research efforts as major global challenges cannot be mastered by one (sub-)discipline. Consequently, digital and sustainability transformation researcher may increase their interaction with one another in terms of discussions, critiques, insights, and collaboration.

Second, our work on the twin transformation construct and its capabilities has implications for digital transformation research with regard to the macro level (generic elements of the transformation process) and micro level (inner workings) of an organizational transformation (Baiyere et al. 2020; Wessel et al. 2021). Regarding the macro level, our work expands Wessel et al.'s (2021)

process model of transformation, calling for a more detailed understanding of the drivers of an organization's digital transformation agenda and activities. Wessel et al. (2021) focus on *technological change* as a main driver of digital transformation. Our work suggests taking Wessel et al.'s (2021) findings one step further by considering the organization's global environment as a relevant driver of digital transformation, in the sense of social and environmental sustainability aspects as part of the *environmental context* (Dyllick and Muff 2016). Regarding the micro level of the *transformation activity*, Wessel et al. (2021) conclude that digital technologies (re-)define an organization's value proposition. Our research supports this finding and, at the same time, extends the relationship with a third player – the impact of organizational sustainability: Organizational sustainability (1) may (re-)defines the value proposition (Bocken et al. 2014), (2) provides a purpose for digital transformation efforts (Crome et al. 2023b), and (3) guides the design of adequate digital transformation solutions to appropriately address technological, organizational, or cultural aspects (e.g., innovative business models; Geissdoerfer et al. 2018).

Third, in our work we build on previous sustainability transformation research by using digital transformation to help solve complicated sustainability transformation issues. Specifically, our work extends Dyllick and Muff's (2016) widely used Business Sustainability Typology (Dyllick and Muff 2016). This typology distinguishes between three levels of sustainability transformation. Our results imply that a fourth level would be necessary to consider enabling digital transformation perspectives. The concern triggering a (twin) transformation at this level would stem from the digital and sustainability problem spaces – such as globalization calling for digitalization or the climate crisis calling for sustainable development. Moreover, our work has implications for Dao et al.'s (2011) Integrated Sustainability Framework, which was published in the IS domain, is widely used, and has highlighted the role of IT in organizational sustainability efforts. Our research supports and extends their framework in two aspects. First, we identify dynamic twin transformation capabilities that enable sustainability solutions using digital transformation to enhance organizations' overall sustainability. In doing so, we address Dao et al.'s (2011) call for integrating sustainability into an organization's core processes, products and services. Second, we cover the sustainability of digital technologies while also encouraging sustainability through digital transformation solutions. Thereby, we build on Dao et al.'s (2011) claim to develop capabilities that promote the use of clean technologies and processes by adding the perspective of making digital transformation sustainable, demonstrating the twin transformation capability “deploy digital technologies that foster sustainability

practices.” By applying our dynamic twin transformation capabilities, organizations can combine digital and sustainability transformation efforts in a targeted manner.

5.2 Practical Implications

The core practical implications of our work are twofold. Our results provide organizations with a new holistic perspective on the interplay between digital and sustainability transformation, thus assisting practitioners in assessing the status quo and creating a twin transformation capability development roadmap.

First, our work provides a holistic perspective for practitioners to understand the construct and gives guidance on how to perform twin transformation. By carefully identifying elements of twin transformation and developing relevant twin transformation capabilities, we provide practitioners with a new strategic view. As one of our key informants stated, “*It is certainly an important topic at the strategic level, but not one for which we, as a company, are already clear what the blueprint is or how it is typically done*” (I19). We believe organizations have a significant role to play in responding to major global challenges. With our work, practitioners can capitalize on our twin transformation capability framework to understand how to foster twin transformation holistically in their organization. As another key informant put it, “*Yes, I think both trends are perceived. The strategic interconnection is also clear. The translation of these perceived trends and entanglements into very concrete actions is something that I think must be concretely formed in the near future*” (I19).

Second, and at the same time, organizations should incorporate strategic digital and sustainability themes into their vision, mission, and principles to better identify and communicate the overall goal and direction of their twin transformation efforts. With the help of our twin transformation construct and capability framework, organizations can assess the status quo of current twin transformation capabilities. This will shed light on the progress of the organization's twin transformations. It will also support management in developing the required twin transformation capabilities. Our framework can be used to build a top-down roadmap for developing twin transformation capabilities by operationalizing an organization's vision. With a clear knowledge of an organization's long-term future, including the main purpose of value creation, it becomes possible to determine and concretize future core twin transformation capabilities.

5.3 Limitations

As with any research project, our study has some limitations. The first limitation refers to the breadth (i.e., a

limited number of interviews) and depth (i.e., in most cases, only one person per organization) of the interviews. Interviews with more key informants per organization and industry would contribute to further contextualized versions of the twin transformation capability framework highlighting certain situational opportunities or constraints that affect the feasibility of certain capabilities, depending on the context. The second limitation of this study is its explorative nature, in the sense that we consulted key informants to identify twin transformation capabilities that had not yet been covered in the literature. Engaging with existing literature on capabilities required for a separate digital or sustainability transformation would help to derive further twin transformation capabilities. The third limitation is that we derived the twin transformation capability framework from a static point of view, and not yet accounting for interdependencies in terms of time or content. The interdependencies of various twin transformation capabilities in terms of time could be investigated – for example, by developing a process view to shed light on the succession of each twin transformation capability.

5.4 Future Research

We conclude that the presented definition of the twin transformation construct, in combination with the outlined dynamic twin transformation capabilities, provide relevant opportunities for future research on understanding the twin transformation interplay. There are various opportunities for future research that could support organizations during their twin transformation. First, the development of a maturity model with the aim to provide prescriptive guidance for an effective twin transformation could constitute a stimulus for further research. This would help organizations to evaluate their current twin transformation maturity and to derive concrete action fields from developing the required twin transformation capabilities. Second, future research could identify and assess related twin transformation readiness or success factors and develop suitable measurement tools. This would enable organizations to pave their way to become twin transformers. Third, scholars could conduct case studies to reveal further empirical insights about twin transformations. Empirical insights provide the foundation for deriving context-specific characteristics of twin transformations and illustrating ordinary twin transformation capabilities. Organizations require ordinary twin transformation capabilities to sustain their twin transformation, which is initialized by dynamic capabilities in the long term.

6 Conclusion

Organizational metamorphosis towards digital transformation represents a single-sided butterfly, unable to fly. Mindful of the significant challenges of current times, the equal integration of sustainability transformation enables the butterfly to take off, responding simultaneously to global crises such as climate change. In this work, we conceptualize the twin transformation construct, namely the value-adding interplay between digital transformation and sustainability transformation efforts that improve an organization. To enhance this symbiotic relationship, we present a capability framework for organizations to twin transform. Our work provides a foundation to guide IS scholars into this symbiosis, creating the basis for theory development and moving sustainability to the center of IS research. By recognizing and understanding relevant capabilities, our work offers practical value for organizations on their way to becoming twin transformers as well as an investigation of the reinforcing interplay between digital and sustainability transformation for research.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s12599-023-00847-2>.

Acknowledgments We gratefully acknowledge the Bavarian Ministry of Economic Affairs, Regional Development and Energy for their support of the project “Fraunhofer Blockchain Center (20-3066-2-6-14)” that made this paper possible.

Funding Open Access funding enabled and organized by Projekt DEAL.

Open Access This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article’s Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article’s Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

References

- Abdelkafi N, Täuscher K (2016) Business models for sustainability from a system dynamics perspective. *Organ Environ* 29:74–96. <https://doi.org/10.1177/1086026615592930>
- Acciarini C, Borelli F, Capo F, Cappa F, Sarrocco C (2022) Can digitalization favour the emergence of innovative and sustainable business models? A qualitative exploration in the automotive sector. *J Strateg Manag* 15:335–352. <https://doi.org/10.1108/JSMA-02-2021-0033>

- Ahlemann F, Karger E, Kreimendahl S, Obermeier S, Ludwig D, Maierhofer M, Oetken P (2021) Future IT Report 2021. Die IT im Rasanten Wandel. https://www.campana-schott.com/media/user_upload/Downloads/Publications/2021/Broschuere_Future_IT-Report-2021_DE.pdf. Accessed 21 Mar 2023
- AlNuaimi BK, Singh SK, Ren S, Budhwar P, Vorobyev D (2022) Mastering digital transformation: the nexus between leadership, agility, and digital strategy. *J Bus Res* 145:636–648. <https://doi.org/10.1016/j.jbusres.2022.03.038>
- Baiyere A, Salmela H, Tapanainen T (2020) Digital transformation and the new logics of business process management. *Eur J Inf Syst* 29:238–259. <https://doi.org/10.1080/0960085X.2020.1718007>
- Balta WD, Jacob, Chawla M, Lin S (2022) Sustainability as a transformation catalyst. <https://www.ibm.com/downloads/cas/N3RANMKO>. Accessed 22 Mar 2023
- Barreto I (2010) Dynamic capabilities: a review of past research and an agenda for the future. *J Manag* 36:256–280. <https://doi.org/10.1177/0149206309350776>
- Battleson DA, West BC, Kim J, Ramesh B, Robinson PS (2016) Achieving dynamic capabilities with cloud computing: an empirical investigation. *Eur J Inf Syst* 25:209–230. <https://doi.org/10.1057/ejis.2015.12>
- Bharadwaj A (2000) A resource-based perspective on information technology capability and firm performance: an empirical investigation. *MIS Q* 24:169. <https://doi.org/10.2307/3250983>
- Bharadwaj A, El Swaly OA, Pavlou PA, Venkatraman N (2013) Digital business strategy: toward a next generation of insights. *MIS Q* 37:471–482. <https://doi.org/10.1615/TelecomRadEng.v76.i10.20>
- Bhattacharjee A (2012) Social science research: principles, methods, and practices, 2nd edn. Textbooks Collection, University of South Florida
- Bianchi G, Testa F, Tessitore S, Iraldo F (2022) How to embed environmental sustainability: the role of dynamic capabilities and managerial approaches in a life cycle management perspective. *Bus Strateg Environ* 31:312–325. <https://doi.org/10.1002/bse.2889>
- Bocken N, Short SW, Rana P, Evans S (2014) A literature and practice review to develop sustainable business model archetypes. *J Clean Prod* 65:42–56. <https://doi.org/10.1016/j.jclepro.2013.11.039>
- Boh WF, Melville NP (2022) Call for contributions research commentary on digital resilience for the climate crisis. *MIS Q*. https://entuedu-my.sharepoint.com/personal/nbsitservices_staff_main_ntu_edu_sg/_layouts/15/onedrive.aspx?id=%2Fpersonal%2Fnbisitservices%5Fstaff%5Fmain%5Fntu%5Fedu%5Fsg%2FDocuments%2Fdownload%2FCall%20for%20Contributions%5FDR%2DClimate%20Crisis%5F2022%2Epdf&parent=%2Fpersonal%2Fnbisitservices%5Fstaff%5Fmain%5Fntu%5Fedu%5Fsg%2FDocuments%2Fdownload&ga=1
- Boh WF, Constantinides P, Padmanabhan B, Viswanathan S (2020) Call for papers on digital resilience. *MIS Q*. <https://misq.umn.edu/skin/frontend/default/misq/pdf/CurrentCalls/DigitalResilience.pdf>
- Bonina C, López-Berzosa D, Scarlata M (2021) Social, commercial, or both? An exploratory study of the identity orientation of digital social innovations. *Inf Syst J* 31:695–716. <https://doi.org/10.1111/isj.12290>
- Buzzao G, Rizzi F (2021) On the conceptualization and measurement of dynamic capabilities for sustainability: building theory through a systematic literature review. *Bus Strateg Environ* 30:135–175. <https://doi.org/10.1002/bse.2614>
- Chanias S, Myers MD, Hess T (2019) Digital transformation strategy making in pre-digital organizations: the case of a financial services provider. *J Strateg Inf Syst* 28:17–33. <https://doi.org/10.1016/j.jsis.2018.11.003>
- Chiou T-Y, Chan HK, Lettice F, Chung SH (2011) The influence of greening the suppliers and green innovation on environmental performance and competitive advantage in Taiwan. *Transp Res Part E Logist Transp Rev* 47:822–836. <https://doi.org/10.1016/j.tre.2011.05.016>
- Cici C, D’Isanto D (2017) Integrating sustainability into your core business. *SYMPHONYA Emerg Issues Manag* 1:50–65. <https://www.conference-board.org/retrievefile.cfm?filename=sustainability-rwg-project-brief.pdf&type=subtitle>
- Corbett J, Mellouli S (2017) Winning the SDG battle in cities: how an integrated information ecosystem can contribute to the achievement of the 2030 sustainable development goals. *Inf Syst J* 27:427–461. <https://doi.org/10.1111/isj.12138>
- Corbin JM, Strauss A (1990) Grounded theory research: procedures, canons, and evaluative criteria. *Qual Soc* 13:3–21. <https://doi.org/10.1007/BF00988593>
- Crome C, Graf-Drasch V, Hawlitschek F, Zinsbacher D (2023a) Circular economy is key! designing a digital artifact to foster smarter household biowaste sorting. *J Clean Prod* 423:138613. <https://doi.org/10.1016/j.jclepro.2023.138613>
- Crome C, Oberländer AM, Graf-Drasch V, Hinsén S, Huber F, Pantzer J, Schleich E, Wilkens H (2023b) Digital und nachhaltig die Zukunft sichern. https://www.ey.com/de_de/forms/download-forms/2023/02/ey-studie-digital-und-nachhaltig-die-zukunft-sichern
- Daily BF, Huang S (2001) Achieving sustainability through attention to human resource factors in environmental management. *Int J Oper Prod Manag* 21:1539–1552. <https://doi.org/10.1108/01443570110410892>
- Dangelico RM, Pujari D, Pontrandolfo P (2017) Green product innovation in manufacturing firms: a sustainability-oriented dynamic capability perspective. *Bus Strateg Environ* 26:490–506. <https://doi.org/10.1002/bse.1932>
- Dao V, Langella I, Carbo J (2011) From green to sustainability: information technology and an integrated sustainability framework. *J Strateg Inf Syst* 20:63–79. <https://doi.org/10.1016/j.jsis.2011.01.002>
- Del Río Castro G, Camino González Fernández M, Uruburu Colsa Á (2021) Unleashing the convergence amid digitalization and sustainability towards pursuing the sustainable development goals (SDGs): a holistic review. *J Clean Prod*. <https://doi.org/10.1016/j.jclepro.2020.122204>
- Demartini M, Evans S, Tonelli F (2019) Digitalization technologies for industrial sustainability. *Procedia Manuf* 33
- Doherty NF, Terry M (2009) The role of IS capabilities in delivering sustainable improvements to competitive positioning. *J Strateg Inf Syst* 18:100–116. <https://doi.org/10.1016/j.jsis.2009.05.002>
- Dyllick T, Muff K (2016) Clarifying the meaning of sustainable business: introducing a typology from business-as-usual to true business sustainability. *Organ Environ* 29:156–174. <https://doi.org/10.1177/1086026615575176>
- El Hilali W, El Manouar A, Idrissi MAJ (2020) Reaching sustainability during a digital transformation: a PLS approach. *Int J Innov Sci* 12:52–79. <https://doi.org/10.1108/IJIS-08-2019-0083>
- Ellström D, Holtström J, Berg E, Josefsson C (2022) Dynamic capabilities for digital transformation. *J Strateg Manag* 15:272–286. <https://doi.org/10.1108/JSMA-04-2021-0089>
- Felipe CM, Leidner DE, Roldán JL, Leal-Rodríguez AL (2019) Impact of IS capabilities on firm performance: the roles of organizational agility and industry technology intensity. *Decis Sci* 51(3):575–619. <https://doi.org/10.1111/deci.12379>
- Feroz AK, Zo H, Chiravuri A (2021) Digital transformation and environmental sustainability: a review and research agenda.

- Sustain (Switzerland) 13:1–20. <https://doi.org/10.3390/su13031530>
- Forcadell FJ, Aracil E, Úbeda F (2020) The impact of corporate sustainability and digitalization on international banks' performance. *Glob Policy* 11:18–27. <https://doi.org/10.1111/1758-5899.12761>
- Geissdoerfer M, Savaget P, Bocken NM, Hultink EJ (2017) The circular economy – a new sustainability paradigm? *J Clean Prod* 143:757–768. <https://doi.org/10.1016/j.jclepro.2016.12.048>
- Geissdoerfer M, Vladimirova D, Evans S (2018) Sustainable business model innovation: a review. *J Clean Prod* 198:401–416. <https://doi.org/10.1016/j.jclepro.2018.06.240>
- Gimpel H, Graf-Drasch V, Kammerer A, Keller M, Zheng X (2020) When does it pay off to integrate sustainability in the business model? A game-theoretic analysis. *Electron Mark* 30:699–716. <https://doi.org/10.1007/s12525-019-00361-y>
- Gioia DA, Corley KG, Hamilton AL (2013) Seeking qualitative rigor in inductive research: notes on the Gioia methodology. *Organ Res Methods* 16:15–31. <https://doi.org/10.1177/1094428112452151>
- Gregor S (2006) The nature of theory in information systems. *MIS Q* 30:611–642
- Gregor S, Hevner AR (2013) Positioning and presenting design science research for maximum impact. *MIS Q* 37:337–355
- Gurbaxani V, Dunkle D (2019) Gearing up for successful digital transformation. *MIS Q Exec* 18:209–220. <https://doi.org/10.17705/2msqe.00017>
- Hanelt A, Bohnsack R, Marz D, Antunes Marante C (2021) A systematic review of the literature on digital transformation: insights and implications for strategy and organizational change. *J Manag Stud* 58:1159–1197. <https://doi.org/10.1111/joms.12639>
- Hanelt A, Piccinini E, Gregory RW, Hildebrandt B, Lutz M (2015) Digital transformation of primarily physical industries – Exploring the impact of digital trends on business models of automobile manufacturers. In: 12th International Conference on Wirtschaftsinformatik, pp 1313–1327. <https://aisel.aisnet.org/wi2015/88>
- Hartl E, Hess T (2017) The role of cultural values for digital transformation: insights from a Delphi study. In: Proceedings of the Americas Conference on Information Systems. <https://aisel.aisnet.org/amcis2017/Global/Presentations/8>
- Heckathorn DD (1997) Respondent-driven sampling: a new approach to the study of hidden populations. *Soc Probl* 44:174–199. <https://doi.org/10.2307/3096941>
- Herden CJ, Alliu E, Cakici A, Cormier T, Deguelle C, Gambhir S, Griffiths C, Gupta S, Kamani SR, Kiratli Y-S, Kispataki M, Lange G, Moles de Matos L, Tripero Moreno L, Betancourt Nunez HA, Pilla V, Raj B, Roe J, Skoda M, Song Y, Ummadi PK, Edinger-Schons LM (2021) Corporate digital responsibility. *Sustain Manag Forum* 29:13–29. <https://doi.org/10.1007/s00550-020-00509-x>
- Hernández-Chea R, Jain A, Bocken NM, Gurtoo A (2021) The business model in sustainability transitions: a conceptualization. *Sustain (switzerland)* 13:1–25. <https://doi.org/10.3390/su13115763>
- Huber R, Oberländer AM, Faisst U, Röglinger M (2022) Disentangling capabilities for Industry 4.0 – an information systems capability perspective. *Inf Syst Front*. <https://doi.org/10.1007/s10796-022-10260-x>
- Karnebogen P, Oberländer AM, Rövekamp P (2021) A means to an end of the other – research avenues at the intersection of organizational digital transformation and digital business ecosystems. In: Proceedings of the 42nd international conference on information systems. https://aisel.aisnet.org/icis2021/adv_in_theories/adv_in_theories/2
- Keller R, Ollig P, Rövekamp P (2022) Pathways to developing digital capabilities within entrepreneurial initiatives in pre-digital organizations: a single case study. *Bus Inf Syst Eng* 64:33–46. <https://doi.org/10.1007/s12599-021-00739-3>
- Kırmızı M, Kocaoglu B (2022) Digital transformation maturity model development framework based on design science: case studies in manufacturing industry. *J Manuf Technol Manag* 33:1319–1346. <https://doi.org/10.1108/JMTM-11-2021-0476>
- Konopik J, Jahn C, Schuster T, Hoßbach N, Pflaum A (2021) Mastering the digital transformation through organizational capabilities: a conceptual framework. *Digit Bus* 2:100019. <https://doi.org/10.1016/j.digbus.2021.100019>
- Kranz J, Kolbe LM, Koo C, Boudreau M-C (2015) Smart energy: where do we stand and where should we go? *Electron Mark* 25:7–16. <https://doi.org/10.1007/s12525-015-0180-3>
- Kraus S, Durst S, Ferreira JJ, Veiga P, Kailer N, Weinmann A (2022) Digital transformation in business and management research: an overview of the current status quo. *Int J Inf Manag*. <https://doi.org/10.1016/j.ijinfomgt.2021.102466>
- Kreuzer T, Lindenthal AK, Oberländer AM, Röglinger M (2022) The effects of digital technology on opportunity recognition. *Bus Inf Syst Eng* 64:47–67. <https://doi.org/10.1007/s12599-021-00733-9>
- Kumar N, Stern LW, Anderson JC (1993) Conducting interorganizational research using key informants. *Acad Manag J* 36:1633–1651. <https://doi.org/10.5465/256824>
- Lahtinen S, Yrjölä M (2019) Managing sustainability transformations: a managerial framing approach. *J Clean Prod* 223:815–825. <https://doi.org/10.1016/j.jclepro.2019.03.190>
- Lehnhoff S, Staudt P, Watson RT (2021) Changing the climate in information systems research. *Bus Inf Syst Eng* 63:219–222. <https://doi.org/10.1007/s12599-021-00695-y>
- Loeser F (2013) Green IT and green IS: definition of constructs and overview of current practices. In: Proceedings AMCIS 2013. <https://aisel.aisnet.org/amcis2013/GreenIS/GeneralPresentations/4>
- Maffei A, Grahn S, Nuur C (2019) Characterization of the impact of digitalization on the adoption of sustainable business models in manufacturing. *Procedia CIRP* 81:765–770. <https://doi.org/10.1016/j.procir.2019.03.191>
- Markus ML, Rowe F (2023) The digital transformation conundrum: labels, definitions, phenomena, and theories. *J Assoc Inf Syst* 24:328–335. <https://doi.org/10.17705/1jais.00809>
- Mihale-Wilson C, Hinz O, van der Aalst W, Weinhardt C (2022) Corporate digital responsibility: relevance and opportunities for business and information systems engineering. *Bus Inf Syst Eng* 64:127–132. <https://doi.org/10.1007/s12599-022-00746-y>
- Miles MB, Huberman AM (1994) *Qualitative data analysis: an expanded sourcebook*. Sage, Thousand Oaks
- Miranda S, Berente N, Seidel S, Safadi H, Burton-Jones A (2022) Editor's comments: computationally intensive theory construction: a primer for authors and reviewers. *MIS Q* 46:46:iii–xviii
- Montealegre R, Iyengar K, Sweeney J (2019) Understanding ambidexterity: managing contradictory tensions between exploration and exploitation in the evolution of digital infrastructure. *J Assoc Inf Syst* 20:647–680
- Mousavi S, Bossink B, van Vliet M (2018) Dynamic capabilities and organizational routines for managing innovation towards sustainability. *J Clean Prod* 203:224–239. <https://doi.org/10.1016/j.jclepro.2018.08.215>
- O'Reilly CA, Tushman ML (2008) Ambidexterity as a dynamic capability: resolving the innovator's dilemma. *Res Organ Behav* 28:185–206. <https://doi.org/10.1016/j.riob.2008.06.002>
- O'Reilly CA, Tushman ML (2013) Organizational ambidexterity. *Acad Manag Perspect* 27:324–338. <https://doi.org/10.1201/b11422-19>

- Oghazi P, Mostaghel R (2018) Circular business model challenges and lessons learned-an industrial perspective. *Sustain (switzerland)* 10:1–19. <https://doi.org/10.3390/su10030739>
- Ollagnier JM, Brueckner M, Berjoan S, Dijkstra S (2021) A twin strategy that will strengthen competitiveness. https://www.accenture.com/_acnmedia/PDF-144/Accenture-The-European-Double-Up.pdf. Accessed 22 Mar 2023
- Ortega-Gras JJ, Bueno-Delgado MV, Cañavate-Cruzado G, Garrido-Lova J (2021) Twin transition through the implementation of Industry 4.0 technologies: desk-research analysis and practical use cases in Europe. *Sustain (Switzerland)*. <https://doi.org/10.3390/su132413601>
- Osmundsen K, Iden J, Bygstad B (2018) Digital transformation: drivers, success factors, and implications. In: *Proceedings of the Mediterranean Conference on Information Systems*, vol 12, pp 1–15. <https://aisel.aisnet.org/mcis2018/37>
- Padmanabhan B, Fang X, Sahoo N, Burton-Jones A (2022) Machine learning in information systems research. *MIS Q* 46:iii–xix
- Parmiggiani E, Monteiro E (2018) Shifting baselines? Recommendations for Green IS. In: 39th international conference on information systems. <https://aisel.aisnet.org/icis2018/green/Presentations/4>
- Peters J, Simaens A (2020) Integrating sustainability into corporate strategy: a case study of the textile and clothing industry. *Sustain (switzerland)* 12:1–35. <https://doi.org/10.3390/su12156125>
- Piccoli G, Ives B (2005) Review: IT-dependent strategic initiatives and sustained competitive advantage: a review and synthesis of the literature. *MIS Q* 29:747–776
- Plekhanov D, Franke H, Netland TH (2022) Digital transformation: a review and research agenda. *Eur Manag J*. <https://doi.org/10.1016/j.emj.2022.09.007>
- Podsakoff PM, MacKenzie SB, Podsakoff NP (2016) Recommendations for creating better concept definitions in the organizational, behavioral, and social sciences. *Organ Res Methods* 19:159–203. <https://doi.org/10.1177/1094428115624965>
- Porter ME (1995) *Competitive advantage: creating and sustaining superior performance* (republished with a new introduction, 1998). Free Press
- Recker J, Chatterjee S, Sundermeier J, Graf-Drasch V (2022) JAIS special issue call for participation digital responsibility: social, ethical, and ecological implications of IS. *J Assoc Inf Syst*. <https://aisel.aisnet.org/jais/SI-DigitalResponsibility.pdf>
- Santos RC, Martinho JL (2019) An Industry 4.0 maturity model proposal. *J Manuf Technol Manag* 31:1023–1043. <https://doi.org/10.1108/JMTM-09-2018-0284>
- Sarker S, Xiao X, Beaulieu T, Lee AS (2018) Learning from first-generation qualitative approaches in the IS discipline: an evolutionary view and some implications for authors and evaluators, part 1/2. *J Assoc Inf Syst* 19:752–774. <https://doi.org/10.17705/1jais.00508>
- Sarkis J, Koo C, Watson RT (2013) Green information systems & technologies – this generation and beyond: introduction to the special issue. *Inf Syst Front* 15:695–704. <https://doi.org/10.1007/s10796-013-9454-5>
- Seidel S, Recker J, Pimmer C, vom Brocke J (2014) IT-enabled sustainability transformation-the case of SAP. *Commun Assoc Inf Syst* 35:1–17. <https://doi.org/10.17705/1cais.03501>
- Seidel S, Bharati P, Fridgen G, Watson RT, Albizri A, Boudreau M-C, Butler T, Kruse LC, Guzman I, Karsten H, Lee H, Melville N, Rush D, Toland J, Watts S (2017) The sustainability imperative in information systems research. *Commun Assoc Inf Syst* 40:40–52. <https://doi.org/10.17705/1CAIS.04003>
- Soluk J, Kammerlander N (2021) Digital transformation in family-owned mittelstand firms: a dynamic capabilities perspective. *Eur J Inf Syst* 30:676–711. <https://doi.org/10.1080/0960085X.2020.1857666>
- Speziale M-T, Kloviene L (2014) The relationship between performance measurement and sustainability reporting: a literature review. *Procedia Soc Behav Sci* 156:633–638. <https://doi.org/10.1016/j.sbspro.2014.11.254>
- Steininger DM, Mikalef P, Pateli A, Ortiz-De-guinea A (2022) Dynamic capabilities in information systems research: a critical review, synthesis of current knowledge, and recommendations for future research. *J Assoc Inf Syst* 23:447–490. <https://doi.org/10.17705/1jais.00736>
- Suddaby R (2010) Editor’s comments: construct clarity in theories of management and organization. *Acad Manag Rev* 35:346–357. <https://doi.org/10.5465/amr.35.3.zok346>
- Svahn F, Mathiassen L, Lindgren R (2017) Embracing digital innovation in incumbent firms: how Volvo Cars managed competing concerns. *MIS Q* 41:239–253. <https://doi.org/10.25300/MISQ/2017/41.1.12>
- Tan B, Nielsen P (2022) Information systems and sustainable development. *Inf Syst J: Special Issue Call for Papers*. <https://onlinelibrary.wiley.com/pb-assets/assets/13652575/Information%20Systems%20and%20Sustainable%20Development%20v2-1634817401587.pdf>
- Teece D (2007) Explicating dynamic capabilities: the nature and microfoundations of (sustainable) enterprise performance. *Strateg Manag J* 28:1319–1350. <https://doi.org/10.1002/smj.640>
- Teece D (2014) The foundations of enterprise performance: dynamic and ordinary capabilities in an (economic) theory of firms. *Acad Manag Perspect* 28:328–352
- Teece D, Pisano G, Shuen A (1997) Dynamic capabilities and strategic management. *Strateg Manag J* 18:509–533. <https://doi.org/10.1093/0199248540.003.0013>
- Veit DJ, Thatcher JB (2023) Digitalization as a problem or solution? Charting the path for research on sustainable information systems. *J Bus Econ*. <https://doi.org/10.1007/s11573-023-01143-x>
- Vial G (2019) Understanding digital transformation: a review and a research agenda. *J Strateg Inf Syst* 28:118–144. <https://doi.org/10.1016/j.jsis.2019.01.003>
- vom Brocke J, Watson RT, Dwyer C, Elliot S, Melville N (2013) Green information systems: directives for the IS discipline. *Commun Assoc Inf Syst* 33:509–520. <https://doi.org/10.17705/1cais.03330>
- Wade M, Hulland J (2004) Review: the resource-based view and information systems research: review, extension, and suggestions for future research. *MIS Q* 28:107–142. <https://doi.org/10.2307/25148626>
- Warner KS, Wäger M (2019) Building dynamic capabilities for digital transformation: an ongoing process of strategic renewal. *Long Range Plan* 52:326–349. <https://doi.org/10.1016/j.lrp.2018.12.001>
- Watson, Boudreau, Chen (2010) Information systems and environmentally sustainable development: energy informatics and new directions for the IS community. *MIS Q* 34:23. <https://doi.org/10.2307/20721413>
- Weritz P, Braojos J, Matute J (2022) Exploring the antecedents of digital transformation: dynamic capabilities and digital culture aspects to achieve digital maturity. In: *Proceedings AMCIS*. https://aisel.aisnet.org/amcis2020/org_transformation_is/org_transformation_is/22
- Wessel L, Baiyere A, Ologeanu-Taddei R, Cha J, Blegind Jensen T (2021) Unpacking the difference between digital transformation and IT-enabled organizational transformation. *J Assoc Inf Syst* 22:102–129. <https://doi.org/10.17705/1jais.00655>
- Winter SG (2003) Understanding dynamic capabilities. *Strateg Manag J* 24:991–995. <https://doi.org/10.1002/smj.318>
- Wu Q, He Q, Duan Y (2013) Explicating dynamic capabilities for corporate sustainability. *EuroMed J Bus* 8:255–272

- Yazici HJ (2020) An exploratory analysis of the project management and corporate sustainability capabilities for organizational success. *Int J Manag Proj Bus* 13:793–817. <https://doi.org/10.1108/IJMPB-08-2019-0207>
- Zeiss R, Ixmeier A, Recker J, Kranz J (2021) Mobilising information systems scholarship for a circular economy: review, synthesis, and directions for future research. *Inf Syst J* 31:148–183. <https://doi.org/10.1111/isj.12305>
- Zimmer MP, Järveläinen J (2022) Digital–sustainable co-transformation: introducing the triple bottom line of sustainability to digital transformation research. In: Kreps D et al (eds) *IFIP international conference on human choice and computers*. Springer, pp 100–111