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# Digital sustainable business models: Using digital technology to integrate ecological sustainability into the core of business models

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## Abstract

When presented with the latest statistics on global warming, it becomes evident that ecological sustainability will be equally important as economic sustainability for companies. A new wave of start-ups shows that ecological sustainability can be integral to a business model (BM) without compromising economic success. Like start-ups that designed their BMs to be ecologically and economically sustainable, incumbents also need to undergo two fundamental transformations in parallel: digital and sustainable BM transformation. While each transformation alone is considered demanding, we examined 31 start-ups to develop a taxonomy of digital sustainable BMs to understand how companies can master these complementary challenges and provide guidelines on achieving ecological and economic sustainability by implementing digital BMs. We use this taxonomy to derive four distinct archetypes of how sustainability can be an integral part of the BM: *Sustainable Software Solutions*, *Sustainable Product-Service Systems*, *Sustainability Intelligence*, and *Digital Sustainable Platforms*. For each archetype, we reveal the role of digital technology in creating ecological BMs and how these BMs create sustainable value from an ecological, economic, and technological perspective. Therefore, we go beyond using digital technology to optimise production or logistics or enable remote work and implement sustainability as an integral part of the core logic of the organisation and its identity. For practice, our strategy guidelines contribute to creating a sustainable reality based on digital technology implemented in the BMs.

**KEYWORDS**
business model, business model archetypes, digital sustainable business model, green information systems, sustainability, taxonomy

## 1 | INTRODUCTION

Companies are the most significant contributors to climate change and need to balance ecological sustainability to limit their environmental impact while being profitable to meet economic needs. Therefore, most companies use the easy way of using the economic surplus to offset carbon emissions, plant trees, or remove plastic waste from the oceans. However, the impact of such initiatives is limited to containing the environmental damage created rather than addressing its causes. Furthermore, measures, such as offsetting emissions mainly influence the public perception of acting sustainably rather than addressing its cause (Pizzetti et al., 2021; Walker & Wan, 2012) and are often only pursued as long as companies are economically successful.

A new wave of highly profitable start-ups shows that ecological sustainability can be integral to a business model (BM) without compromising economic success. For example, *LettUs Grow* has digitally controlled farms that optimise resource usage through data analytics. *Tado°* offers a digital automation service to ensure sustainable heating, and *Octopus Energy* uses a digital platform to make sustainable energy cheaper. By utilising digital sustainable BMs (Bocken et al., 2014; Schaltegger et al., 2016), including the value proposition, value delivery, and value capture (Ritter & Lettl, 2018; Teece, 2010), those start-ups do not curb to environmental damage reactively but use digital technologies proactively to tackle global warming as an integral part of their BM.

While these start-ups designed their BMs from scratch to be ecologically and economically sustainable, incumbents often need to undergo two challenging transformations in parallel: digital and ecological BM transformation (Vial, 2019; Watson & Kranz, 2021). Each transformation fundamentally affects how they do business (Teece, 2010) and how they identify as an organisation (Wessel et al., 2021). This conundrum reveals why incumbents are reluctant to engage in ecological transformations and focus on digital transformation to ensure competitiveness (Lokuge et al., 2021; Sedera et al., 2017).

When confronted with the latest statistics on global warming (Pörtner et al., 2022), it becomes evident that incumbents can no longer compromise on ecological sustainability (Gregori & Holzmann, 2020). Start-ups, such as *LettUs Grow* or *Tado°* show that the value proposition can go beyond cost efficiency and legal compliance (Sedera et al., 2017) and become ecologically sustainable through digital technologies. These start-ups illustrate that ecological and economic sustainability are complementary and can be integral to a company's BM (Lokuge et al., 2021). Hence, as most companies are currently transitioning towards a digital BM (Vial, 2019), they can integrate ecological sustainability into their BMs as part of the same transformation, creating a new value proposition and reducing effort and costs compared to two separate transformations.

Similar to practise, information systems (IS) research has usually considered the challenges of digital and ecological transformation separately. The literature on digital transformation uses the BM as a mediating construct to analyse the value of digital technology and successful economic digital BMs (e.g., Al-Debei & Avison, 2010; Zott & Amit, 2007). In turn, the literature on ecological sustainability in IS has been looking for opportunities on how digital technology influences operational processes or transformations towards a more sustainable economy and society (e.g., Hedman & Henningsson, 2016; Malhotra et al., 2013).

Although we see examples of ecological digital BMs in practice and calls to integrate digital transformation with ecological sustainability (Lokuge et al., 2021), we lack an integrative perspective on how companies can use digital technologies to become both ecologically and economically sustainable (e.g., George et al., 2021; Gregori & Holzmann, 2020). By combining research on digital BMs and ecological BMs, we explore how start-ups use digital technologies to create economically and ecologically sustainable BMs. Learning from start-ups enables incumbents to combine ecological and economic aspects in their digital transformation efforts rather than going through two separate transformations, making them part of the solution and not the problem of global warming. Hence, we propose the following research question: *What is the role of digital technologies in creating digital BMs that integrate ecological and economic value creation?*

To this aim, we first built on 31 start-ups to develop a taxonomy that identifies and structures the dimensions and characteristics of digital sustainable BMs (Nickerson et al., 2017). We use the BM as the unit of analysis to operationalise business strategy and strategy formation (Lanzolla & Markides, 2021). Second, we use the taxonomy to perform a qualitative cross-case analysis (Miles et al., 2020) and derive salient archetypes of how ecological and economic sustainability can be an integral part of the BM. Afterwards, we continue to discuss the role of digital technology in creating both ecological and economic value for each archetype.

Our results contribute to the research of digital and ecological BMs and their transformation by showing how digital technology can create both ecological and economic sustainability (Nambisan, 2017; Satalkina & Steiner, 2020). Therefore, we go beyond using digital technology to optimise production or logistics or enable remote work and implement ecological sustainability as a core logic of the organisation and its identity. Our strategy guidelines contribute to creating a sustainable reality based on the digital technology implemented in the BMs and respond to different calls in research to provide more practicable insights on sustainability in IS (Malhotra et al., 2013; Seidel et al., 2017). For practice, the BM archetypes and value creation strategies support BM changes to master the ecological transformation and digital transformation together.

## 2 | THEORETICAL BACKGROUND

We first discuss research on the three intersections of BM, IS, and ecological research to investigate digital sustainable BMs (see Figure 1). First, we define the "business model" as our unit of analysis and how digital technologies enable digital BMs. Second, we present related work on ecological and sustainable BMs. Third, we briefly discuss how IS research has addressed ecological challenges in Green IS.

### 2.1 | Business models and digital business models

A BM describes how value is created, delivered to the customer, and captured for the company (Teece, 2010). The BM consists of three dimensions: value proposition, value creation and delivery, and value capture (Teece, 2010). It is a mediating construct that aligns general business strategy and operational business processes (Al-Debei & Avison, 2010). In this tactical role, BM is essential to achieving a competitive advantage, which determines company performance. Consequently, different BM designs yield different competitive outcomes (Lanzolla & Markides, 2021). In sum, the BM design and changes thereof are critical decisions that influence economic success.

To remain economically successful in the course of the digital transformation, companies are required to take advantage of digital technologies and integrate them into the BM (Amshoff et al., 2015; Bleicher & Stanley, 2016). Hence, companies need to develop a compelling BM, as digital technologies have no strategic value until they are leveraged by the BM (Chesbrough, 2010; Zott et al., 2011). To develop a compelling BM, companies need to

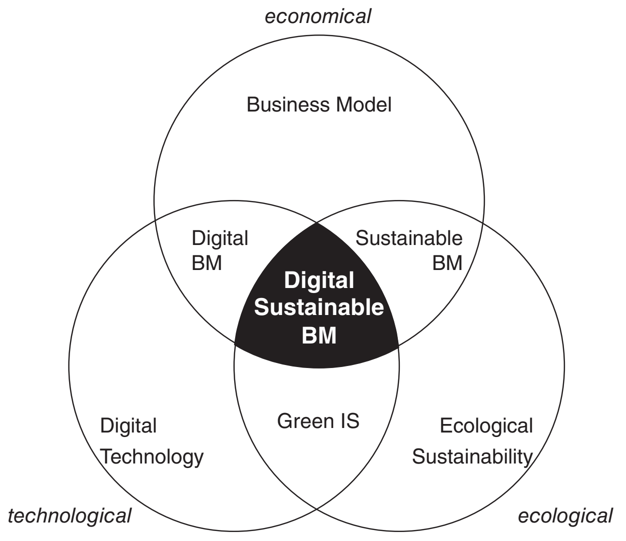


**FIGURE 1** Intersection of perspectives covered in this paper.

**TABLE 1** Information technology use in start-up business models (Steininger, 2019).

| BM definition | Facilitator<br>IT-facilitated BM | Mediator<br>IT-mediated BM | Outcome<br>IT-bearing BM | Ubiquity<br>Digital BM |
|---|---|---|---|---|
| Integration of IT | Supporting activity by enhancing efficiency and facilitating operations | Channel to the customer and enabling new operations | IT products are created and sold (e.g., software or hardware) | Completely digital products (sold digitally) |
| Affected BM components | Infrastructure management | Infrastructure management and customer interface | Infrastructure management and value proposition/ product | Entire BM |

understand the affordances provided by digital technologies (Bleicher & Stanley, 2016). If successful, digital technologies and BM designs are a source of competitive advantage and superior company performance (Chesbrough, 2010; Teece, 2010).

The resulting digital BMs (DBMs) are defined as BMs where digital technologies fundamentally change the features of the BM and enable resource optimization (Bican & Brem, 2020; Veit et al., 2014). Steininger (2019) offers a classification of DBMs presented in Table 1. The classification describes four roles of IT for value creation (facilitator, mediator, outcome, and ubiquity) based on the BM pillars of infrastructure management, customer interface, and value proposition (Osterwalder et al., 2005). IT-facilitated BMs integrate digital technology in infrastructure management to support efficiency and facilitate operations (Steininger, 2019). IT-mediated BMs integrate digital technology in the infrastructure management and the customer interface to enable new operations and digital sales channels, while the primary value is still created with physical products or services (Steininger, 2019). When the DBM is designed around creating and selling digital products, such as software or hardware, the role of IT is classified as "Outcome" (Steininger, 2019). In entirely digital BMs, where all elements of a BM are digital, such as digital platforms, IT becomes "ubiquitous" (Steininger, 2019).

## 2.2 | Sustainable business models

Sustainable BMs are designed around economic, ecological, and social value, also known as the triple bottom line (Elkington, 1998; Evans et al., 2017; Schaltegger et al., 2016; Upward & Jones, 2015). This is also reflected in the definition of sustainable BMs, which comprises a sustainable value proposition, value creation and delivery, and economic value creation under the sustainable management of social, environmental, and economic capital (Schaltegger et al., 2016). Thus, all BM elements (i.e., value proposition, value creation and delivery, and value capture) must be sustainable (Boons & Lüdeke-Freund, 2013; França et al., 2017).

Research has identified archetypes of sustainable BMs that range from a product technology perspective to a functional perspective to a company perspective. From a product technology perspective, sustainable BMs reduce (e.g., efficiency maximisation), reuse (e.g., closed-loop production), or replace (e.g., substitution with renewables) the resources needed to manufacture or operate products (Lüdeke-Freund et al., 2016). Efficiency maximisation refers to improving resource or energy use, reducing emissions or waste, and implementing sustainable supply chains by redesigning products or processes (Lüdeke-Freund et al., 2018). Closed-loop production creates new value from waste, for example, by reusing, recycling, or remanufacturing (Clinton & Whisnant, 2019). Substitution with renewables replaces finite with non-finite renewable resources (Lüdeke-Freund et al., 2018).

From a functional perspective, sustainable BMs replace the need for ownership by providing services to deliver the proposed functionality (functionality delivery), ensure sustainability along the entire supply chain (stewardship), or encourage sustainable consumption (sufficiency encouragement) (Bocken et al., 2014). Delivering functionality instead of ownership, for example, through sharing options and usage-based pricing, concentrates on the functional customer need in the value proposition (Clinton & Whisnant, 2019). The stewardship pattern aims to ensure sustainability throughout the supply chain, including suppliers, employees, customers, and the environment, for example, through ethical sourcing (Wells, 2015). Promoting sufficiency aims to change customers' consumption patterns to slow down resource use, for example, by promoting long-life products (Clinton & Whisnant, 2019).

From a company perspective, sustainable BM patterns include scale-up solutions, inclusive value creation, and repurposing for society and the environment (Bocken et al., 2014; Lüdeke-Freund et al., 2016). These patterns focus on the responsibility of the company to improve its sustainability (Bocken et al., 2014). Scale-up solutions aim to provide and establish sustainable value at larger scales. This scaling is achieved with incubators, open innovation, or franchising models (Bocken et al., 2014; Clinton & Whisnant, 2019). Inclusive value creation is achieved through shared or collaborative consumption to reduce unsustainable impacts (Brenner, 2018; Schaltegger et al., 2016). The pattern of repurposing for society and the environment focuses on environmental and social benefits rather than economic benefits, using social, non-profit, or hybrid models, such as cooperative ownership and net-positive initiatives. (Bocken et al., 2014; Clinton & Whisnant, 2019; Lüdeke-Freund et al., 2016).

## 2.3 | Sustainability in IS research

IS research has not yet considered ecologically sustainable BMs. However, ecological sustainability is being addressed in IS research as Green IS (Elliot., 2011; Malhotra et al., 2013). Green IS investigates how digital technologies can change business processes towards more ecological sustainability (Watson et al., 2008) and emerged because digital technology can be a contributor and a possible solution for ecological sustainability challenges (Elliot., 2011; Melville, 2010). It focuses primarily on company structures or individuals and how their behaviour influences business and societal transformation (Elliot., 2011; Hedman et al., 2012). For example, it defines the functional affordances necessary for an ecological sustainability transformation and changing organisational practices (Hanelt et al., 2017; Seidel et al., 2013).

Chen et al. (2008) built a framework grounded on the corporate sustainability framework (Dyllick & Hockerts, 2002), describing how digital technology contributes to ecological sustainability by defining three dimensions: equity, efficiency, and effectiveness. Equity is a value principle aiming at a fair distribution of resources, especially with regard to future generations, but also with regard to the consequences of climate change that are unfairly distributed across the globe (Dyllick & Hockerts, 2002). It places sustainability at the heart of organisations. Digital technologies are tools for informing and educating relevant stakeholders about these values and the corresponding actions (Watson et al., 2008).

Efficiency targets economic and ecological benefits by reducing the cost of value creation. Usually, this refers to reducing the resource input required to create the product or service. This reduces costs, such as raw material costs, and also reduces the waste of resources, such as unused raw materials, reducing power usage or carbon emissions. Digital technologies enable efficient operations, for example, through analytics-based route optimization of the logistics network (Chen et al., 2008; Dyllick & Hockerts, 2002; Watson et al., 2008). In contrast, effectiveness aims for an ecological sustainable solution in the long term (Chen et al., 2008; Watson et al., 2008). Effectiveness means not only reducing negative ecological impacts (i.e., increasing efficiency), but also eliminating any negative impacts on the environment. Effectiveness through digital technology is achieved, for example, through telecommuting, which eliminates the need to commute to work, thus eliminating carbon emissions associated with transportation.

As digital technologies can also support the implementation of ecologically sustainability and the creation of ecological sustainable value (Bican & Brem, 2020; Seele & Lock, 2017), George et al. (2021) introduced the term digital sustainability, describing entrepreneurial or managerial activities that incorporate digital technologies to create ecologically sustainable value. The term aims at the strategic implications of ecological sustainability and suggests having sustainable value at the core of the value proposition, thus the core of the BM (George et al., 2021).

However, little attention has been paid to this combination of digital and ecological sustainable BM, that is, ecological and economic performance. Using digital technology can support the realisation of the United Nations Sustainable Development Groups (UNSDGs) (Bican & Brem, 2020; George et al., 2021) and create business value. In combination, there is vast potential for digital sustainable BMs to create socio-environmental value using digital technology (Gregori & Holzmann, 2020). Since this intersection is only emerging, it is unclear how ecological sustainability and digital technology can be combined in BMs.

## 3 | RESEARCH METHODOLOGY

Our research aims to identify and structure archetypes and characteristics of digital sustainable BMs that contribute to achieving an ecological sustainable economy by leveraging digital technologies in BMs and opening up future research avenues for scholars. Therefore, we follow a two-step research approach: First, we develop a taxonomy following Nickerson et al. (2017) and Kundisch et al. (2021). In IS and management research, taxonomies are proven to structure emerging or complex phenomena, such as sustainable BMs (Kundisch et al., 2021). We identify the characteristics of digital sustainable BMs from a sample of 31 start-ups and structure them in the taxonomy. Second, we derive patterns in combinations of these characteristics based on qualitative cross-case analysis (Cao et al., 2018; Yin, 2018). The patterns show different archetypes of digital sustainable BMs that reveal similarities and differences in how companies create, capture, and deliver sustainable value.

### 3.1 | Research scope

We define the scope of our empirical analysis along the technological dimension, based on (Steininger, 2019), and the ecological dimension, based on Chen et al. (2008), and the economic dimension, as depicted in Figure 2. First, our analysis only includes start-ups that employ digital technologies as a fundamental part of their BM. We use the framework of IT-associated entrepreneurship to assess the use of digital technology in the start-ups' BMs (Steininger, 2019). To ensure the appropriate integration of digital technologies into the BM, we exclude BMs using digital technology as a facilitator for value creation, since today nearly every company uses digital technology in its business infrastructure to enhance efficiency. Second, we focus the scope of the sustainability dimension on efficiency and effectiveness (Chen et al., 2008). We exclude equity because of its inherent complexity regarding time and space. Eco-equity must be considered both globally (e.g., fairness in addressing the impacts of climate change in Africa and Asia created in Europe and the Americas) and over time (e.g., fairness for future generations). Third, we look for financially viable BMs that are designed to be profit-driven to ensure that BMs are economically relevant and meet "the needs of the present." (United Nations General Assembly, 1987, p. 16).

## 3.2 | Sample and data collection

We collected our case sample of start-ups from Crunchbase. Crunchbase has proven to be a valuable data source for IS research by providing company descriptions and classifications of young, mostly digital start-ups with innovative BMs (Miric et al., 2021). Start-ups are known for creating innovations and building successful BMs around themselves (Nambisan, 2017; Satalkina & Steiner, 2020). Thus, start-ups are also a driving force for disrupting industries towards ecological sustainability (Schaltegger et al., 2016). We only included start-ups with ecological sustainable value propositions that are between 4 and 10 years old to ensure that they have solidified their BM (Innocenti & Zampi, 2019) and that they can still be considered start-ups (Kollmann et al., 2020). The ecological sustainable value propositions were evaluated based on ecological efficiency and effectiveness (Chen et al., 2008). The sample only includes start-ups headquartered in Europe to allow comparability regarding funding opportunities and governmental support.

Based on these criteria, we collected a sample of 50 start-ups. Six start-ups (e.g., *Uniper*, *Enapter*, and *Fastned*) were excluded since they went public and were no longer considered start-ups (Kollmann et al., 2020). Furthermore, two start-ups (*Otovo* and *Karma*) did not provide an English website and had to be excluded. One website was unavailable, and the start-up was thus deleted from the dataset (*Jeff*).

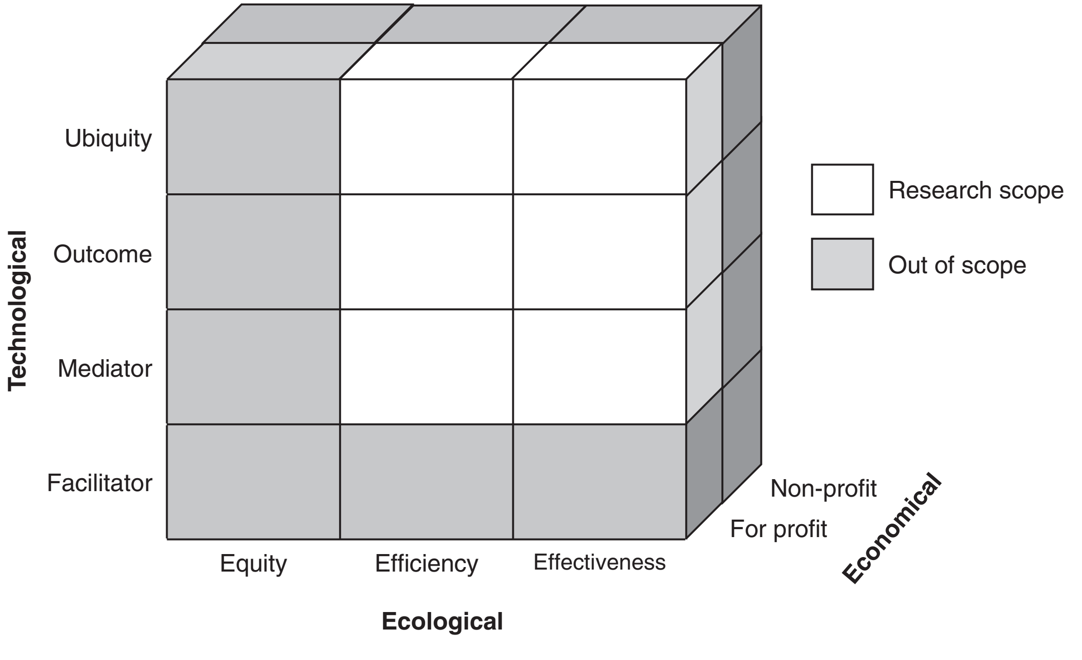


FIGURE 2 Definition of the research scope.

The remaining start-ups were assessed regarding their integration of digital technologies in the BM based on the classification of Steininger (2019). We excluded start-ups that only facilitate and support the use of IT because digital technologies are not an essential part of their BM. In addition, IT-mediating BMs that only implement IT in their customer channel for e-Commerce activities such as online stores or online configurators were excluded due to the little differential value achieved by e-Commerce in today's business environment. On the basis of these criteria, 10 start-ups were eliminated. Eventually, the final sample consisted of 31 start-ups.[1]

## 3.3 | Taxonomy development

We applied the taxonomy development method of Nickerson et al. (2017) to develop a digital sustainable BM taxonomy. Initially, we defined the meta-characteristic and ending conditions. As visualised in Figure 1, the taxonomy combines three constructs: BMs, digital technology, and ecological sustainability. To structure the characteristics of such digital sustainable BMs, we chose the BM as a conceptual representation to be our meta-characteristic (Massa et al., 2017). We adopted the eight objective and five subjective conditions suggested by Nickerson et al. (2013) regarding the ending conditions.

We created the taxonomy in an iterative process. Overall, we performed seven iterations. For the first iteration, we chose the conceptual-to-empirical approach. We derived dimensions and characteristics from our review of 73 papers.[2]

We applied the empirical-to-conceptual approach in the following four iterations until the ending conditions were fulfilled. In each round, a subset of eight start-ups was chosen (seven in the last round). A structured qualitative analysis of the data collected was conducted (Miles et al., 2020). We collected data from company websites, Crunchbase, LinkedIn, Dealroom, and news articles that focused on reliable, business-oriented information sources. If only a part of the start-up provides an ecological sustainable offering, only this part is considered for the analysis (e.g., Enfuce's My Carbon Action).

The data from the structured qualitative analysis was coded using the taxonomy from each previous step. More dimensions and characteristics were added, and existing ones, if necessary, were merged, split, or removed. For some dimensions, we depart from Nickerson et al.'s "mutually exclusiveness" criterion Nickerson et al. (2017). For example, a combination of ecological sustainability patterns is required to achieve overall sustainability (Bocken et al., 2014). Therefore, some dimensions emerge that allow multiple characteristics to capture the complexity of digital sustainable BM while keeping the taxonomy concise and comprehensive (Kundisch et al., 2021; Püschel et al., 2016).

After we completed this iterative process for all four sub-samples, we classified all 31 start-ups in the taxonomy to verify that all BMs can be classified. All ending conditions were met, as no changes were needed for this verification. To arrive at the final taxonomy, we took a final conceptual-empirical approach to achieve usefulness and desired embeddedness in the various research streams on economic, ecological, and digital value creation.[3] Therefore, we aggregated several dimensions to avoid duplicate information. For example, we initially separated the revenue model and pricing strategy but aggregated the characteristics into one dimension to provide a concise description of the value capture mechanisms.

## 3.4 | Digital sustainable business model archetypes

In our second step, we performed a qualitative cross-case analysis (Miles et al., 2020) to identify archetypes of digital sustainable BMs. Such a qualitative approach is more suitable for small-to-medium datasets like ours.

[1]Appendix S1 includes the list of start-ups included in the case sample.
[2]Appendix S1 includes a description of our literature review method
[3]Appendix S1 shows the evolution of the taxonomy through the seven iterations.

We performed a variable-based cross-case analysis (Miles et al., 2020). Variable-based analysis extends our research design to identify the characteristics and elements of digital sustainable BMs and classify them in a taxonomy. The taxonomy developed provides a set of variables to code the cases and for subsequent cross-case analysis. One author created the dataset consisting of the start-ups used to develop the taxonomy and coded which characteristics from the taxonomy apply to their BM.[4]

The variable-based cross-case analysis uses the coded variables and their interrelationships to search and compare data patterns rather than explicit cases (Miles et al., 2020). We looked for patterns by searching for similarities to form initial groups and then searching for differences between those groups (Eisenhardt, 1989). We progressed through the dataset in four steps in five workshops with all authors. First, we started with the existing classifications for sustainable and digital BMs that define our research scope: The eco-dimensions (Chen et al., 2008) and the role of IT in value creation (Steininger, 2019). This grouped BMs based on their overall ecological purpose and the generic use of IT. This initial step revealed that if IT is used as a mediator, the BM creates eco-effective value, while if IT is ubiquitous in the value creation, the BM serves as an enabler for ecological sustainability.

Second, we differentiated the cases based on ecological sustainability patterns. This step revealed that eco-effective BMs follow the breakthrough and aikido strategies for competitive differentiation because they produce sustainable alternatives to market-dominant products. The aikido strategy is especially dominant if IT serves as a mediator in value creation. These cases also leverage a value-creating network. Furthermore, we found that the open BM strategy is used in approximately half of BMs with ubiquitous IT use. Third, we compared the cases based on the dimensions of their value proposition, especially their digital offering. In this way, we determined how the digital elements of the BM relate to the physical products and services, which ultimately led to the formation of the four archetypes. Finally, we completed the cross-case analysis by adding the BM dimensions revenue model, role in value creation, and differentiation strategy, specifying the details of the four BM archetypes.

During the workshops, we used spreadsheets to compare multiple variables simultaneously (Eisenhardt, 1989). We used colour coding to facilitate the identification of patterns that combine similar coded variables. By sorting and filtering, we applied the three steps to iterate through the dataset. Each step resulted in variable combinations discussed in the group and ultimately aggregated to create the BM archetypes. In cases of ambiguity, we referred back to the raw data collected to better understand each case.

# 4 | RESULTS

## 4.1 | Taxonomy of digital sustainable business models

The final taxonomy of digital sustainable BMs consists of three categories (*Value Proposition*, *Value Creation and Delivery*, *and Revenue Model*) and seven dimensions with three to seven characteristics each (see Table 2).[5] In addition to categories, their dimensions, and characteristics, we added the three perspectives guiding our research scope to illustrate the perspective (technological, ecological, or economical) the respective dimension refers to.

## 4.2 | Archetypes of digital sustainable business models

Based on the developed taxonomy, we identified four archetypal patterns of digital sustainable BMs: *Sustainable Software Solution*, *Sustainable Product-Service System*, *Sustainability Intelligence*, and *Digital Sustainable Platform*.

[4]The cases coding according to the taxonomy elements is available in the digital Appendix S1.

[5]Appendix S1 explains the taxonomy divided according to its categories and defines each characteristic. We also included three exemplary applications of the taxonomy in Appendix S1.

TABLE 2 Taxonomy of digital sustainable business models.

| Category | Perspective | Dimension | Characteristics | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Value Proposition | *Technological* | *Digital offering* | Physical product with embedded digital technology (13) | Physical product and digital complement (16) | | Digital product and physical complement (4) | | Digital product (10) | |
| | *Ecological* | *Eco-dimension* | Efficient (7) | | Effective (12) | | Enabling (12) | | |
| | *Economical* | *Differentiation strategy* | Aikido (16) | Breakthrough (22) | Customer centricity (27) | | Open BM (14) | Value network (12) | |
| Value Creation and Delivery | *Technological* | *Role of IT* | Mediator (5) | | Outcome (16) | | Ubiquity (10) | | |
| | *Ecological* | *Sustainability patterns* | Resource optimization (19) | Servitization (12) | Closed loop (10) | Renewables (15) | Stewardship (24) | Sufficiency (18) | Inclusive value (12) |
| | *Economical* | *Role in value creation* | Integrator (11) | Orchestrator (4) | | Intermediary (6) | | Service & Support (10) | |
| Value Capture | *Economical* | *Revenue model* | One-time sales (9) | Recurring revenue (14) | Commission (6) | | Advertising (1) | Freemium / Add-on (8) | |

**TABLE 3** Definitions of the four digital sustainable business model archetypes.

| | Archetype (*n*) | Definition | Examples |
|---|---|---|---|
| 1 | Sustainable software solution (6) | Sustainable software solutions are software platforms or layers to optimise the impact of ecological sustainability on their customers' resource consumption and $CO_2$ production. | Beryl, Tado°, Rocsole |
| 2 | Sustainable Product-Service System (13) | Sustainable Product-Service Systems are physical products enhanced by a digital complement, such as mobile apps, to optimise the ecological sustainability of product use. | LettUs Grow, Zola Electric, Sono Motors |
| 3 | Sustainability Intelligence (8) | Sustainability Intelligence BMs combine data analytics with sustainability science to provide transparency for companies' ecological sustainability assessment and sustainable decision-making. | Arabesque, Plan A, Reactive Technologies |
| 4 | Digital Sustainable Platform (4) | Digital Sustainable platforms create multi-sided markets that facilitate ecological sustainable value co-creation with complementors, such as circularity, creating sustainable value networks. | Tise, Too Good To Go, ClimatePartner |

Table 3 defines each BM archetype and includes three exemplary start-ups. The numbers in parentheses after each archetype indicated the number of start-ups that gave rise to the archetypes.[6]

### 4.2.1 | Archetype 1: sustainable software solution

The *Sustainable Software Solution* archetype describes sustainable digital BMs that offer software to solve ecological sustainability-related problems for their customers. At the core of sustainable BMs is a software solution that solves specific ecological problems in BMs, business processes, or private consumption with a high environmental impact. Their digital offering puts the digital product first. They either have digital-only products (i.e., software) or create the proposed value through the software but need a physical complement such as sensors or actuators. Hence, IT is the outcome of the value creation process that integrates into the value creation of customers' BMs. The software thus increases ecological sustainable efficiency or enables ecological sustainable effective BMs for the customers. The software solution optimises the resource utilisation of customers' BMs by reducing resource consumption, carbon emissions, and waste production, or enabling resource sharing. Value is captured almost exclusively through subscription models, which have proven successful for software BMs. For example, *Beryl* develops the software backend for micro-mobility sharing services, such as bike-sharing, offered by municipalities that want to establish sustainable

[6]Appendix S1 includes an overview of which start-up is included in which archetype.

micro-mobility concepts to reduce car traffic. The advantage of the value proposition of *Sustainable Software Solutions* over comparable non-digital BMs is the software's ability to collect and use data to optimise the sustainability of its customers' BMs. For example, *Enerbrain* analyses sensor data collected in buildings to optimise their ecological sustainability and improve living conditions.

Thus, these digital sustainable BMs provide digital solutions to improve the ecological sustainability of their customers' BMs. Instead of delivering the final value (e.g., a physical product) in the value chain, such as operating the bike-sharing service themselves, sustainable software solution providers provide specific functionality, requiring customer centricity, to enable many effective sustainable BMs (e.g., bike-sharing services) or make the value creation of a BM more resource-efficient (e.g., housing).

### 4.2.2 | Archetype 2: sustainable product-service system

The archetype *Sustainable Product-Service System* represents IT-mediated (IT mediating the customer interface), and IT-bearing BMs (IT as the outcome of value creation) designed around a physical product. The product has a digital complement, such as IoT or mobile applications, to form a product-service system (PSS), optimising the usage of an ecologically effective product. Characteristic of this archetype is the use of renewable energy and reusable resources (closed loop). The pioneering combination of physical and digital creates customer-centric PSSs that follow a breakthrough strategy by offering sustainable alternatives to common products, such as cars. The digital technology is tightly coupled to the core product to enhance its ecological sustainability and allow for additional functionalities or BM elements (e.g., digital services). The digital complement specialises in making this product more efficient (e.g., less energy) and its use more effective (e.g., reliable harvest). Aiming at ecological sustainability as an increasingly important customer purchase criterion, companies of this archetype try to establish a sustainable product that is fundamentally different from the competition and possibly represents the new industry standard.

The BM's value proposition maximises resource efficiency and effectiveness through its PSS. For example, *LettUs Grow* produces vertical farms that require less water, less space, and less transportation than traditional agriculture. The farms are equipped with sensors and actuators controlled by proprietary software. The software enables remote monitoring, automation, and optimization of the crop in terms of illumination, aeration, fertilisation, and irrigation to maximise yield with minimal use of resources. In addition, *Sustainable Product-Service Systems* add functionality to the physical product after it is sold and installed at the customer. For example, *Sono Motors* provides a mobile app complementing its solar-powered cars that enables its customers to share their cars with others without handing over physical keys, offering ride shares, power shares, and of course, usage analytics that are all targeted towards increasing the ecological sustainability of the already sustainable car.

### 4.2.3 | Archetype 3: sustainability intelligence

The *Sustainability Intelligence* archetype encapsulates purely digital, data-centric BMs that leverage the vast amounts of data available today combined with ecological sustainability and climate change science to provide insights for sustainability assessment and enable sustainable decision-making. It is exclusively a business-to-business BMs that creates transparency for different stakeholders regarding the ecological sustainability performance of their customers. To provide sustainability intelligence, the BMs follow a customer-centric strategy to enable sustainable decision-making specific to the individual customer. For the BMs of the *Sustainability Intelligence* archetype, IT becomes ubiquitous as they are built around data analytics software that integrates and orchestrates various data sources from public sources, customer-internal systems, or installed sensors. Using data analytics techniques, such as machine learning, computer vision, and artificial intelligence, the data analytics software enables the assessment of sustainability performance and sustainable decision-making by customers putting the BM in a service provider role.

For example, *Arabesque* offers a data analytics platform that calculates different sustainability metrics about their carbon footprint, conformance with the UN Global Impact Principles (i.e., human rights, labour, environment, and anti-corruption), or their ESG (environmental, social, and governance) score. The information provided by the platform enables investors to make ecological investment decisions, but *Arabesque* also helps rated companies analyse their performance relative to their peers. Similarly, *Planet A* analyses its clients' carbon data on its data analytics platform and recommends individualised strategic options for decarbonization.

Other examples within this archetype promote real-time data monitoring, for example, from IoT sensor networks, to automate the sustainable operation of networked IoT infrastructure. *Reactive Technologies*, for example, combines real-time monitoring and predictive analytics to manage power grids. Natural power fluctuations due to renewable generation require real-time grid control measures that are not necessary with fossil generation. *Reactive Technologies'* software provides the data transparency needed to operate renewable energy power grids and effectively manage power generation, storage, and the grid.

#### 4.2.4 | Archetype 4: digital sustainable platform

*Digital sustainable platforms* are purely digital BMs that leverage multi-sided markets and apply them to a sustainability context to co-create ecological sustainable value with their complementors. This value proposition enables individuals and companies to behave or do business sustainably. By creating a digital platform, the BMs serve as intermediaries or matchmakers in a value network who receive a commission for each successful transaction on their platform. The purpose of these *digital sustainable platforms* covers a variety of sustainability goals, such as sufficiency, through food waste reduction and overall responsible consumption; closed loops and circularity by enabling reuse and repurposing; and inclusive value creation through collaboration in the value network. Many are part of a circular economy ecosystem that seeks to give products and resources a new purpose instead of wasting them. Start-ups *PHENIX* and *Too Good To Go*, for example, offer digital platforms for their partners, such as restaurants, supermarkets, or hotels, to sell surplus food that would otherwise go to waste to individuals at reduced prices. *Tise* is a digital platform for used clothing and other items. Compared to similar platforms, such as eBay Classifieds or Craigslist, *Tise* mixes classifieds with social networking elements that connect sustainably-minded users, thus leveraging cross-side and same-side network effects.

*Digital Sustainable Platforms* also encourage sustainable consumption by rewarding users for their engagement on the platform (e.g., by selling or buying second-hand items). With points collected from transactions on the platform, users can buy discount codes or vouchers for (of course sustainable) partner companies. Such network effects that postulate sustainable behaviour across multiple actors can also be found in the BM of *Climatetrade*. *Climatetrade* offers a marketplace for carbon offsetting projects. Blockchain technology allows tracing offsetting investments. An API for the *Climatetrade* platform enables companies to offer their customers the option of offsetting the carbon emissions generated by online purchases, for example, on the *Climatetrade* platform.

*Digital sustainable platforms* are completely digital BMs (Steininger, 2019) that enable their ecosystem to co-create sustainable value. *Digital sustainable platforms* orchestrate multi-sided markets and connect complementors and customers to make their respective BMs more sustainable. All complementary services on the platforms aim to increase ecological sustainability, making transactions between supply and demand more efficient (as they are digital) and more sustainable. For example, *Tise* makes selling and buying second-hand clothing more accessible and efficient and creates circularity in fashion. Through the network effects in their ecosystems, the enablement of new sustainable BMs scales, and eventually, the platform establishes itself in a larger (circular) ecosystem (e.g., fashion retail or food).

## 5 | DISCUSSION

Sustainable start-ups leverage digital technologies to create ecological sustainable value propositions without compromising economic sustainability. These digital sustainable BMs improve the ecological sustainability of the start-ups' value creation instead of reducing the damage afterward, thus serving as prime examples for others to follow. Since research has considered the transformation towards ecologically sustainable BMs and digital BMs for economic sustainability separately, we intend to understand the complementary value of digital technologies and ecological sustainability by qualitatively assessing these digital sustainable BMs in detail to guide companies in their transformation towards sustainable and digital BMs, as both transformations are complementary.

We decomposed the dimensions and characteristics of these digital sustainable BMs into a taxonomy. Based on the taxonomy, we derived four archetypes of digital sustainable BMs: *Sustainable Software Solutions*, *Sustainable Product-Service Systems*, *Sustainability Intelligence*, and *Digital Sustainable Platforms*. Analysing these archetypes based on their ecological, economic, and digital value, we clarify the role of digital technology in the value creation of digital sustainable BMs (see Table 4). Based on digital BM innovation research, we discuss how these digital sustainable BMs create value and competitive advantage, encouraging companies to engage in digital and ecological sustainable transformations.

### 5.1 | Ecological, economic, and digital value

Leveraging the combination of ecological sustainability and digital technology for competitive advantage comes down to the value creation of the BMs (Porter & Kramer, 2011; Rashid et al., 2013). The ecological value of digital sustainable BMs has various expressions in the different BM archetypes. We articulate the changes in value creation, thus the transformations of the BM towards the archetypes of digital sustainable BMs in Figure 3.

Sustainable software solutions enable more efficient and optimised resource depletion. The software enables optimisation, creating cost reductions due to reduced resource usage (e.g., energy or raw materials). Thus, the role of digital technology for ecological sustainability in this archetype is to optimise the BM's ecological efficiency. This has been a primary focus in Green IS research analysing how software can be used for optimisation, such as logistic efficiency (e.g., Watson et al., 2010). Unlike Chen et al. (2008) argument that such digitally achieved efficiencies are driven by economic decisions and “mimetic pressure” to be sustainable, the start-ups represented in this archetype identify as sustainability enablers for their customers, creating ecological and additional economic value.

Transforming the BM towards sustainable software solutions will be complex for non-software companies (Steininger, 2019). The changes in value-creation activities are profound and change organisational logics when adding ecological sustainable and digital value to the BM. However, some examples, such as Amazon, added software-based BMs to their BM portfolio, creating a new business unit or founding a new organisation for this BM (Teece et al., 2022). Thus, companies developing internal software solutions to increase their ecological sustainability can market this sustainable software solution similarly. However, these companies will and should look for sustainable software solution providers that enable them to transform their BM into a digital sustainable BM by integrating these sustainable software solutions for (eco-)efficiency in their value creation (#1 in Figure 3) (Amit & Zott, 2001; Chen et al., 2008). For software companies to become sustainable software solution providers, the transformation is only ecological sustainable, not digital. Thus, the path is comparably shorter because the economic and digital value creation remain similar or even the same, but adds new ecological sustainable value to the value proposition (cf. Amit & Zott, 2001).

Sustainable PSSs support the creation of novelty value (Amit & Zott, 2001) with ecological sustainable products. In sustainable PSS creating ecological sustainable products, the digital value corresponds to the digital hardware (e.g., sensor systems) required to create sustainable infrastructure (e.g., energy storage). The economic value is created by differentiating the product from its competition based on its ecological value, addressing customers who

**TABLE 4** Digital sustainable business model archetypes and the role of digital technology for sustainability.

| Business model archetype | Sustainable software solution | Sustainable product-service-systems | | Sustainability intelligence | Digital sustainable platform |
|---|---|---|---|---|---|
| Ecologic value | Reducing resource depletion | Creating sustainable products and infrastructure | Easing customer access to sustainable solutions; making them more attractive | Creating knowledge and transparency about unsustainable operations, enabling them to become sustainable | Enabling customers to participate in a circular economy |
| Economic value | Cost-reduction through reduced resource usage | Alternative solutions | Simplify scaling and lower entry barriers | Identify inefficiencies, waste, and improvement opportunities in business operations | Gaining access to large customer bases profiting from network effects |
| Digital value | Software optimising resource consumption | Creating digital hardware necessary for sustainable infrastructure | Software making sustain-ability accessible | Data analytics to create knowledge about sustainability of companies | Digital platforms enabling circular consumption |
| Role of digital technology for sustainability | Digital tech. for optimization | Digital tech. for social good | Digital tech. for delivery and diffusion | Digital tech. for knowledge creation | Digital tech. for circularity |

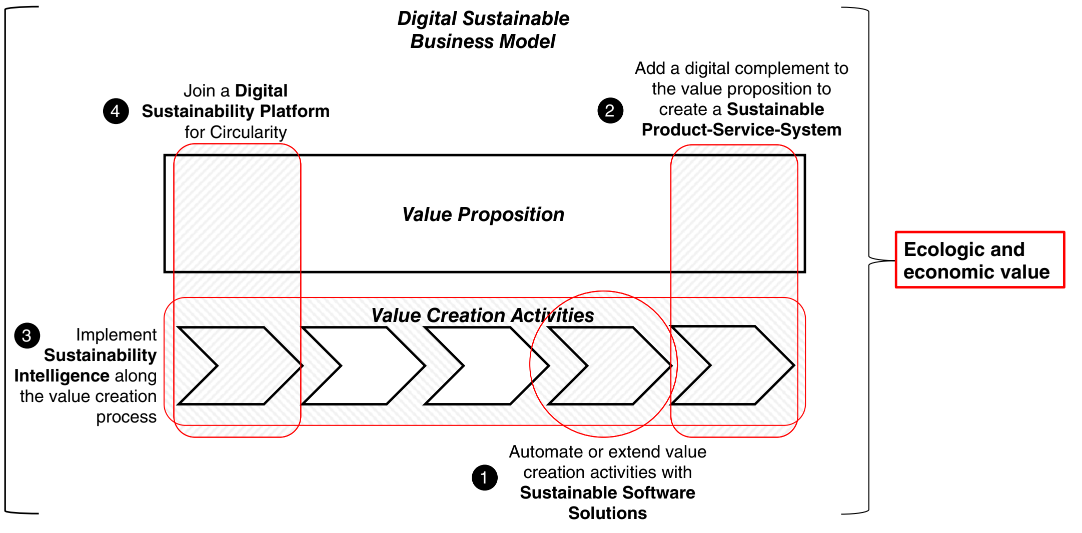


**FIGURE 3** How digital sustainable BMs enable digital ecological transformations.

desire more ecological sustainable and more efficient products. For this part of the archetype of sustainable PSS, digital technology creates a hardware platform, fostering an ecosystem that builds on this hardware (cf. "complementaries" in Amit & Zott, 2001). A BM innovation towards this BM archetype (#2 in Figure 3) affects the overall value proposition by focusing on the sustainable usage of the product and changing the user interaction, thus adding novel ecological sustainable and digital value to the value proposition (cf. Amit & Zott, 2001).

Sustainable PSSs can also lower the entry barriers for customers adopting sustainable products. Increasing the diffusion of sustainable products through digital technology increases the ecological impact of the BMs and their economic value as it attracts more customers. Therefore, in this part of the sustainable PSS archetype, digital technology is an enabler of value delivery and diffusion, extending BM design patterns that serve the same purpose (Bocken et al., 2014). By adding the complementary digital value to the BM, the digital technology enhances the value proposition, for example, with digital services (#2 in Figure 3) as offered by Sono Motors, but also magnifies the economic value by attracting more customers. As digital technology is added as a complement on top of a physical product to make it more ecologically sustainable, irrespective of the product's sustainability, the implementation does not interfere with the core value. This archetype can also be leveraged to create novelty (Amit & Zott, 2001) in ecological and economic value creation for regular products by enabling more sustainable usage, as argued before.

The sustainability intelligence BM archetype creates ecological and economic value based on the insights and knowledge resulting from data analytics. Here, the role of digital technology is knowledge creation. This mainly refers to identifying inefficiencies and waste that, when avoided, reduce costs, and increase efficient resource consumption. Based on the progress in data and process analytics, it extends the role of IS for eco-equity to provide access to ecological information (Chen et al., 2008) towards creating knowledge about sources and solutions to unsustainable business practices. It is comparable to the sustainable software archetype. However, sustainable software extends or automates activities in the value-creation process, while sustainability intelligence improves the value-creation process ex-ante.

Integrating the value proposition of these sustainability intelligence providers into their value creation and operational activities (#3 in Figure 3), companies gain information and knowledge about ecological and economic inefficiencies that help to innovate their processes. As many companies are creating data-driven decision-making processes and implementing process mining solutions or robot process automation, adding sustainability intelligence to these processes in the same transformation enables them to optimise sustainably for efficient value creation

(Amit & Zott, 2001). On the other hand, the providers of these solutions, such as Celonis, SAP, or Oracle, that access the sustainability-relevant company data and have the analytical capabilities to optimise for economic efficiency can add ecologic sustainability to their analytics portfolio to enhance their value proposition towards sustainability, potentially creating lock-in effects for extant customers innovating towards ecologic sustainability (Amit & Zott, 2001).

Finally, digital sustainable platforms allow users and complementors to participate in a circular economy. Digital technology, as an enabler of these platforms, also serves as an enabler of circularity and, thus, of ecological value creation. The economic value for the platform owner is created through transactions on the digital platform (Hein et al., 2020). Additional economic value is created for users and complementors who gain easy access to one another, profiting from savings or additional revenue created by the circularity (Adam et al., 2022; Ciulli et al., 2020). These digital sustainable platforms enable others to integrate ecological value in their BMs by providing digital services that allow others to act more sustainably.

BM innovation towards digital platform BMs (#4 in Figure 3) and how digital platforms enable economic value creation for entire ecosystems have recently been a major topic in IS research (e.g., Hein et al., 2020; Sandberg et al., 2020). However, the creation of ecological value has not been considered, even though the opportunities offered by these digital sustainable platforms can propel the digital transformation towards ecological sustainability for entire ecosystems. Digital sustainable platforms encompass all types of value creation discussed for the other archetypes. Some companies may innovate their BM to become a digital sustainable platform, but like the innovation to become a sustainable software solution provider, the BM innovation is complex (Steininger, 2019). Many more companies will join and use the platforms (Hein et al., 2020; Sebastian et al., 2017), integrating their value creation into their own BMs to innovate towards more sustainability and benefit from the platform services and network effects, as these digital sustainable platforms make sustainable products and services more accessible for sustainable PSS.

## 5.2 | Theoretical contributions

Sustainability must balance the current needs of economic sustainability and future ecological implications (United Nations General Assembly, 1987). IS research has provided important insights into both challenges separately. The digital transformation literature explains how digital technology creates economic value and successful digital BMs (e.g., Chong et al., 2019). The Green IS literature explains how digital technology creates ecologically sustainable business processes and contributes to a sustainable and just society (e.g., Hedman & Henningsson, 2016). Our main contribution is to combine these two perspectives to achieve ecological sustainable development that meets the needs of both present and future generations (Evans et al., 2017; Lokuge et al., 2021).

Following recent calls (Evans et al., 2017; Lokuge et al., 2021), we argue that it is beneficial for companies to simultaneously address the economically necessary digital transformation and the ecologically necessary sustainable transformation. Hence, we addressed the research question of how digital technologies can help companies become more sustainable rather than compensating for their impacts after the damage is done. Our findings contribute to the digital and ecological sustainable BMs' research and their transformation by showing how digital technology creates sustainable value and how start-ups lead this way (Nambisan, 2017; Satalkina & Steiner, 2020). We identify four BM archetypes and discuss how they create ecological and economic value. Drawing from the literature on sustainability, BM innovation, and digital transformation, we articulate the role of digital technology in ecological and economic value creation.

First, we contribute to sustainable BM and Green IS research by analysing and articulating the benefits of digital technologies to create ecological sustainable BMs. We show that many companies fall short when they address sustainability only for cost and compliance reasons (Lokuge et al., 2021; Sedera et al., 2017; Van Osch & Avital, 2010). There are opportunities to create additional value and competitive advantages based on achieving ecological sustainability with digital technologies. The BM as an operationalization of business strategy can provide a starting point for strategy formation (Lanzolla & Markides, 2021). With the four digital sustainable BM archetypes and their implementations in the BM taxonomy, we contribute an ecological perspective to the predominantly economically oriented research on digital sustainable BMs. To this end, we offer specific and actionable strategic pathways to create ecologically and economically sustainable BMs (Vermeulen, 2017). This links the ecological strategy, such as the beliefs-actions-outcomes framework (Melville, 2010), and digital transformation strategies, such as the clarification that digital transformations require a change of value proposition and organisational identities (Wessel et al., 2021). We provide the actions (i.e., BM characteristics) and outcomes (i.e., digital sustainable BM archetypes with new value propositions) to go beyond using digital technology to optimise production or logistics or enable remote work and on to implementing ecological sustainability as a core logic of the organisation and its identity. Considering the ontological reversal of digital technology shaping the physical reality (Baskerville et al., 2020), our strategy guidelines contribute to creating a sustainable reality based on digital technology implemented in the BMs. Our guidelines respond to different calls in research to provide more practicable insights on ecological sustainability in IS (Malhotra et al., 2013; Seidel et al., 2017).

Second, we contribute to Green IS research by explicitly analysing the role of digital technology in ecological sustainable value creation. We find digital sustainable BMs to enable their customers to become more sustainable, as depicted in Figure 3. Therefore, companies adapting digital sustainable BMs serve as incubators of digital ecological transformations, maximising the positive environmental impact. This extends the argument of Malhotra et al. (2013), who called for research on eco-effectiveness and using digital technology to achieve eco-efficiency. We identify the use of digital technology to achieve "eco-enablement" and extend the sustainability framework of Chen et al. (2008) by presenting how digital technologies, especially digital BMs, enable third parties to become more ecologically sustainable.

Third, the four digital sustainable BM archetypes and the comprehensive classification of digital sustainable BMs in a taxonomy provide a new perspective (i.e., ecological sustainability) for digital BM research. We provide a transparent classification scheme for companies engaging in sustainability and how they create ecological, economic, and digital value (Täuscher & Laudien, 2018). They support our understanding of both sustainability and BMs and provide a common foundation for future research to build upon (Baden-Fuller & Haefliger, 2013; Rich, 1992). We also identified several areas for such future research. We have identified four key research areas to which IS research can significantly contribute. Since there is an ongoing discussion in the community about making IS research more impactful, contributing to solving our biggest challenge might be an excellent place to start.

## 5.3 | Practical implications

For practice, the underlying research identifies which sustainability strategies, digital technologies, and BMs are used by ecological sustainable start-ups and how they are integrated into the various BMs. This also supports entrepreneurs in analysing sustainable strategies generally, and helps other successful start-ups use specific BM characteristics. Practitioners, in general, can benefit, as start-ups are often seen as initiators of a sustainability transition (Schaltegger et al., 2016). The sample contains recently founded companies and start-ups valued at more than 1 billion US dollars, demonstrating that a lasting and successful establishment in the market is possible for digital sustainable BMs.

Depending on a company's current BM, companies face several challenges when transforming towards a more ecological sustainable BM. Our archetypes present BM configurations that can be used in BM design to guide how companies with similar kinds of value creation leverage digital technologies for a digital sustainable BM. For example, a consumer goods manufacturer can use the *Sustainable Product-Service System* archetype to innovate its BM for more sustainability-oriented value creation. The archetypes also guide related challenges, such as how a

**TABLE 5** Practical guidance of the digital sustainable business model archetypes.

| Sustainability challenge | Archetype helps to… |
|---|---|
| Improve the sustainability of a specific element in the value creation | *Sustainable Software Solutions* provide specialised solutions to solve sustainability challenges. |
| Improve the sustainability of the core product/service itself | *Sustainable Product-Service Systems* demonstrate how digital technologies can be embedded as part of the product or create additional services that allow for sustainable product usage. |
| Identify new sustainability improvement opportunities in the value-creation process | *Sustainability Intelligence* analyses data to identify value-creation activities with high sustainability impact or high improvement potentials. |
| Engage in value co-creation to improve the sustainability of the product life cycle | *Digital Sustainable Platforms* provide a multi-sided market connecting multiple actors to achieve a common sustainability goal. |

manufacturer might engage with a *Digital Sustainable platform* to create circularity in its products. Table 5 presents exemplary sustainability challenges and how the archetypes help to approach those challenges.

## 5.4 | Limitations

The results of this research are limited in some respects. Digital ecology is only an emerging topic in both research and practice. The population of companies suitable for our analysis is, therefore, limited. Nevertheless, we identified a suitable sample of sustainable start-ups for our exploratory research approach that allowed us to thoroughly conduct the Nickerson et al. (2017) taxonomy development method. Our sample also allowed us to derive generalizable archetypes, and we are confident that we captured a sufficient diversity of digital sustainable BMs. A larger sample size could verify and contextualise these archetypes, for example, for specific industries, which was not within the scope of our research.

We must also acknowledge the limitations of our sampling strategy. In selecting start-ups, we followed Crunchbase's ranking based on success and interest metrics. Our sample could be biassed towards highly successful start-ups. Since we excluded start-ups founded in the last 4 years, our sample could also be missing newer BM designs, such as those based on AI, blockchain, and Web3. However, we have already observed the use of these technologies in our sample. Also, none of the sampled BMs is perfectly sustainable in all aspects of value creation. Perfect sustainability will likely remain a utopia, but current BMs need to improve their sustainability, and the BMs in our sample are at least more sustainable than current business practices. For these reasons, the taxonomy can and should be extended and updated in the future, especially in aspects related to achieving eco-equity that we had excluded from our research scope.

The exclusion of eco-equity from our research scope results in an incomplete perspective on sustainability as defined by the triple bottom line (Elkington, 1998). We do not account for the fair distribution of natural resources to create eco-equity or social compensations for the (historically created) negative consequences of resource depletion for underprivileged regions or future generations. An analysis of related BM characteristics warrants an ethical, regulatory, and global perspective on what is fair that exceeds the scope of this research. We recognise an emerging interest in this perspective in the IS literature (e.g., Clemons et al., 2022), but a more sophisticated discussion about social sustainability to achieve eco-equity across time and space is needed.

Finally, start-up BM analysis is recommended for developing BM taxonomies, but it also has limitations (Möller et al., 2021). As discussed earlier, it might not be easy for incumbents to change their BM to a similar BM design.

**TABLE 6** Summary of avenues for future research and exemplary research questions.

| Research area | Exemplary research question | Useful theories |
|---|---|---|
| New BM configurations for sustainable value creation | How do BM configurations of digital sustainable BMs differ from regular digital BMs?<br>How can data create sustainable value for companies and society?<br>How does the presence of a digital sustainable platform lead to an increased commitment to sustainability in their ecosystem? | Resource-based view<br>Diffusion of innovation theory<br>Platform ecosystems |
| Competing with sustainability | How do companies create a competitive advantage with and from sustainable BMs?<br>How do companies respond to increased sustainable competition? | Theory of disruptive innovation<br>Contingency theory |
| Transitioning to a sustainable BM | How do companies change their BMs to integrate sustainability?<br>How do companies manage different sustainability requirements in different markets?<br>How can companies influence their value network to implement sustainability? | Dynamic capabilities<br>Resource-based view<br>Open innovation<br>Leadership theories |
| Policy Implications | How do companies respond to increasing legal sustainability requirements?<br>How can policymakers balance and incentivise sustainable value creation and economic growth?<br>How can regulations ensure equitable value creation? | Actor-network theory<br>Social influence theory |

However, during the time of this research, SAP, as a global company, adopted a new digital sustainable BM that can be located within our *sustainability intelligence* archetype.[7]

## 5.5 | Future research

Our analysis of digital sustainable BMs provides a common ground for future research on the relationship between digital technologies and sustainable development. Using the BM as the unit of analysis in our research allowed us to synthesise a variety of characteristics across industries and economic purposes. The identified digital sustainable BM archetypes provide a generalised distinction of how companies can integrate sustainability in their BM with the help of digital technologies. In the following, we discuss how IS research can build on our results in future research at the intersection of IS and sustainability and further analyse the two types of sustainable value creation. The avenues for future research and potential research questions are summarised in Table 6.

First, since digital platforms are a major topic of interest in IS research, their role in sustainability transformation needs further research. In digital platform ecosystems, we observe how digital platforms influence the BMs of actors in their ecosystems. Introducing new digital platforms or changing established digital platforms provides opportunities and introduces threats for customers and complementors. A sustainability transformation of the focal digital platform may thus trigger a wave of sustainability transformations in its ecosystem. As the archetype of *digital*

[7]https://blogs.sap.com/2021/09/02/product-deep-dive-welcome-to-product-footprint-management-from-sap/

*sustainable platforms* illustrates, digital platforms enable such transformations. However, future research is needed to investigate the effects of these platforms on their ecosystems and their role as orchestrators in the circular economy. Research questions include how ecosystem actors leverage sustainability platforms' sustainable value propositions and if the focal platform's change in an ecosystem causes a butterfly effect, diffusing sustainability through the ecosystem.

Second, data leverage, value creation from data, and data-based BMs are other major focuses of IS research. For most digital BMs, data is vital. IoT, blockchain, or AI-based BMs use and produce data, much of which is relevant for sustainability. Use cases from comparative contexts, such as regulatory applications, have shown the benefits of data-driven applications (Jensen et al., 2019). In the sustainability context, we have identified the *sustainability intelligence* archetype that leverages these digital technologies to provide transparency to outside stakeholders. However, implementing transparent and trusted blockchain storage, combining available data from IoT systems and analytical capabilities using AI in operational business processes and data-driven business applications still holds potential for sustainable business value. Especially in complex supply chains and business ecosystems, data-driven digital technologies provide tremendous value to account for emissions, identify reduction potentials, or enable novel data-driven sustainable BMs. Data can be used to capture, allocate, and equitably distribute the consumption of natural resources in the complexity of global ecosystems to compensate for inequalities in their use and negative consequences and create eco-equity. Therefore, analysing the sustainable value of data while focusing on the eco-equity dimension, which was excluded in this study, can help us understand and design BMs for companies to consume natural resources more socially sustainably.

Third, while we provide archetypes and a descriptive analysis of sustainable BMs, more research is needed to investigate how companies can leverage sustainability as a competitive advantage. Future research needs to take a process- or activity-oriented perspective to analyse the pathways, challenges, and best practices of such BM changes and provide recommendations on how incumbents can successfully transform their BM using digital technology. Besides, start-ups and incumbents must integrate economic and ecological sustainability in their BMs. Our archetypes indicate possible targets for these actions and potential applications of specific digital technologies for improved sustainability, but the path to get there is still uncertain (Foss & Saebi, 2017). For policymakers, sustainability is a core challenge to balancing a prospering economy, reducing emissions, and increasing the economy's overall sustainability. During the COVID-19-induced lockdowns, we observed how various BMs were affected in various ways. Digital BMs were often affected less negatively or even profited (Floetgen et al., 2021). Research on (digital) sustainable BMs is needed to support policymakers, provide recommendations on balancing economic growth on both micro and macro levels, and the impact of potential sustainability regulations such as emission certificates or bans on certain BM activities to ensure equity.

Fourth, our archetypes serve as ideal BM designs that demonstrate how digital technology can be used to enable sustainable BMs. IS research should further analyse the role of digital technologies for sustainability-oriented BMs. Faraj and Pachidi (2021, p. 7) point out, "… it is difficult not to see deterministic thinking in the formulation of 'adopting technology X leads to competitive advantage [or sustainability].' To make those claims, most authors fall back on an intermediate vocabulary of BMs, strategic disruption, opportunity seizure, artful execution, but the essential agency is that of technology changing organizations." While we are guilty of using the BM as the intermediate unit of our analysis, it provides a common ground. However, more clarification and theorising about how digital technology changes the form of organising the BM is needed. As outlined earlier, there is little difference between digital sustainable BM and digital BM from a taxonomic perspective. Adopting a configurational perspective that allows investigating how the different characteristics are organised to form the sustainable BM may reveal different insights into the design of digital sustainable BMs that are not observable in our variance-based analysis of digital sustainable BM archetypes.

## 6 | CONCLUSION

The need to address sustainability as a fundamental issue in companies' operations is urgent. Companies need to become more sustainable from their core business logic, which is represented by their BM, instead of taking the easy way out and planting a tree. For start-ups, it is easier to make the BM sustainable from the beginning than to change an established BM that has been running successfully for many years (Aspara et al., 2011; Gregori & Holzmann, 2020). Nevertheless, incumbents can manage this upheaval and transform their BM into a sustainable BM with the help of digital technologies, combining the economically necessary digital transformation with the ecologically necessary sustainable transformation. Also, incumbents do not have to manage this upheaval alone. As we have shown, some companies are using digital sustainable BMs to enable other BMs to become more sustainable.

To conclude, we must acknowledge two things. First, organisational change is a challenging task. Changing fundamentally to become more sustainable is even more challenging. Therefore, we analysed start-ups that did not have to change but were able to design themselves to be sustainable from the beginning. They serve as prime examples and sources of inspiration for other companies to imitate to ease the challenge of organisational change. Second, the start-ups in our sample are not perfect. None of them is 100% sustainable in all aspects of their BM. However, they are more sustainable than the standard practice. Taking them as examples hopefully creates a more sustainable economy that reduces its impact on future generations and fosters innovation to become even more sustainable.

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## DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available in the supplementary material of this article.

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