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Editorial

Reviewing Literature on Digitalization, Business Model Innovation, and Sustainable Industry: Past Achievements and Future Promises

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Abstract: Digitalization is revolutionizing the way business is conducted within industrial value chains through the use of Internet of Things (IoT) technologies, intensive data exchange and predictive analytics. However, technological application on its own is not enough; profiting from digitalization requires business model innovation such as making the transition to advanced service business models. Yet, many research gaps remain in analyzing how industrial companies can leverage digitalization to transform their business models to achieve sustainability benefits. Specifically, challenges related to value creation, value delivery, and value capture components of business model innovation need further understanding as well as how alignment of these components drive sustainable industry initiatives. Thus, this special issue editorial attempts to take stock of the emerging research field through a literature review and providing a synthesis of special issue contributions. In doing so, we contribute by developing a framework that communicates and sets the direction for future research by linking digitalization, business model innovation, and sustainability in industrial settings.

Keywords: digitalization; business model innovation; advanced services; digital services; product–service systems (PSS); sustainability; circular economy; value creation; value capture

1. Introduction

Industries are entering the fourth industrial revolution (Industry 4.0) through capitalizing digitalization, which is revolutionizing the way business is conducted in industrial value chains [1–3]. We are witnessing a new age, where industry is becoming increasingly ‘smart’ with the use of Internet of Things (IoT) technologies, intensive data exchange and predictive analytics [1,4]. The benefits are many: automation and optimization of processes can improve productivity and profitability by saving costs, speeding up production, and significantly reducing errors [5–7]. Most industry experts view this transformation through a positive lens; according to recent BCG and PwC reports, Industry 4.0 is expected to increase efficiency by 15–20% and account for more than 20% of the revenue generation over the next five years. These numbers show that the use of digital technologies represents a significant potential for business model innovation in a business-to-business (B2B) setting, while providing new revenue and value-producing opportunities [8]. Those companies that are able to capitalize on digitalization potential driven by big data and analytics will outperform their peers in revenue growth and operating efficiency [9].

The perceived opportunities and benefits are motivating numerous industrial companies to experiment with innovative business models, based on digital technology [10]. According to

Visnjic et al. [11], these business models create and capture value over the product life cycle according to the solution delivered (e.g., pay-per-service-unit, performance-based). In order to exploit the benefits accruing, companies need to innovate their business model, building it around digital technologies such as artificial intelligence, digital platforms and big data analytics. We follow Foss and Saebi [12] in defining business model innovation as: “designed, novel, non-trivial changes to the key elements of a company’s business model and/or the architecture linking these elements.” This implies that business model innovation can be focused on introducing novel components into individual elements of the business model as well as across elements, aligning them within an architecture of value creation [12,13]. However, we find increasing evidence that most incumbent firms across industries are ill prepared to benefit from the promise that digitalization holds out [1,4]. Numerous business-model innovation-related challenges have been reported in the literature. For example, a key challenge for many companies is identifying, selecting and implementing customized digital innovations to benefit their operations [6]. Another challenge relates to the need for better understanding of how to design, customize, evaluate, and sell/purchase intangible offerings. This is evident in the case of digitally enabled advanced service business models where the offer is neither a product nor a service but a promise of delivering a certain outcome for customers [11,14]. A new demand from digital technologies and business model innovation is to facilitate continuous improvement in order to keep up with competitors and provide long-term value to customers [15,16]. Thus, exploiting digitalization goes hand-in-hand with business model innovation, which requires novel offerings and processes that define how value is created, delivered and captured between providers, customers, and other value chain actors.

Yet, the literature is still nascent in these domains and many research gaps remain. Consequently, we have conducted a literature review to identify underlying research themes and to suggest directions for future research. Thus, the purpose of this special issue introduction, is to propose a research agenda for advancing academic discussion about how industrial companies can leverage digitalization for business model innovation. In particular, knowledge is sought concerning achievement of sustainable industry benefits, which represent the greatest potential for economic, environmental, and social impact through incorporation of the new business logic.

2. A Literature Review of Digitalization and Business Model Innovation

To advance understanding of commercializing digitalization efforts, the present study comprises a systematic literature review with specific focus on research related to digitalization and business models. According to Cook et al. [17], a systematic review differs from a general review in that it adopts a replicable, scientific, and transparent process based on theoretical synthesis of existing studies. In this way, bias is limited and the legitimacy of data analysis is enhanced. These benefits lead to more reliable results, which provide a stable basis for drawing conclusions [18].

A literature search was conducted through the authors’ library service using the Scopus database, one of the largest multidisciplinary abstract and citation databases of peer-reviewed literature. The database covers research from both major and minor publishers, including Elsevier, Emerald, Springer, and Wiley. Because this database covers peer-reviewed multi-disciplinary research studies, there was a high level of confidence that studies on digitalization and related fields with a business or management focus would be found. Several keywords were used to find relevant articles, such as *Internet of Things*, *Industry 4.0*. The articles resulting from the initial search were refined through the three steps described below.

Step 1: Identifying publications and applying practical screening. The first step begins by setting certain practical screening criteria to ensure that only quality publications are included in the review. During the first search, therefore, conference articles, working papers, commentaries, and book review articles were excluded, aiming instead for a focus on journal publications and book chapters. No other quality criteria—for example, journal rankings—were used for filtering. Indeed, publications that cover the topic of digitalization may not always be published in highly ranked journals given the

evolving status of the topic. The chosen keywords for the literature search were designed to cover digitalization and closely related topics that study a similar phenomenon. In addition to 'digitalization', the terms 'digitization', 'IoT', 'Internet of Things', 'Industry 4.0', 'remote monitoring', and 'smart factory' were used in the search. Furthermore, relevant papers had to include the term 'business model' in the title, abstract or keywords to meet the search criteria. Confined to the subject areas of business, social science, economics and environmental science, this search identified 196 articles considered relevant for the purposes of analysis. The citation information, abstracts, and keywords of all articles were exported to an Excel spreadsheet for further analysis.

Step 2: Applying theoretical screening criteria. Because the focus of the study is on the digitalization of business models, only conceptual or empirical studies that had digitalization and business model aspects as their main focus were retained for further analysis. More specifically, all abstracts were read carefully and the full papers were retrieved of only those that highlighted commercialization aspects of digitalization or certain business model elements. After a second round of screening, 91 articles were retained.

Step 3: Final filtering, reference analysis and interviews with experts in the fields. In this final stage, all 91 articles that met the inclusion criteria were downloaded and read in detail in a final analysis of the content. Each article's cited references were used as a secondary source of literature analysis. In addition, six interviews with research experts in the field were performed to identify relevant articles. This led to the identification of 15 additional articles that were perceived to provide prominent contributions to an understanding of digitalization and business models. Thus, this systematic literature analysis is based on a total of 106 articles. To analyze the articles, an open coding content analysis technique was utilized. When using this technique, notes and headings are written in the text based on their association with the research focus. While inductively reviewing the studies, it was acknowledged that each study can contribute to several different headings. Thereafter, all headings were collected and discussed in relation to the three business model elements—value creation, delivery, and capture.

3. Review of Articles, Journal Outlets, Theoretical Perspectives

A bar graph illustration (see Figure 1) of the 106 articles published over the years shows that the field is still young but emerging. The first article dates from 2012, and that was then followed by a steady increase up to 45 articles in 2018, clearly demonstrating that the topic had expanded in importance. Even though the literature search was conducted in October 2018 (before the calendar year was complete), the number of papers published in 2018 was more than three times the 2016 figure.

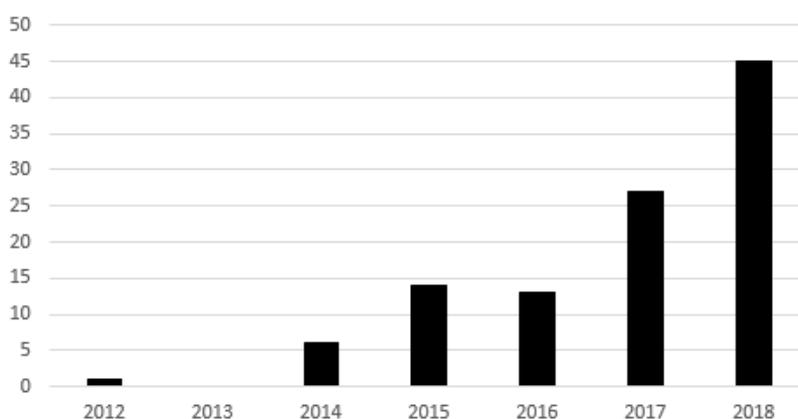


Figure 1. Distribution of publications over time.

The 106 articles have been published in 73 different journals (see Table 1), demonstrating the relevance of the topic to a wide array of research disciplines. It is also reasonable to conclude that this research stream will continue to grow through contributions from multidisciplinary research work. The table below shows the top contributing journals, that have two or more articles included in the literature review. Besides focusing on production, marketing, and innovation management, many journals publish work on sustainability and social change. It should be added that, currently, the special issue contributions (i.e., six articles) have been excluded from the systematic search; this explains why the Sustainability journal has a lower ranking in the table. However, after publication of the special issue contributions, we expect that the Sustainability journal will not only be a top-ranked outlet but will also become a leading journal promoting discussion on the topic of digitalization and business models with the focus on sustainability.

Table 1. Top journals with at least two publications included in the review.

Journal	Number of Articles
<i>International Journal of Production Economics</i>	6
<i>Technological Forecasting and Social Change</i>	5
<i>International Journal of Innovation Management</i>	4
<i>Journal of Business and Industrial Marketing</i>	3
<i>Research-Technology Management</i>	3
<i>Sustainability</i>	3
<i>Technology in Society</i>	3
<i>Business Horizons</i>	2
<i>Business Process Management Journal</i>	2
<i>Industrial Management and Data Systems</i>	2
<i>Info</i>	2
<i>International Journal of Production Research</i>	2
<i>International Journal of Social Ecology and Sustainable Development</i>	2
<i>Journal of Information Technology Teaching Cases</i>	2
<i>Journal of Manufacturing Technology Management</i>	2
<i>Quality-Access to Success</i>	2
<i>Review of Managerial Science</i>	2
<i>Service Business</i>	2
<i>Strategic Change</i>	2

We find that the emerging literature on digitalization and business models in the business-to-business context draws quite widely from diverse theoretical perspectives. Table 2, shows studied topics based on theoretical perspectives and have been categorized according digitalization, business model components, as well as key references. Clearly multiple theoretical approaches are used by researchers to understand and explain the phenomena predicated on digitalization and business models. Specifically, this review identifies the following theoretical perspectives: resource-based view and dynamic capabilities, service-dominant logic, network theory, platform literature, transition theory, sustainability, entrepreneurship and transaction cost economics. However, we confine our discussion to only a few of the theoretical perspectives—those where we can source a sufficient number of studies to draw meaningful conclusions.

In line with other similar review studies [19], we find evidence of medium to low levels of maturity in the application of theoretical perspectives when trying to understand how digitalization enables business model innovation and implementation. A dominant view within the field originates from the *resource-based view (RBV)*, which is used frequently, explicitly or implicitly, to emphasize the role of the company's resources and capabilities in sustaining its competitive advantage [7]. Existing studies discuss the need for new capabilities [4,7], investments and skill development [20], co-creation with customers [21], and big data as an intellectual and economic resource [22], to ensure consequential exploitation of digitalization and business models. Furthermore, a sub-stream of RBV is related to research on *dynamic capabilities*, which is frequently mentioned and used to describe the company's

ability to address rapidly changing environments. For example, Rachinger et al. [23] developed a framework that identifies digitalization activities in the dynamic-capability phases of ‘sensing’, ‘seizing’, and ‘reconfiguring’ that relate to the business model elements of value proposition, value delivery, and value capture. Researchers who have placed dynamic capability at the centre of their framework have argued for an environment-strategy-structure fit [24], facilitating the dynamics of digital business models, and policy level changes for digitalization adaptation [25].

Table 2. Mapping theoretical perspectives and key references.

Theoretical Perspective	Digitalization	BM-Value Creation	BM-Value Delivery	BM-Value Capture	Key References
Resource-based view (RBV) and dynamic capabilities (M)	-Conceptualizing digitalization capabilities -Internet of Things (IoT) strategy	-Value co-creation with customers -Developing absorptive capacity	-Mass service customization -Dynamic orchestration of supply chains	-Reconfigure offers, resources and revenue streams	Gauthier et al., 2018; Hasselblatt et al., 2018; Kohtamäki and Helo, 2015; Raichinger et al., 2018
Transition theory (L)	-Enabler for new pathways	-Radical innovation -Possible pathways	-System is transitioned -Structural changes	-Focus on workable actions to economic and social systems	Gorissen et al., 2016; Sung, 2018; Parida et al., 2015
Entrepreneurship (L)	-Generate value from technology	-Opportunity recognition -Creativity -Disruptive business models	-New actors in the ecosystem	-Generate value from technology	Ehret and Wirtz, 2017; Krotov, 2017
Transaction cost theory (L)	-Reduced measurement costs	-Encourage non-ownership contracts	-Deliver outputs	-Manage downside risk	Ehret and Wirtz, 2017
Platform theory (L)	-Digital platform perspective	-Build information module	-Integration between back-end and front-end	-Customization and standardization	Cenamora et al., 2017; Eloranta and Turunen, 2016

Note: High (H), medium (M) and low (L) represents the extent of studies applying a specific theoretical perspective.
BM: Business Models

In addition, we would like to highlight four theoretical perspectives that represent low levels of maturity. Based on transition theory, Gorissen et al. [26] present a transformative business model innovation approach that favors more radical, structural changes in the business model instead of continual adaptation to suboptimal solutions. While other researchers propose concrete and workable action plans, transitioning to economic and social systems that can accommodate innovative changes is of particular importance. Building on the call for more radical change, several researchers incorporate entrepreneurship theory into their studies to accelerate the value generated from technology [27]. To achieve this, entrepreneurs contemplating higher valued uses from resources perceive upside opportunities and consequently become part of the IoT asset owners’ ecosystem. Similarly, [28] advocates greater creativity and entrepreneurship in developing more disruptive business models that deploy the full potential of digitalization and IoT. Ehret and Wirtz [27] include transaction cost theory in their research to explain what IoT can offer to better manage downside risk and to encourage non-ownership contracts in which the output is purchased. Finally, studies by Cenamor et al. [3], Eloranta et al. [29], and Eloranta and Turunen [30], recognize the importance of platform thinking in undertaking digital transformation in pursuit of strategic opportunities; they propose the use of a platform to share information, and to achieve a higher degree of customization and operational efficiency through front-end and back-end integration. Hence, we call for fuller adoption of a theoretical

perspective to draw rich conclusions from the current phenomena-driven research on digitalization and business models.

4. Digitalization Enabling Business Model Innovation for Sustainable Industry

In the following three sections, we review the literature relating to digitalization and enabling digital technologies (Section 4.1)—how it can enable innovation across the three business model elements of value creation, value delivery and value capture (Section 4.2), and how successful business model innovation provides the key to ensuring sustainability benefits (Section 4.3).

4.1. Digitalization and Enabling Digital Technologies

The existing literature is dominated by arguments about the potential of digitalization and digital technologies to enable business model innovation [1,3]. However, this special issue and literature review argues that appropriate business models are crucial to derive the benefits from digital technology economically, environmentally, and socially. Indeed, the emergence of digital technologies and applications such as the Internet of Things (IoT), Industry 4.0, artificial intelligence, automation, remote monitoring, predictive maintenance, smart contracts, big data, the cloud, analytics, and smart connected products offers many business development opportunities [1,5]. Table 3 shows how many articles have used each concept included in the literature review in either the title or the abstract. However, this variety of technologies and their applications makes it conceptually challenging to define digitalization. Building on prior definitions (see Table 4) and our understanding of the field, we define digitalization as ‘*use of digital technologies to innovate a business model and provide new revenue streams and value-producing opportunities in industrial ecosystems*’. This definition holds at its heart the view that digitalization is much more than just the application of various digital technologies.

Table 3. Use of different concepts relating to digitalization in reviewed articles.

Keyword	Number
Internet of Things (IoT)	44
Digitalization	20
Industry 4.0	17
Digitization	8
Remote monitoring	2
Smart factory	1

From a review of the literature, three main digitalization functionalities have been identified that facilitate value-creating and value-capturing opportunities in a business-to-business setting [1,4,22]. The first functionality is the collection of operational data through sensors that can configure hardware components to sense and capture information with low human intervention. Second, connectivity enables the efficient sharing of data among digital units through wireless communication networks. Third, analytics is the ability to transform the data available into valuable insights and actionable directives. Increased knowledge is provided through optimization and storage in the cloud. These functionalities create numerous opportunities for value generation [4] and offer a progression that moves from monitoring to control and optimization, leading ultimately to autonomous products enabled by digitalization [1].

Table 4. Definitions of digitalization.

Reference	Definition
Gardner glossary, 2018	Digitalization is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business.
Gobble, 2018	Digitization is the straightforward process of converting analog information to digital. Digitalization refers to the use of digital technology, and probably digitized information, to create and harvest value in new ways.
I-scoop.eu, 2018	Digitalization means turning interactions, communications, business functions and business models into (more) digital ones which often boils down to a mix of digital and physical as in omnichannel customer service, integrated marketing or smart manufacturing with a mix of autonomous, semi-autonomous, and manual operations
Luz Martín-Peña et al., 2018	Industry 4.0 is being encouraged by the introduction of digital technologies that push the specialization of the value chain and also connectivity between actors. Industry 4.0 heralds greater operational efficiency and the development of new products, services, and business models.
MIT Sloan Management Review, 2018	Digitalization is the innovation of business models and processes that exploit digital opportunities.
Rachinger et al., 2018	Digitization (i.e., the process of converting analogue data into digital data sets) is the framework for digitalization, which is defined as the exploitation of digital opportunities. Digitalization by means of combining different technologies (e.g., cloud technologies, sensors, big data, 3D printing) opens unforeseen possibilities and offers the potential to create radically new products, services and BM.

Although numerous opportunities and applications of digital technology have been proposed, recent discussion has also recognized the multitude of organizational and business challenges associated with digitalization. Porter and Heppelmann [1] list five common mistakes to be avoided when developing advanced offers based on digital technologies. First, functionalities are sometimes included that customers do not want to pay for. The feasibility of a technological feature does not automatically qualify it for development. Questions about added value for the customer are left unanswered or even unasked, leading to a costly and complex technology that ultimately dissipates the total value of the product and service offering. Second, security and privacy risks should not be underestimated given that smart, connected products open new gateways to internal corporate systems that contain critical data in need of protection. Third, companies often fail to anticipate competitive threats where new competitors with superior digitally enabled products and services, such as performance-based business models, emerge quickly and reshape the competitive boundaries of the industry. Fourth, a common mistake is to delay the start, enabling competitors and new entrants to move ahead in capturing and analyzing data. The final mistake is the overestimation of internal capabilities to undertake the digital transformation. Digitalization creates a high demand for new technologies, skills, and processes throughout; a realistic assessment of the capabilities to be developed in-house and those to be developed by new partners is very important. For example, Hasselblatt et al. [7] identify five distinct capabilities that can leverage an IoT strategy. Similarly, Lenka et al. [4] highlight the importance of digitalization capabilities for value co-creation with customers when pursuing a servitization strategy. Furthermore, they identify three underlying sub-components of digitalization capabilities: intelligence capability, connect capability, and analytic capability. All of these challenges are closely related to the inability of companies to transform their business models based on digitalization [20,31]. For example, advanced service business model literature recognizes the need to revise value creation, delivery and capture activities [18]. In practice, companies need to develop a sound understanding of what to offer, how to achieve it, and why it has profit potential, whilst remaining in touch with the wider ecosystem beyond

company boundaries. In the section below, we apply a business model lens to identify on-going dialogues, and we recommend future trends for research on leveraging digitalization through business model innovation.

4.2. Digitalization and Business Model Innovation Components

4.2.1. Digitalization and Value Creation

The value-creation dimension of the business model describes what is offered to the customer. This refers to the types of product and service offered by the company. There are many different ways that digitalization can create value for the customer through new, and often more advanced, service offerings.

First, we increasingly witness companies *creating novel offering configurations enabled by digital technology*. Digitalization allows companies to either revise or extend their portfolio of products and services by incorporating IoT components or even combining different offerings with unique opportunities [3,7]. From studying the literature, we see that significant opportunities lie in configuring advanced services based on digital platforms [3]. This provides a unique perspective on business model value creation by leveraging contributions from different roles in the ecosystem. Digitalization can also play a complementary role in increasing value and reducing transaction costs, even when it is product/service smoothing or adaption rather than digitalization that is the main value driver [32,33]. However, these novel offerings are by no means assured; firms can fall into a trap by employing digitalization solely in an attempt to sustain the market position of their existing products and services [28,34].

Second, it is vital for firms to focus on *understanding customer needs* concerning digital solutions. Adding connected sensors and actuators to present offerings in an unsystematic manner does not necessarily lead to market success; evaluating market needs on an on-going basis is crucial [32]. Several researchers highlight the importance of specifying and quantifying value creation to communicate the benefits of the particular business model, so that offering functions that are not requested by, and do not create any value for, the target customer is avoided [35–37]. Thus, firms would benefit from initially mapping out potential digital technology applications and the potential value benefits they can bring [6]. Moreover, digital components are sometimes added without a clear understanding of customer needs and without a value proposition that is unique to the client [38].

Third, digitalization enables the *creation of value through ecosystem orchestration or collaboration*. Existing literature generally upholds a positive view of digitalization as a radical and disruptive innovation possessing the potential to reshape competitiveness in industrial ecosystems. Studies show that approaching digitalization with a more visionary and creative mindset will lead to totally new business models incorporating entirely novel functions where the digital component is the main value driver [28,32,34]. In many cases, the realization of digital value creation will occur beyond firm boundaries and across networks in the form of collaborative value creation [27,39,40]. In addition, firms may benefit from leveraging collaboration with innovative start-ups and SMEs that are more likely to adopt a pathfinder ethos when it comes digitalization-based value creation [40]. Customers will invariably play a central role in this process, because they will be integrated into the value-creation process e.g., through self-service or data source [33]. An important criterion for value creation is that digital technology should not replace but rather complement human capabilities in the value-creation processes [6]. This may be especially true in the case of advanced services where relational interaction with customers is important and over-reliance on digital systems to the detriment of personal interaction can have negative effects on the value-creating potential of the new offering and how it is perceived.

4.2.2. Digitalization and Value Delivery

The business model component of value delivery describes how activities and processes are employed to deliver the promised value. This includes, for example, specific delivery resources and capabilities that are needed (e.g., service support staff, online monitoring systems). How value is delivered to the customer will significantly change in digitally enabled business models. These changes will occur both inside the company and within the business ecosystem that is external to the company. Indeed, digital transformation has a major impact on internal resources, capabilities, activities, and roles [26,41].

First, revised digital business models often require *developing and applying new capabilities*. Raichinger et al. [23] identify organizational capacity and employee competence as the major future challenges of digitalization. Digitalization capabilities for the delivery of business model innovation can be developed in a stepwise way to ensure maturity progression [20]. Key activities to build digital capabilities in manufacturing firms include investing in intelligent and connected information technology (IT) functionalities, building skills in advanced analysis of customer usage data at front-end units and automating basic data analysis and support for service innovation [3,20]. The development of information technology capabilities [25] are strongly correlated to internal employee capabilities [35,37]. However, there will be a shortage of industry 4.0-qualified personnel; companies will be required to invest in the education and training of their employees to fit new job profiles and new workplaces as well as to better integrate low qualified and elderly personnel [6,42,43]. But, to succeed with digital transformation, a firm mentality and culture that supports the transformation and actively searches for opportunities will need to be established [6,33,36].

Second, new business models require *revising operational processes and activities for global delivery*. In addition, to successfully deliver value from digitalization, companies need to be able to develop scalable platforms that utilize modularity to achieve both efficiency and effectiveness in what they offer [3,7,44]. Digital capabilities enable continuous improvement of routines related to information flow, integration of service activities, and centralized monitoring of service processes. Consequently, fewer delays and a more responsive customer service result, which is critical for service provision [20,21]. For example, a warning signal (e.g., risk of breakdown) from customer usage data can immediately flow through the entire system and trigger the necessary changes in spare-parts levels, service staff scheduling, and can even lead to the automated re-routing of service plans [21,45,46].

Third, new business models create the need for *revised roles and responsibilities in industrial ecosystems*. There is wide consensus among researchers that the business ecosystems external to the company will become much more important and affect value delivery significantly. This is because relationships become intensified, interdependent, and globally distributed [20,27,39,47]. The collection, storing and sharing of data will require firms to become more collaborative, facilitating higher information transparency, inter-company connectivity, and joint data analysis [39,42,47]. This need for intensified collaboration is of particular benefit to young firms because their future depends on partnerships that will succeed [37]. It may well become difficult for existing actors to keep their powerful positions in the supply chain when faced with other actors working in, for example, software development, data interpretation, and services, with potentially stronger prospects of dominating the supply chain [35,48]. Therefore, every company needs to determine which partners and complementary actors will be needed to deliver value and how this partnership should look [36]. Lenka et al. [4] have shown how co-creation with customers is enabled by digital technology. This co-creation is highly challenging because it leads to role ambiguities between actors (e.g., unclear role descriptions). Different relational response strategies (e.g., role adaption) are, therefore, required to cope with unclear expectations, responsibilities and demands [49]. Both vertical and horizontal industry partnerships will evolve and innovation centers and partnerships with public organizations will increase in importance with digitalization [50].

4.2.3. Digitalization and Value Capture

Value capture is the third business model component. It concerns the revenue model and its financial viability, with particular attention to potential revenue streams and the cost structure. Capturing value from digitalization can accrue in various ways—for example, from decreased costs, higher revenues, or the capture of new revenue streams. To secure the profitability of the business model over time, it is very important to put in place an appropriate risk management system where the financial gains more than match any negative consequences such as high delivery costs. From reviewing the literature, it is evident that limited attention has been given to the value-capturing dimension of digitally enabled business models, even though discussions on cost and revenue are at the heart of digitalization.

First, digitalization can *improve internal processes that enable improved cost efficiency* leading to a positive effect on performance [6,22,33,51]. Other efficiency benefits can be achieved through streamlining the delivery process by capitalizing on product data flow and stressing the requirements relating to improved customer interaction [3]. These efficiency advances are among the main drivers of digital business model development [25]. When aiming for cost efficiency, it is also important to continuously review co-creation initiatives so that the extra costs occurring from joint digitalization efforts are weighed in the balance [43,44]. However, the heaviest costs come from product development and IT infrastructure, which require very substantial upfront investment and continuous updating over time [35,36].

Second, the fact that the use of digital technology can enable *new or increased revenue streams* is described frequently in the literature [22,23,43]. For example, the increase in perceived value would enhance price margins [33], but most benefits are expected from new revenue or pricing models based on subscriptions, pay-per-use or similar method where the customer pays for the use or result instead of the particular product [35,36,50]. These new revenue models enabled by digital technology will open up more flexible and customized pricing that can be changed over time and in real time based on operational data. These situations also give customers the opportunity to choose fixed prices, pay-per-use, or hybrid models, facilitating greater value creation through increased customization and shifts in responsibility [52]. Emerging technologies such as ‘block chain’ may have a particularly interesting role in changing the value-capture mechanisms by enabling increased transparency among multiple actors.

Third, digitalization represents new and increased risks that are related to the implementation of business model innovation stemming from interdependencies in the ecosystem. This increased uncertainty needs to be handled, and new *risk management approaches* are required that focus on developing a flexible risk management system [27,47]. However, a key benefit of digitalization comes from creating transparency in provider-customer relationships by providing real-time data insights. This then affords the opportunity to establish more outcome-based service contracts, where pricing is closely connected to the real value created. This transparency provides opportunities to both sides to work fairly and achieve common goals [52,53].

4.3. Digitalization Enabling Business Model Innovation and Sustainable Industry

The implementation of digitalization is a challenging undertaking and requires a continuous commitment to making the organization fully capable and mature. However, this commitment to digitalization initiatives coupled with judicious implementation of business model innovation can certainly yield important benefits to the triple bottom line. Thus, creating a sustainable industry is the goal, the success of which depends on targeting the economic, sustainable, and social benefits over the long term. Many companies are working with this holistic perspective in mind, and digitalization is the essential enabler to make this development a reality. It is important to highlight that the benefits can be achieved either through direct or indirect effects that are created simultaneously; it is important to visualize these and to facilitate them.

The general industrial view is that value creation is best achieved through incremental and radical digitalization advances, directly impacting the company's economic performance [54]. Increased process efficiency is achieved through continuous analysis of operational data, facilitating the identification of process–performance bottlenecks to be eliminated [3]. Autonomously self-correcting systems can increase process efficiency, translate into less equipment down time, optimized capacity, and reduced repair-time averages, to name only some of the potential benefits [6]. Second, lower operational costs are achieved through process optimization and monitoring in the interests of cost-efficient resource utilization. Enhanced predictive approaches allow quality defects and operational problems to be spotted sooner rather than later. In addition, analytics can facilitate identification of the root causes of defects—whether they are human, machine, or environmental—leading to the gains of lower scrap rates and lead times [1,5].

Accordingly, environmental benefits can be achieved both through incremental improvements in efficiency and radical organizational methods [26,55]. Functionalities supporting sustainability range from improved product design to predictive maintenance and product tracking [56]. Sustainability is also achieved through operational manufacturing efficiencies that reduce the environmental footprint compared to conventional manufacturing processes. For example, reducing scrap rates and equipment wear and tear can be achieved by monitoring operational data [6].

Social benefits accruing from digitalization are many. Increased safety through greater process autonomy can reduce the incidence of human error and accident. For example, sensors can shut down an operation on detection of an operator entering a prohibited area [6]. Dangerous jobs in underground mining, for example, can be eliminated by using remotely operated or autonomous machines. Social benefits can also accrue when employees are given more knowledge-intensive and rewarding tasks. For example, instead of operating in a constant state of firefighting readiness to deal with machine breakdowns, maintenance personnel can use data to better understand the operational attributes of the equipment and thus work with predictive maintenance. In addition, repetitive and fatiguing work activities can be replaced by more rewarding tasks that give greater job satisfaction, reducing injuries and staff turnover [6]. Furthermore, the often-unobserved benefits of hidden values or digital dark matter include a positive correlation to national competitiveness and an improved potential for regional development, especially for remote regions [40,57]. This type of indirectly created value that stems from digitalization will significantly benefit society overall and deserves, therefore, to win special consideration from policy makers.

5. Theoretical Implications and Suggestions for Future Research

5.1. Theoretical Implications

This special issue editorial was initiated with the goal of proposing a research agenda to advance academic discussion on how industrial companies can leverage digitalization for business model innovation in order to achieve sustainable industry. The literature review shows that business models are recognized as the key factor in enabling sustainable industry through digitalization. The literature on business models for digitalization has expanded exponentially during the last three years, and many important findings have been published. Based on a review and analysis of the existing literature, we are able to organize the existing studies into a framework (see Figure 2) that clearly shows the linkages between digitalization, business model innovation, and sustainability industry. The framework logic suggests that digitalization, fueled by applying diverse digital technologies, is enabling business model innovation. In turn, this is leading to changes in the value creation, value delivery and value capture components, enabling sustainable industry benefits.

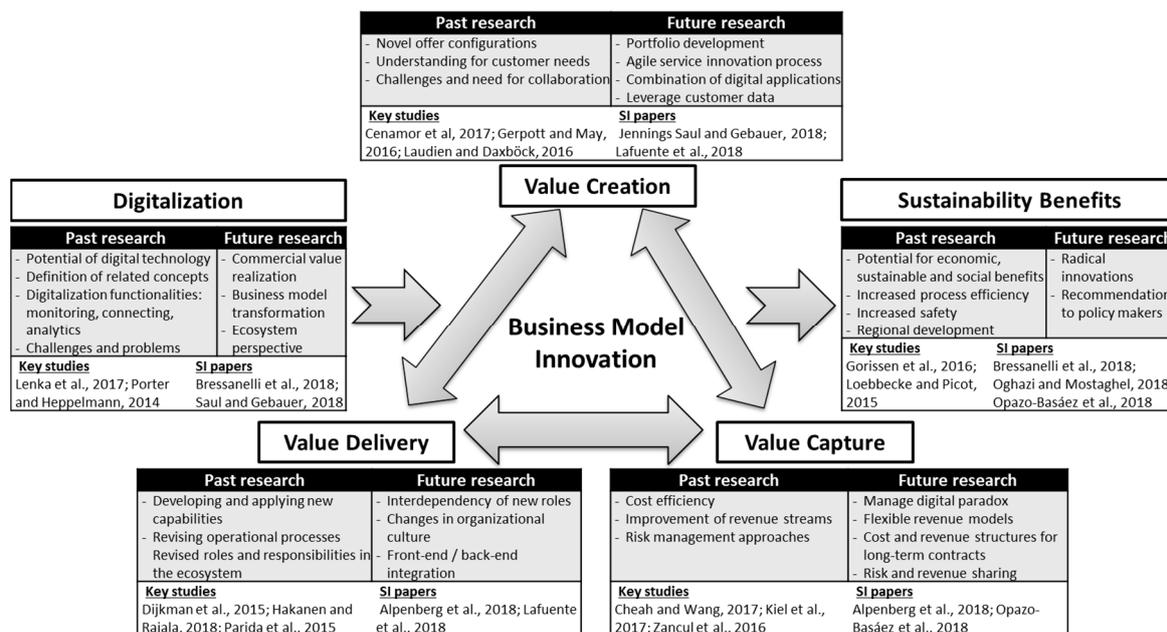


Figure 2. Special issue framework for mapping current and future topics for research on digitalization-enabling business model innovation for sustainable industry.

On an aggregate level, the insights gathered from the literature review provides important implications for research. Specifically, we have identified three theoretical implications that can help to shape the development of a future research agenda on digitalization and business model innovation.

First, researchers and practitioners have been focusing on the promise of digitalization and have worked diligently to understand how best to benefit from digital technologies [1]. However, the review of literature shows that digitalization-related studies are widely dispersed, and there is a need to differentiate between digital technologies per se and digitalization. A progressive starting point for research would be to establish a commonly agreed definition of digitalization, which is currently lacking. In this special issue, we propose that digitalization represents the *use of digital technologies to innovate a business model and provide new revenue streams and value-producing opportunities in industrial ecosystems*. This puts the focus on digitalization as a “means to an end not an end in itself” i.e., ensuring how to profit from digitalization through business model innovation is central to a critical discussion on digitalization.

Second, building on current discussions in the business model innovation literature [12,18], we affirm the need to approach the business model from the perspective of its sub-components, i.e., value creation, value delivery and value capture in order to properly understand the implications of digitalization in all its facets. When this is done, it then becomes evident that companies that intend to benefit from digitalization need to evaluate and understanding their shortcomings in relation to each of these dimensions. It can be the case that companies are skilled in addressing challenges related to understanding the unique value of their offering (i.e., value creation) and how to capture monetary value (i.e., value capture), but they lack deeper insights into the kind of strategic partnerships that are needed to deliver on the promise (i.e., value delivery). This view asserts the need for business model ‘alignment’. According to Ritter and Lettl [13], business model alignment ensures that all the components work together to achieve the overall business logic of the company. It can also be argued that business model ‘misalignment’ can lead to value leakages, which negatively influence performance. Thus, the identification of areas concerning antecedents and processes that lead to business model alignment/misalignment sets an important agenda for further research.

Finally, a recurring theme in the literature review on digitalization and business model innovation has been the call for an ‘ecosystem’ perspective. Current business model innovation practices often take

too firm-centric a view rather than an ecosystem actor-centric perspective (e.g., providers, customers, service partners, and digital actors) [3]. Therefore, important questions related to digital transformation such as the distribution of activities, roles, models for cost and revenue sharing, procurement, value creation, and value capture are currently left unanswered [20,57]. Indeed, implementation of digitalization-enabled business model innovation requires a significant transformation of the company's ecosystems (especially towards customers) to a state where value is co-created by providers, ecosystem partners, and customers through the optimization of resource usage, and the effective operation and leveraging of digital technologies.

5.2. Suggestions for Future Research

In addition to showing the key themes of research on the linking digitalization, business model innovation and sustainable industry, Figure 2 also shows suggestions for future research. Although existing studies have made significant contributions to the literature, several areas remain open to further research. Below, we identify those gaps that need to be filled by the researcher community. We categorize these future research themes in relation to business model innovation components.

5.2.1. Future Research on Digitalization, Business Model Innovation and Value Creation

How can companies manage a portfolio of digitally enabled business models? As companies venture into the digital age, they need to develop numerous advanced services for customers. However, how to develop these new business models, how to assimilate their co-existence with products and product-centric services, and how to manage their impact on the company's overall business model(s) remain less understood. In the shift to advanced digital business models, firms are at risk of cannibalizing existing business models—thus, stirring up strong internal resistance and weakening the commitment to value-creation efforts.

How can agile service innovation processes be organized to create value from digitalization? The benefits of the agile approach have been widely studied within the IT industry, but its application may become even more important in traditional B2B industry since companies need to work iteratively with innovation, progressively building software and analytics to create greater value from digitalization. Indeed, companies need to be 'quick on their feet' in responding to customer needs. Building on digital competences such as software updates provides new ways to not only customize services but also promote continuous innovation [3]. Yet, the literature on digital servitization and business models has scarcely researched such processes and how they unfold. What are the key phases, activities and roles, and how should the customer be involved in value creation?

How can value-creation opportunities from emerging digital technologies such as IoT, AI, Cloud computing, blockchain and big data be exploited? Many of these technologies are very much in the early stages of being applied in practice, and there remains much that is unclear for the literature on management to study further. For example, how these technologies individually and together contribute to value and to future company competitiveness remains clouded.

How data from customer operations can be leveraged in order to create new and innovative digitally enabled business models? We know that customer data is a source of value but how to truly exploit the data and analytics in pursuit of higher value creation has not been widely studied in the research literature.

5.2.2. Future Research on Digitalization, Business Model Innovation and Value Delivery

How do roles and responsibilities in value delivery change among ecosystem actors engaged in digitalization? Revised roles in the industrial ecosystem will lead to new interdependencies and power relationships as well as the demand for new capabilities. Being able to orchestrate an ecosystem relationship with a delivery network would be necessary for key players, but insights on how to develop such capabilities are not well understood.

How does organizational culture changes along with digital servitization? As delivery organizations increasingly focus on advanced service-based business models, there is a need to undergo an internal

cultural shift. For many engineering-intensive manufacturing companies, it has been problematic to mentally shift from selling equipment and aftersales service to selling digital solutions. A deeper understanding of how a digitalization culture can be instilled across the firm's delivery network is a necessity. Thus, the distribution channels required by digital servitization calls for a cultural shift.

How can digitalization facilitate front-end (e.g., service delivery network) and back-end (e.g., head office) integration? Digitalization reduces the challenges posed by geographical distance as it provides direct access to customer usage information and enables the remote uploading of new equipment functionalities. But often the competences at the back end and the front end do not match the requirements of digitalization. On both sides, new routines and capabilities need to be developed, and consideration has to be given to how these functions can work better in co-creating value. Understanding digital transformation from both the back end and the front end is key to successful provision of, for example, advanced services to global markets.

5.2.3. Future Research on Digitalization, Business Model Innovation and Value Delivery

How do firms cope with the digital paradox i.e., being unable to capture value from their digital investments? Digital investment can be costly and, with unclear value propositions and revenue models, it is by no means certain that value can be captured. It is suggested that aligning value capture to other business model components can reduce the likelihood of encountering digital paradox. Nevertheless, understanding how firms can manage the digital paradox and capture value in digitalization is an issue of considerable importance.

What types of revenue model are needed to capture value from digital business models? Studies have begun to identify a variety of revenue models such as pay-per-use and subscription, but insights into how different revenue models can be matched to changing customer needs are still lacking. Future studies could seek to discover the conditions under which particular revenue models work best and how customers could be persuaded to change the way they procure digital solutions. Digitalization provides much greater opportunities for companies to be flexible when faced with changing conditions—for example, how to enable value capture in the future through block chain and smart contracts.

How can firms get paid for data and how can revenue models based on sharing data be implemented in ecosystems? This is a critical issue facing much of the industry today. The willingness to share and/or pay for data is low since firms currently struggle under the weight of unclear ownership and revenue models. Significant research opportunities exist in understanding how payment for data usage can be assured among multiple ecosystem actors.

How to design and implement mechanisms to continuously re-negotiate cost structure and revenue models in performance-based contracts? Many new business models involve signed contracts between provider and customer that run over three to five years. A pressing challenge in these circumstances is how to provide incentives to both sides so that common goals are met over an extended period. How can companies work together with their partners to align incentives over time?

How to ensure the sharing of risk and revenue among multiple actors in the ecosystems? What should be the financial terms of engagement when multiple actors are asked to collaborate and co-create value. Companies would need to ensure that 'opportunistic behaviors' do not become prevalent and that each actor is placed to earn a fair share of revenue. There are many research avenues pointing in this direction.

6. Introduction to the Special Issue Contributions

This special issue, which is entitled, 'leveraging digitalization for business model innovation' called for a more critical discussion and outlook on creating business value through digitalization and how this can contribute to a more sustainable and circular economy. Numerous research themes were identified and contributions were requested from the wider research community. Below, we list some examples of the core topics that we intended to cover in the special issues, but it should be noted that contributions were not limited to these topics.

- Opportunities and benefits from digitalization transformation
- Dark side of digitalization and organizational change
- Digitalization-enabled business model innovation
- Understanding and aligning key components of the business model: value creation, value delivery and value capture
- Value co-creation in multi-actor ecosystems (including large companies and small and medium enterprises (SMEs))
- Customer perspective on business model innovation
- Achieving circular benefits through digitalization

Against this backdrop, a large number of article contributions were received in the first round. After careful screening and three review rounds from special issue editors and expert reviewers, six articles were selected for publication. In this editorial, we have attempted to set the stage for the special issue contributions and provide a holistic understanding of the topic of how digitalization enables business model innovation (see Figure 2).

The paper written by Bressanelli et al. [56], develops a conceptual framework on the role of digital technologies as an enabler of the circular economy in usage-focused business models. The study shows how digital technologies help overcome the drawback of usage-focused business models in adopting the circular economy. In addition, Jennings Saul and Gebauer [58] use multiple case studies to provide an understanding of the challenges that organizations face when engaging in digital transformation, and how organizations can develop individual digital transformation pathways, which provide a framework for digital transformations with specific focus on Bottom of the Pyramid markets.

Besides Jennings Saul and Gebauer [58], who discuss digital transformation in relation to innovative service offers, Lafuente et al. [59] employ fuzzy set analysis (qualitative comparative analysis) to evaluate how the development of sustainable and traditional product innovation strategies is conditioned by the learning capabilities and entrepreneurial orientation of the business. Knowledge intensive business services (KIBS) firms are known to leverage the knowledge-based and customer orientations that characterize their business model in order to compensate for the lack of important organizational characteristics.

Alpenberg et al. [60] demonstrates how local governments are adopting a key role in developing a sustainable ecosystem by becoming more environmentally oriented. The authors develop a framework for setting environmental goals, identifying suitable environmental indicators, and reporting to a wide range of stakeholders. The increasing environmental orientation in the public sector is due to the implementation of digitalized performance measurement systems.

The study by Opazo-Basáez et al. [61] in this special issue examines the effect of digital and green servitization on the firm's productivity. The findings show that implementation of digital and green servitization is positively associated with higher productivity outcomes, once these two forms of servitization are made to coexist and operate jointly.

Most of the studies in this special issue focus specifically on sustainability benefits, including Oghazi and Mostaghel [62] who study circular business models (CBM). CBMs offer solutions to move towards zero waste, improving environmental impacts, and increasing economic profit. However, despite the considerable benefits of CBMs, failure rates are high. Thus, there is a clear need to identify the obstacles standing in the way of CBM transition.

To conclude, this special issue sets out with the goals of taking stock of the literature and promoting new dialogues on the broad topics of digitalization and business model innovation. The review of the literature clearly demonstrates that these topics are on a high growth path both within academia and in practice. Yet, the greater part of current research is fragmented across disciplines, and largely phenomena-driven and lacking conceptual clarity. The proposed framework for digitalization-enabled business model innovation for industry sustainability provides a way of organizing existing studies, and of mapping out what has been done and what needs to be further developed. In this introduction

to the special issue, our goal is to legitimize the importance of understanding digitalization and its implications for business model innovation. We hope that future researchers will respond to the call for extensive research on these topics and their interlinkages and, in so doing, promote the development of novel insights, both theoretical and practical.

The six articles included in this special issue on “leveraging digitalization for business model innovation” provide only a selection of the myriad research avenues open to sustainability and digitalization research. As guest editors, we hope that this special issue provides a further step in the realizing the significant potential of digitalization and business model innovation research in contributing to both organizational success and industrial sustainability. It is our hope that the discussion in this special issue inspires researchers to further pursue this important research domain.

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