Business Model Research in the Age of Digitalization—A Systematic Literature Research for the Derivation of a Taxonomy of Business Models in the Manufacturing Industry

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***Abstract*—Advancing digitalization and its impact on business models leads to various streams in research that emerge in parallel and provide different explanatory and systematization approaches of digital business models. The large number of contributions induces fragmented concepts and unclear terminologies. In particular, most existing conceptualizations neglect the examination of the business model concept taking into consideration the advancing digitalization, especially in the manufacturing industry, or only consider domain-specific aspects. Therefore, there is a lack of systematic approaches to structure the research area. This unclear understanding of the terminology leads to challenges in practice. In addition, in most cases, companies have only fuzzy ideas of what characterizes business model innovation in the digital age and which element form a digital business models. Thus, the following contribution is devoted to a systemization of the questioned research field in order to enable further research initiatives and to support companies to develop digital business models.**

***Index Terms*—Digital business model, manufacturing industry, business model innovation, digitalization, taxonomy**

I. Introduction

Continuing digitalization and digital business is a term that has recently created much attention in the scientific and practitioners' community. The steadily advancing penetration of all sectors and branches of industry with digital technologies is accompanied by new challenges that companies have to face (Yoo *et al*., 2012; Brettel *et al*., 2014; Schuh *et al*., 2019). Companies are forced to use digital technologies sensibly in both their strategy and their business model to innovate accordingly, generate novel offerings and to optimize internal processes (Yoo *et al*., 2010; Bharadwaj *et al*., 2013). Profiting from digitization is, in this context, usually a more complex undertaking than companies assume. Companies often invest in digital technologies without fully understanding the implications of the digital era (Porter and Heppelmann, 2014). As for digitalization represents a multidimensional and interdisciplinary process of change. This digital transformation is "one of the great challenges of our time—it is above all unprecedented and without blueprints" (Hanselka *et al*., 2020).

Within the research area of production technology, the technological dimension of the phenomenon digitalization has already been explored in greater depth in numerous research papers (e.g., Yoo *et al.*, 2012; Schuh *et al*., 2018; Nambisan *et al*., 2019). However, digitalization means much more than the mere adaptation of technology into production systems or products. The full value of digitalization is only revealed when it is implemented holistically within suitable value creation principles especially concerning efficient business models.

Meanwhile the discourse in the innovation management and information systems research has shifted form products and services, company resources and revenue models towards a more strategic and comprehensive consideration of business models. This way of interpreting a business model encompass, form a conceptual point of view, serval components of value creation systems (Gassmann *et al*., 2013; Nambisan *et al*., 2017; Weking *et al*., 2018). The business model concept thus also offers an opportunity to describe value creation systems in the manufacturing industry.

Consequently, it can be stated that digital technologies, which are partly already deployed in value creation systems, only develop their full potential when they are integrated and synthesized into suitable business models. However, this economic and business management dimension in the manufacturing industry has been little explored so far (Brettel *et al.*, 2014; Teece, 2018; Bittencourt, Alves, and Leão, 2021).

Additionally, in the current macro environment the dominant characteristics of digital technologies (Nambisan *et al.*, 2017) are disruptively changing traditional value creation structures and evoking new ways of aligning value creation logics and business processes that cannot be fully captured or described by existing principles of strategic alignment (Quinton *et al*., 2018; Kindermann *et al*., 2020). Consequently, the digital transformation of industrial value creation requires novel ways of aligning management, organization and value creating systems. The overall objective of this research approach is to understand how technological developments can be transferred into business potential and translated into economic value. Taking into consideration concrete demands for intensified research approaches the first goal of this research-in-progress contribution is to understand the implications of the phenomena of digitalization for the design of business models (RQ1).

In this context, current publications agree, "the transition to digital value systems often requires new types of skills" (Linde *et al*., 2021). Industry and academia must continuously adapt methods, approaches, and structures to succeed in the digital age. In particular, business success

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depends on the ability to respond appropriately to changing conditions (Gimpel *et al*., 2018). Although the relevance of the challenge of conceptualizing digital value creation logics is well known in both science and practice, there are hardly any application-oriented or professionally comprehensive concepts for this field of tension (Häckel *et al.*, 2021). For example, no approaches or only insufficiently standardized design principles and blueprints can be identified that can examine and enable the development of digital business models. Thus, a key factor lies in the holistic, synergistic use of technology, information systems and business management perspectives. In doing so, this contribution identifies the second overarching research target, to develop a holistic, systematic framework for the digital business model (RQ2).

In order to answer these research questions, this contribution first considers the theoretical background of business model research. Building on this, the influence of digital technologies on the development of business models is examined. Finally, the central results of the associated systematic literature search are structured in a condensed conceptual taxonomy of digital business models and a brief description of corresponding dimensions and characteristics.

II. Theoretical Background

A. Business Models

"Technology by itself has no single objective value. The economic value of a technology remains latent until it is commercialized in some way via a business model" (Chesbrough, 2010). Consequently, business model theory is of particular importance in both innovation management and entrepreneurial practice. In recent publications (e.g., Nambisan *et al*., 2019; Hanselka *et al*., 2020; Kindermann *et al*., 2020; Piller *et al.*, 2022), there is consensus that a differentiated and difficult-to-imitate business model, with an effective and efficient value creation logic, serves as a key component for establishing competitive advantage. Without a carefully thought-out business model, companies fail to achieve their goal of improving their value proposition and profits through innovation. At the same time, "the concept of a business model lacks a theoretical basis in economics or business administration" (Teece, 2010). For the most part, business model theory receives only a superficial discussion. A deeper understanding of its function, origins, and potentials remains largely unexamined. Conceptual diversity and ambiguity prevail. "There are almost as many definitions of a business model as there are business models" (Teece, 2018). Taken this into account, a brief review of the history and development the term "business model" helps to understand current research approaches and ensures a unified understanding of the concept.

In general the term "business model" can be broken down into the components "business", i.e., an explanation of "what" a company does within its business activities, and "model", "what" the corresponding structural arrangement of the business activities looks like. In business administration, a model initially describes a simplified representation of a real system (Horvàth, 1996). According to Stachowiak (1973) a model is an illustration, abbreviation and is based on pragmatism. Concluding also the business model theory cannot be reduced by definition to a generally valid, subject-neutral illustration regulation. The development and creation of a business model has to be analyzed in the specific enterprise context and contains a design thought. First, it is necessary to consider the historical development of the term business model in order to understand current interpretive approaches and definitions. Keeping this in mind, historically, a first mention of the term business model can be traced in publications in the context of management research (Belman *et al*., 1957). In the following formation phase of the term first Chandler (1962) connects a systematic representation of growth and change in enterprises. Building on this, Anshoff (1965) derives implications for corporate strategy. Penrose (1959) sees the source of entrepreneurial growth in the abilities of management to develop additional business areas. Thus, the origins of business model research can be characterized as a subfield of strategy formulation. From a historical perspective, a business model is a "story that explains how enterprises work" (Magretta, 2002). Consequently, according to Porter (2001), strategy and business model inevitably belong together. The business model is part of the strategy.

Based on these fundamental assumptions, current research approaches consider the business model concept in competitive environments. Business models present themselves as a central and necessary feature of competitive market economies, where customers have a choice between bundles of services from different suppliers, where transaction costs are present, and where heterogeneity between customers and producers prevails (Teece, 2012). In this environment, a business model itself can be seen as a source of competitive advantage and determines the company's position on the market (Christensen, 2001). This understanding of competition induces a differentiation of the business model concept. Through the integration of concepts for the generation of competitive advantages, in particular approaches considering strategic innovation decision (Hamel, 2000), into the business model research leads to the extension of the theoretically-organizationally coined definition of a business model. Thus, the business model presents itself as a conceptual and architectural interface between fundamental strategic orientation and operationalization of entrepreneurial goals (business processes). It can be concluded that a business model nowadays is the crucial link between the highly aggregated planning level of corporate strategy and the operational, detailed implementation level of business process models. As a "blueprint of how a company does business" (Osterwalder *et al.*, 2005), a business model represents a concept that enables the design and implementation of corporate- and value creation structures.

Against the background of this historical consideration of the term "business model", combined with an analysis of its function in the current competitive environment, the following central definition approaches are to be interpreted. In recent publications, the definitional approaches according to Chesbrough *et al*. (2010), Osterwalder *et al*. (2005) and Teece (2010) receive particular attention. Within their metamodels, the authors describe individual components and entities of a business model. According to Chesbrough *et al.*

(2010) a business model articulates a company's value proposition, identifies market segments and specifies mechanisms for revenue generation, defines the structure of the value chain, determines cost and revenue structure, describes the company's competitive position, especially in relation to suppliers and partners, and formulates a competitive strategy to defend or expand the current competitive position. According to Osterwalder *et al.* (2005) a business model is a conceptual tool that contains a set of elements and their relationships. It expresses the business logic and provides a description of the value that a company conveys to customers within specific market segments. It describes the architecture of the company and its network for creating, marketing, and delivering the corporate value proposition and specifies mechanisms for generating sustainable revenue. Teece (2010) characterizes a business model as describing the design and architecture of value creation, value delivery, and value capture. The core function of a business model is to specify and bring together customer needs and willingness to pay. Through the right design of business activities and the appropriate construction of the value chain, payment flows are to be converted into profits.

Within a synergetic consideration of the definitions of the business model concept given, a working definition can be cited as a foundation for the further course of the investigation: The business model is a simplified and aggregated representation of the relevant activities of a company. It describes how marketable information, products and/or services are generated with the help of the value creation components of an enterprise (Wolf *et al.*, 2016), consequently, how an organization creates, conveys, and captures value (Osterwalder *et al.*, 2005). Thus, a business model is not to be understood exclusively as a strategic plan, in order to represent a theoretical business system, but as an integrative reference framework, in order to represent apart from creation of value principles also the enterprise organization, structures, processes and interactions, with reference to the enterprise environment.

Digitization affects almost all areas of the economy and society. Therefore, companies are forced to incorporate digital technologies into their strategy and implement them meaningfully in their business models to generate new value propositions or optimize processes (Bharadwaj *et al.*, 2013). The increasing importance of digital technologies in business implies the need for a deeper investigation of the interplay between value creation and technology.

B. Digital Technology and Its Implications for Business

The digitization of industrial value creation is evoking extensive and disruptive change in manufacturing companies. Consecutively, companies must change their organizational structure, processes, and culture, i.e., the company as a whole. This multidimensional process of change is referred to as digital transformation and presents itself as a difficult and complex undertaking for manufacturing industrial companies (Schuh *et al*., 2018). Digitization is seen as an enabler of new and efficient processes, products, and services. At the same time, digitization is not just about integrating technology into products and systems, but also about organizational and cultural change.

"A successful business model creates a heuristic logic that links technical potential to the realization of economic value" (Otto *et al.*, 2015). Classically, the business model unlocks the latent value of a technology (Chesbrough and Rosenbloom, 2002). However, the nature of digital technologies is fundamentally different from the nature of non-digital technologies (Kallinikos *et al*., 2013). There exist profound research approaches to digital transformation regarding the product (Cooper and Edgett, 2012; Porter and Heppelmann, 2014; Anderl *et al*., 2018), production (Sjödin *et al.*, 2020; Bittencourt, Alves, and Leão, 2021), and logistics dimension (Sternad, Lerher, and Gajšek, 2018). Thus, numerous theoretical and domain specific research contributions can be traced in the current literature. An examination of the practice additionally reveals that there is a high level of expertise in industrial companies e.g., in terms of sensors, actuators, and production technologies (Schuh *et al*., 2020) ("technology as a driving force"). The technological dimension has already been intensively studied. Taking this into account it remains to note that in terms of innovation strategy, digitalization follows "the approach of a technological push that relies on engineering power" (Howaldt, Kopp, and Schultze, 2018). What is consecutive missing is an awareness of business models that build on the intensified use of these technologies ("technology as an enabler"). Thus, "the economic use of these new technological opportunities in a dynamic and uncertain digital world requires companies to implement appropriate business models" (Teece, 2018). The creative leap lies in applying and harnessing a new technology for one's own company to revolutionize the business. The fragmented adoption of new technologies, for example in production, alone is not sufficient to succeed in the digital competitive environment (Anand *et al.*, 2010). Digital transformation requires the far-reaching integration of digital technologies and their adaptation within workflows, business processes and all business model dimensions. However, the identification and development of new value creation mechanisms based on advanced Information and Communication Technology (ICT) ("technology as a lever") is currently not the focus of scientific contributions. In this context, technology does not present itself exclusively as a driver of new value propositions, but in particular synergistically as an enabler of new value creation logics. Furthermore, the process of Business Model Innovation (BMI) in the context of digitalization addresses technology-associated opportunities for value creation and technology-induced changes in industry structures. Technologies and business models prove to be complementary (Chesbrough, 2010). At the same time, the question of how new technologies affect traditional business model patterns is still largely unanswered. The (digital) drivers of BMI remain unexplored.

Fundamentally, digital business models differ significantly from traditional business model concepts (Bharadwaj *et al*., 2013). For the most part, however, there is little knowledge about what constitutes a digital business model and how it can be conceptualized (Bock and Wiener, 2017). According to Veit *et al.* (2014) a business model is digital "when changes in digital technologies trigger fundamental changes in the way business is conducted and revenue is generated".

Bärenfänger and Otto (2015) further characterize a digital business model "as a business model whose underlying business logic consciously takes into account the peculiarities of digitization and uses them profitably". In spite of this, in practice, for the most part, companies have no concrete clues as to how a business model should be designed in the digital era and how established business models can be upgraded in the context of digitalization (Grünert and Sejdić, 2017).

Current research approaches have already addressed these issues and developed concepts for domain-specific business models in Industry 4.0-related areas. However, these approaches are either too general or too specific from the perspective of digital business models in the manufacturing industry. Existing research approaches show strong focus on "born-online" and "e-business" business models (Al-Debei and Avison, 2010). Thus, the current literature is limited to only a subset of digital business models. "Born-offline" business of the traditional, manufacturing sector are partly neglected (Yoo *et al.*, 2010). Against this background, the aim of this research approach is to provide an extended conceptual framework for digital business models and especially to structure the research area. Specifically, the elaboration follows the call for research to identify and investigate components that characterize a digital business model (Bock and Wiener, 2017) and responds to the specific call (Oztemel and Gursev, 2020; Weking *et al.*, 2020; Piller *et a*l., 2022) to provide a taxonomy of business models in the context of Industry 4.0.

Thus, there is a need for clearly constructed and well-defined boundary conditions and further knowledge of cause-effect relationships based on causal mechanisms in order to identify key constructs and their linkage. The technological transformation of production systems has mostly been successfully implemented, but what is missing is a digital upgrade of the business model in order to implement a consistent transformation of the company's own value creation principle. The digital business model concept presents itself as the "missing link between strategy and business process implementation, and its relationship to [ICT] is the key to understanding, designing and using the business models and organization of the future" (Veit *et al.*, 2014). Companies struggle to benefit from insights into the occurrence, interactions, and implications of the digital transformation and to fully penetrate digital business model theory. Without adequate digital business models, companies cannot fully benefit from digitalization.

Basically, the business model concept offers the possibility for a complex and multi-layered description of the structure of a company in a systematic, clear, and condensed way (Eriksson and Penker, 2000). At the same time, the study of digital business models represents a novel undertaking (Veit *et al.*, 2014; Wolf *et al.*, 2016). Thus, "previous research offers little conceptual guidance [...] as to what characterizes a digital business model in general and what distinguishes different digital business models from each other" (Bock and Wiener, 2017). According to Osterwalder *et al.* (2005), the business model represents a blueprint of entrepreneurial activities. However, as shown, both the incidence of light, in the form of digitalization, and the template, the innovation and business model theory, are in a state of change in the digital era. To organize and guide entrepreneurial decisions an appropriate ontology is required. In order to engage this task, the present approach first conducts a structured literature search to systematize the research area and builds up a taxonomy to structure the results.

III. Research Design

The motivation presented above and the resulting objective of this paper focus on the need to solve a real-world problem to enable the development of practical knowledge for designing new approaches. Within this contribution, a systematic literature allows to pre-structure the research area before the application of a taxonomic analysis reveals new insights regarding the implications of digitalization for the design of business models.

A. Related Work

In principle, various research contributions have already applied taxonomies to structure emerging, fragmented research fields in business administration, especially business model research (e.g., Täuscher and Laudien, 2018; Möller *et al.*, 2020; Geske *et al.*, 2021). Recent research contributions have developed taxonomies for domain-specific business models in Industry 4.0-related areas, e.g., for AI business models (Geske *et al.*, 2021), platform business models (Täuscher and Laudien, 2018) or start-up business models in the field of logistics (Möller *et al.*, 2020). However, as previously described, these taxonomies are either too general or too specific from the perspective of digital business models in the manufacturing industry. With this in mind, the goal of this contribution is to provide an expanded conceptual framework for digital business models and to deliver an approach to systematize the research area.

B. Systematic Literature Review

"Classification is critical to understanding objective reality" (Lambert, 2015). The unclear characterization of digital business models limits the comparability and referenceability of future research. For analyzing and developing this "missing link" (Veit *et al.*, 2014) this contribution employees the established guidelines to conduct a systematic and rigorous review (Webster and Watson, 2002) (SLR) of the business model literature with special reference to digital business models in the manufacturing industry (Fig. 1). Thus, a strategy for searching extant literature and a set of study selection criteria was developed and a scheme for documenting, processing, and analyzing selected studies was designed.

In order to pre-structure the research area, first the keywords "digital business model" AND "manufacturing industry", as overarching keywords which are derived from the research questions, as well as associated synonyms and various combinations of terms, were used to search manually leading IS journals (e.g., the journals included in the "AIS Senior Scholars' Basket of Eight) and IS conference proceedings (ICIS and ECIS). Second, similar searches were carried out in popular databases (ScienceDirect and WebOfScience) to enrich the manual search by further sources, focusing on the manufacturing industry. In doing so, the title and abstract were each examined for relevance and conformity with the research objective. In order to examine

driving forces and phenomena at the corporate level, the first step is to take a closer look at the overall network of production and distribution relationships, the characteristic macro environment, and horizontal and vertical dependencies. Examining these elements helps to understand companies more precisely in their situational environment. In the sense of the multidisciplinary and multidimensional research approach of the contribution the next step of the investigation is found in a delimitation of the field of action, connected with the identification of research goals and investigation artifacts. For this purpose, the elaboration uses a bibliometric analysis to create a bibliometric network (Zupic and Čater, 2013). For this a "co-word analysis technique" (Callon *et al*., 1991) was conducted. Afterwards in combination with the design proposal of van Eck and Waltman (2010) a cluster analysis was executed. The goal of this step in the course of investigation is to develop a topology of the scientific research landscape. To reach this ambition, the tool VOSviewer was used, which is the most widely used information visualization software to select the top most keywords used by authors in their papers. Exemplary, Fig. 1 shows the connected network of the most common keywords regarding the overarching keywords "digital business model" and "manufacturing industry" in the database "ScienceDirect".

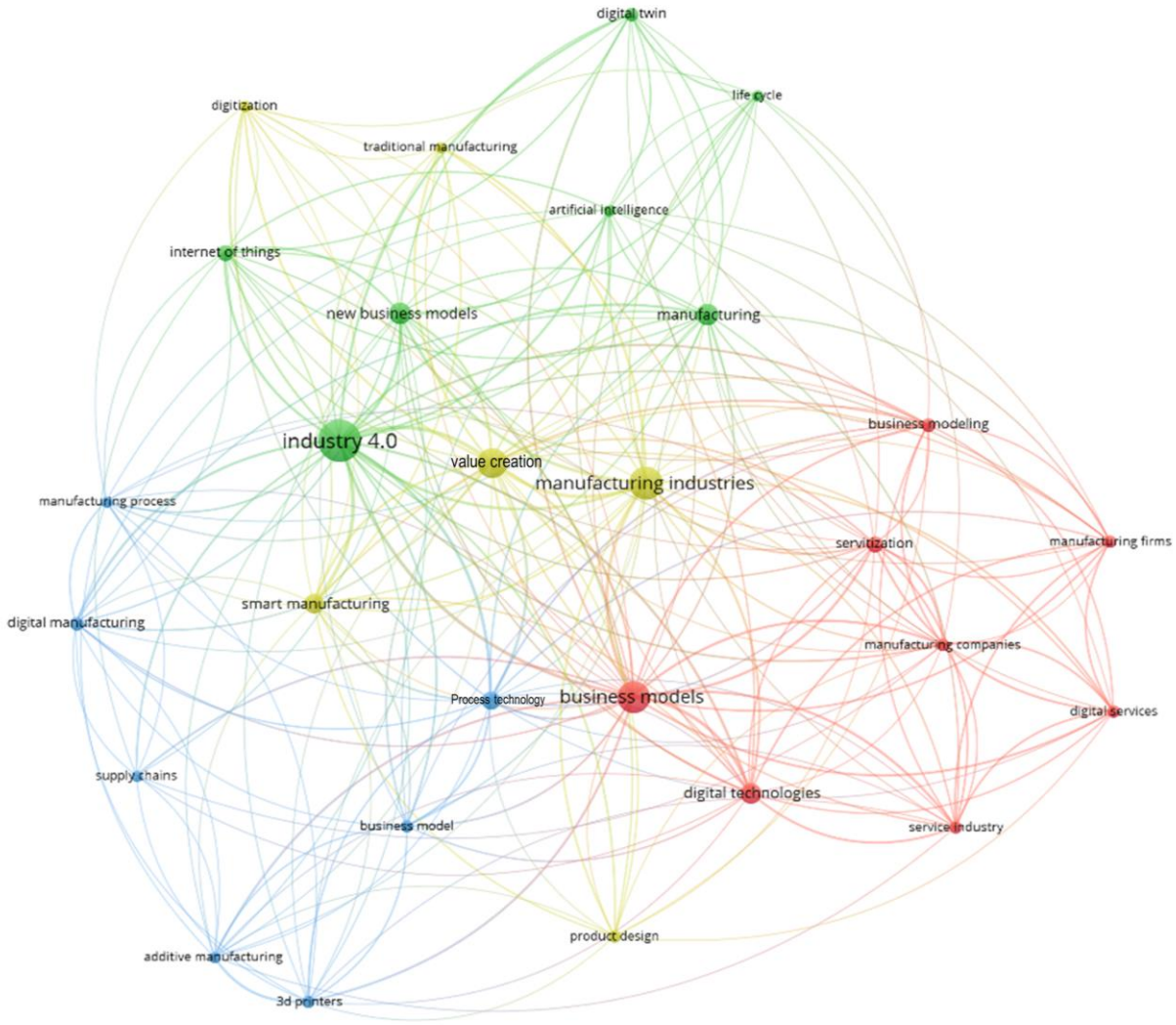

Fig. 1. SLR—Cluster analysis "digital business model" and "manufacturing industry".

In total 68 relevant contributions were identified. Within the contributions, 33 relevant keywords were selected. These keywords can be grouped into four clusters. The red cluster focuses on publications dealing with digital business models in manufacturing firms, especially in the context of servitization. The papers associated with the yellow cluster include issues of the digital transformation in manufacturing firms and focus on the aspect of value creation. The blue cluster aggregates publications dealing with business models based in digital manufacturing process technologies. Lastly, the green cluster represents contributions considering digital business models and the usage of modern ICT.

C. Taxonomy

To analyze the identified contributions Nickerson *et al.*'s (2013) method for taxonomy development was employed (Fig. 2). Taxonomies allow a research field to be organized based on structuring objects and to establish relationships between these objects (Glass and Vessey, 1995). They support the creation of a unifying nomenclature, through the construction of objects and dimensions based on a unified linguistic and definitional foundation. In the context of business model research, taxonomies assist in deriving patterns and clarify components of digital business models.

Taxonomic analysis begins with the establishment and definition of meta-characteristics of the object of study. These meta-characteristics represent the central comprehensive features of the object of study and act as a reference point for developing further, logically resulting features. "The choice of meta-characteristics should be based on the purpose of the taxonomy" (Nickerson *et al*., 2013). Exemplarily, their choice can be based on central theories. Consecutively, this contribution uses the dimensions of the business model definition according to Gassmann *et al.* (2014) "value proposition", "customer", "value chain" and "revenue model", supplemented by a dimension "architecture".

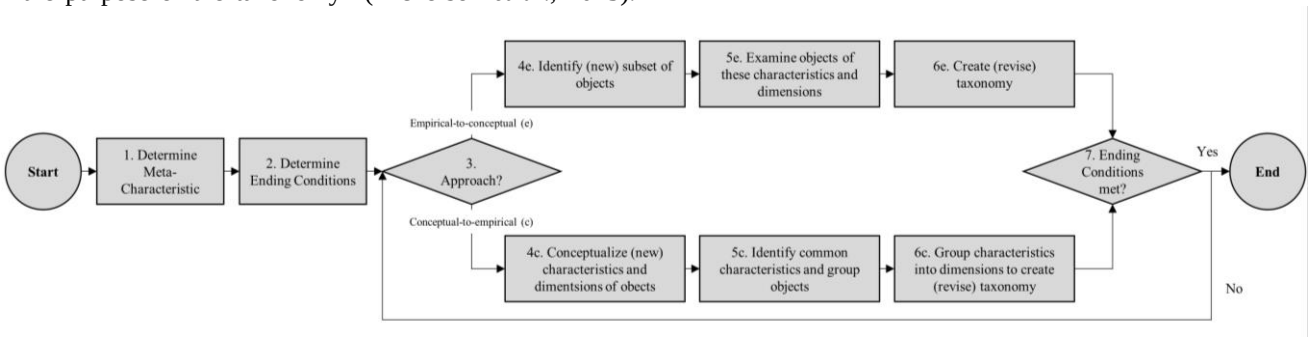

Fig. 2. Taxonomy development according to Nickerson *et al*. 2013.

Meta Dimensions	Dimensions	Characteristics						
Value Proposition	Form	Physical	Digital	Hybrid				
	Product Service-Relation	Product	Product-oriented	Benefit-oriented	Results-oriented	Service		
	Industry 4.0 Maturity Level	Analog	Computerized	Connective	Visible	Transparent	Forecastable	Adoptable
	Modularity	Standard	Variants	Mass Customization				
Customer	Industry Form	Industry-specific	Industry-unspecific					
	Market	Business-to-business (B2B)	Business-to-customer (B2C)	Other				
	Market Structure	One-sided-market	Two-sided-market	Multi-sided-market				
Value Chain	Role	Orchestrator	Integrator	Service Providers and Supporters	Intermediary			
	Key Partner	Intra-Industry Parnetships	Partnerships outside the Industry	Customer	None			
	Interaction Type	Collaboration	Coopetition	Competition				
	Integration	Horizontal	Vertical	Horizontal and Vertical	None			
	Network Effects	Strong	Medium	Weak	None			
	Resources	Tangible	Intangible	Hybrid				
	Governance	Openness	Gatekeeping	Process	Metrics	Relational Control		
Revenue Model	Sales Model	Sale	Rental / Leasing	Licensing	Pay-per-use	Subscription	Broker Fee	Freemium
	Pricing	Effort-based	Market-based	Value-based				
	Earnings Effect	Economic of Scope	Economies of Scale	Economies of Scale and Scope	Other			
Architecture	Organizational Change	Product / Service Expansion	New Product / Service Line	New Department	Spin-off			
	Innovation Type	Evolution	New for the Company	New for the Industry				
	Platform	Transaction Platform	Innovation Platform	Integrated Platform	Investment Platform			

Fig. 3. Taxonomy of digital business models.

Building on these Meta-Characteristics (MD), further Dimensions (D) and Characteristics (C) are identified and grouped. Since the method is characterized by an iterative approach, ending conditions have to be defined. These conditions are both objective and subjective in nature. Nickerson *et al*. (2013) suggest concrete ending conditions. Accordingly, from an objective point of view, the investigation is to be terminated if no new features or dimensions have been added, split, or merged during the last iteration and each dimension and feature is unique. Subjective ending conditions are found in the conciseness and completeness. This approach adopts these ending conditions. The actual development of the taxonomy is either through an "empirical-to-conceptual approach", "conceptual-to-empirical approach" or from a combination of both mechanisms. The method of procedure is to be chosen according to data availability and the objective of the analysis (Nickerson *et al*., 2013).

"Theoretical typologies are based on previous theories in economics, strategy research, and entrepreneurship theory" (Lambert, 2015). Along its meta-theoretical approach and the representation of a research-in-progress issue, this elaboration exclusively follows the "conceptual-to-empirical" method and relies on the results of the previous literature review. Going through the research approach iteratively leads to a first and a multitude of revised taxonomy proposals. The development process of the taxonomy is constantly continued until the ending conditions are reached. This elaboration takes up the design proposal of Becker *et al*. (2009) and uses a "bottom-up approach", in the

form of identifying existing taxonomies to business models (Hartmann *et al.*, 2016; Bock and Wiener, 2017; Remane *et al*., 2017; Blaschke *et al.*, 2019; Möller *et al.*, 2019; Möller *et al.*, 2020; Weking *et al*., 2020; Geseke *et al*., 2021; Kreyenborg *et al.*, 2021; Staub *et al*., 2021 among others) their synergization, enhancement and extension, to include insights and aspects of digital business models. Specifically, a first iteration was dedicated to the harmonization and synthesis of existing taxonomies under the target reference of the digitalization in the manufacturing industry. The following iteration steps incorporated the findings of the elaboration on current developments in technology and innovation management as well as in digital business model theory. The final presentation of the taxonomy (Fig. 3) takes the form of a creative heuristic representation based on the principle of the morphological box (Zwicky, 1962).

The derived taxonomy consists of the five meta-dimensions: "Architecture", "Value Proposition", "Customer", "Value Chain", "Revenue Model" and 20 derived dimensions, with a minimum of two and a maximum of seven characteristics. The 20 dimensions show the key characteristics of digital business models in the manufacturing industry. Along the bottom-up approach and incorporating the results of the previous course of investigation, not every characteristic of the taxonomy is new to the existing research landscape. However, only its synergistic, integrative consideration within this taxonomy enables an analysis and structuring of digital business models in the era of digitalization. Moreover, as called for by Nickerson *et al.* (2013), the taxonomy developed is characterized by conciseness. For reasons of comprehensibility and transparency, the taxonomy contains only a limited number of terms and characteristics. Since this is a research in progress contribution, it is limited to a brief presentation of the interim status with regard to the identified dimensions and characteristics. A detailed analysis of the components is the subject of future planned research.

Value Proposition (MD1)—The "Value Proposition" meta-dimension is the "starting point for any business model" (Bouwan *et al*., 2018). Consequently, the value proposition is the central dimension of a variety of business model concepts (Chesbrough and Rosenbloom, 2002; Osterwalder *et al*., 2005). The value proposition consists of a bundle of products and/or services and represents the sum of all benefits the customer draws from the product or service. In the context of digitalization, this value proposition is mostly based on the use of digital technologies. The dimension of the "Value Proposition" stands in the context of the digitized macro environment under the coinage of digital "value realities" (Keen and Williams, 2013). Basically, the digitized value proposition can be distinguished along the dimension "Form" (D11) based on its physical character into the characteristics "Physical", "Digital" and "Hybrid". Furthermore, there is a tendency from the transition of a product-dominated business model to solution-based models (Kohtamäki *et al.*, 2019). Previous research contributions differentiate between "Product, Service or Product-Service-System (PSS)" (Woodruff, 1997). This elaboration follows the deeper subdivision according to Kreyenborg *et al*. (2021). Thus, a value proposition can be differentiated in the dimension "Product Service Relation" (D12) into the characteristics "Product", "Product-oriented", "Benefit-oriented", "Result-oriented" (Tukker, 2004) and "Service". In terms of the Industry 4.0 Maturity Index (Schuh *et al.*, 2020) (D13), the characteristics "Analog", "Computerized", "Connective", "Visible", "Transparent", "Predictive" and "Adaptable" can be identified. Value propositions in the digital environment are mostly created within ecosystems. For this reason, the "Modularity" dimension (D14) of the value proposition must be taken into account. This dimension represents the connection between the business model core (Hamel, 2000) and possible loosely connected peripheral elements, i.e., to what extent options and variants of the value proposition are provided. The characteristics "Standard", "Variants" and "Mass Customization" can be identified.

Customer (MD2)—In digitalized environments, the tendency of the transition of a product-dominated business model to solution-based models can be highlighted. Effective value creation activities are based on a profound understanding of customers, their reality of life and in part still untapped problems. Direct customer orientation can be identified as a central driving force behind BMI and makes a decisive contribution to success (Becker *et al*., 2011). The "main focus [must be] on serving the customer in the best possible way" (Wagner *et al*., 2015). Consecutively, it is first essential to narrow down the relevant customer group and characterize it in more detail. The dimension "Industry Focus" (Geske *et al.*, 2021) (D21) determines whether the business model concentrates exclusively on a certain industry or is applied across industries. Building on this, the "Market" dimension (D22) subdivides the industry structures along the generic market distinctions into the characteristics "Business-to-business" and "Business-to-customer" (Morris *et al.*, 2005) and "Other". The dimension "Market Structure" (D23) considers the emerging network effects and represents the characteristics "One-Sided-Market", "Two-Sided-Market" (Rochet and Tirole, 2003), "Multi-Sided-Market" (Rochet and Tirole, 2005) and "Other".

Value Chain (MD3)—The "Value Chain" meta-dimension refers to the key resources behind the value proposition, the core competencies required, and provides an overview of partners and suppliers (Gassmann *et al.*, 2013). It represents the totality of all actors related to the creation of the value proposition and forms the technological and organizational infrastructure to deliver products and services (Al-Debei and Avison, 2010). With regard to the digitized macro-environment, a shift away from rigid, linear value chains towards network-like, collaborative forms of value creation in ecosystems is emerging. In traditional product-based business models, central value-creating activities are mostly described along a value chain (Porter, 1985). Consequently, the value chain concept is focused on a physical, analog industry environment. However, the digital macro-environment is dynamic and characterized by actors competing and cooperating simultaneously. The business model in the age of digitization represents an "activity system" (Zott *et al*., 2011). This resulting value network is classically characterized by complex, dynamic exchange processes between companies, customers, suppliers and strategic partners. Within the "Role" dimension (D31),

companies in digital value creation systems assume the function of "Orchestrator", "Integrator", "Service Provider and Supporter", or "Intermediary" (Weking *et al.*, 2018). "Key Partners" (D32) can be found in "Intra-Industry Partnerships", "Non-Industry Companies and Individuals", or the "Customer" (Weking *et al.*, 2018). The different actors of the value creation system can thereby, within the dimension "Interaction Type" (D33), take on the characteristics of "Collaboration", "Competition" (Staub *et al.*, 2021) as well as "Coopetition" (Brandenburger and Nalebuff, 2008). Another central phenomenon in the context of value creation in the digital environment is found in the form of the integration of the value chain. This "Integration" (D34) can be expressed by the characteristics "Horizontal", "Vertical" (Staub *et al.*, 2021) and "Horizontal and Vertical" and describes the merger of serval companies of the same production stage or/and different production stages. The dimension "Network Effects" (D35) describes the intensity of the prevailing connection of actors and the resulting network externalities. Strong network effects describe an increasing benefit from a value proposition for an actor if a large number of other actors also use the value proposition, weak network effects vice versa. Companies need "Resources" (D36) to create value (Wernerfelt, 1984). These resources can represent classic physical, "Tangible", objects, represent digital, "Intangible" input factors or take "Hybrid" forms. Tangible resources can be differentiated into the classic production factors "Labor", "Land", "Capital" (Say, 1821). Digital inputs are subdivided into "Data" and "Information/Knowledge" (Fayyad *et al*., 1996). Finally, the "Governance" dimension (D37) examines the "accessibility" (Staub *et al*., 2021) of a value network. Affiliated characteristics describe the design of a control system (Tiwana, 2014) to manage the value creation process in the ecosystem and to balance openness and control between different stakeholders. Governance represents the "core to manage the interaction between the parties involved in a platform" (Schreieck *et al.*, 2018). Governance mechanisms are consequently "all activities and processes by which [...] actors in the [value creation system are controlled]" (Tiwana, 2014). Tiwana (2014) distinguishes in this regard into the characteristics "Openess", without special regulations, "Gatekeeping", assessment of requirements and conformity, "Process", execution of an evaluation process, "Metrics", comparison with an expectation horizon and "Relational Control", comparison with standards and values.

Revenue Model (MD4)—The "Revenue Model" meta-dimension describes value capture, i.e., how a company generates revenue from the value it creates. It takes into account both revenue streams and cost structure (Al-Debei, El-Haddadeh, and Avison, 2008). The affiliated dimension "Revenue Model" describes the way in which a company generates its income. The characteristics according to which payment streams can be generated (Osterwalder *et al*., 2005; Hartmann *et al.*, 2016). "Sales Model" (D41) refers to the exchange of ownership of a product for a monetary payment. "Rental/Leasing" describes the granting of temporary rights to use a product. "Licensing" embodies the granting of permission to use protected intellectual property in exchange for a fee. A usage fee ("Pay-per-use") is incurred per use of a service. Furthermore, a "Subscription" model can be focused or a "Broker Fee" may be charged for an intermediate service (Hartmann *et al.*, 2016; Schuh *et al*., 2022). "Freemium" refers to the free provision of a basic service combined with chargeable additional services. The dimension "Pricing" (D42) indicates different characteristics for pricing the created added value. Either the pricing can be "Effort-based", "Market-based" (Möller *et al.*, 2019) or "Value-based" (Häckel *et al.*, 2021) based on the resources used or on the added value created for the customer. Finally, the dimension "Revenue Effects" (D43) determines possible effects occurring with regard to "Economies of Scope", "Economies of Scale", "Economies of Scale and Scope", or "Other" effects.

Architecture (MD5)—Its design determines the external appearance, influences functionality and assembles individual components. The "Architecture" meta-dimension follows the idea that BMI "represents novel, non-trivial changes to the key elements of an organization's business models and/or to the architecture that connects those elements" (Foss and Saebi, 2017). The previously explained meta-dimensions are connected within this taxonomy "via an architecture" (Saebi *et al*., 2016). This architecture reflects the overarching design of the value creation process (Teece, 1996). Thus, the architecture represents potential trajectories for the development of a value creation system. Within this taxonomy, the "Architecture" meta-dimension serves as the integration layer of the digital business model meta-dimensions. The dimension "Organizational Change" (D51) describes the anchoring of the business model in the organizational and operational structure and can assume the characteristics "Product/Service Expansion", "New Product/Service Line", "New Department", "Spin-off". Additionaly the "Innovation Type" (D52) deploys the digital business model and in industry landscape and can be characterized as "Evolution"m "New for the Company", or "New for the Industry". Specifically, this dimension is interpreted as "linking architecture that connects the business model components" (Weking *et al*., 2018). Consequently, the "Platform" dimension (D53) grounds the taxonomy of digital business models in the characteristics of "Transaction Platform", with focus on a suitable environment for products and services, "Innovation Platform", to focus joint innovation activities "Integrated Platform", a combination of transaction- and innovation platforms and "Investment Platform", as an instrument to implement a platform portfolio strategy (Hein *et al.*, 2020).

Taking this results into account, it remains to be notice that the integration of digitalization into the area of business model research leads to the emergence of the term digital business model. In principle, the digital business model term follows, at a high level of abstraction, existing and profound business model definitions (e.g., Osterwalder *et al.*, 2005; Chesbrough, 2010; Teece, 2010). As the SLR and cluster analysis indicates, in the context of the manufacturing industry a digital business model is mainly focused on an increased use of digital technologies in a company's business logic (Otto *et al*., 2015). As shown the individual superordinate components of a business model, i.e., the "meta-characteristics", are not necessarily new in the research landscape. However, the use of digital technologies has a significant impact on their characteristics. For example,

the taxonomy emphasis on the evolution of value propositions through the increased embeddedness of digital technologies in physical products (Porter and Heppelmann, 2014) or the transition of value creation mechanisms from linear, rigid value chains towards agile value creation networks. Thus, the taxonomy offers a more detailed perspective of digital business models in the manufacturing industry through highlighting focal dimensions in which companies make use of digital technologies to create, deliver and capture value.

IV. Conclusion and Derived Need for Research

A. Summary

Through the application of the taxonomy development method by Nickerson *et al*. (2013) a taxonomy for digital business models in manufacturing industry was developed. This approach serves as a reference architecture that creates orientation for the development of systems, solution, and application architectures. It provides consistent definitions of systems, decompositions, and design mechanisms, as well as a common vocabulary to discuss specifications of implementations. In summary, this taxonomy of digital business models represents a meta-theoretical framework in order to systematize the research area. For ease of understanding, the model contains a limited number of terms and characteristics and can consequently be described as concise and practicable.

B. Implications and Outlook

From the results serval implications for theory and practice can be drawn. Regarding scientific contributions, the contribution addresses the lack of systematic tools for digital business model development, e.g. (Gassmann *et al*., 2013). In this context, the digital business model concept presents itself as a "missing link between strategy and business process implementation" (Veit *et al*., 2014). This contribution confirms existing business model frameworks take insufficient account of the complexity and specific characteristics of digitalization (Weking *et al.*, 2018). In this regard, Lambert (2015) refers to the importance of appropriate classifications for business model research and calls for further research approaches. "A good classification scheme [forms] the basis of theory development" (Lambert, 2015). Similarly, this work notes that current business model concepts are based on dividing the business model into certain components, e.g. (Osterwalder *et al.*, 2005; Gassmann *et al*., 2013). In the context of digitalization and the increasing usage of digital technology in the manufacturing industry a crucial challenge results: "When the number of components explodes, the greatest difficulty is to identify which combinations of them are of value in each case [...]" (Amshoff *et al*., 2015). Building on the high level of abstraction of the business model definition according to Gassmann *et al*. (2013), this thesis develops a contextual reference model in the form of a taxonomy of digital business models in the context of the analysis and classification of industrial value creation systems. This taxonomy provides the research area with the required "common ground" for focusing further research initiatives e.g. (Suddaby, 2010; Amshoff *et al*., 2015; Weking *et al*., 2020; Anthony *et al*., 2021; Schuh *et al.*, 2022). Based on this "common language", the taxonomy facilitates the comparability and synthesis of existing and future research results and serves in this context as an instrument for reducing complexity.

As for managerial contributions, the developed taxonomy addresses the lack of guidance for BMI in the context of digitalization. The developed taxonomy shows fields of action for the design of digital business models and delivers generic components that characterize a digital business model. As a simplified representation of reality, the model is intended to help minimize the cognitive demands on decision makers and overcome application difficulties with regard to the missing structuring of the field of action.

As noted by Nickerson *et al.* (2013), taxonomies are never perfect, but exist to provide an appropriate solution in a given context. The approach is, naturally, limited by a number of limitations that must taken into account when interpreting the results. Due to the meta-theoretical research in progress approach of this elaboration, the present taxonomy development exclusively uses a "conceptual-to-empirical approach" and thus exclusively derives inductively knowledge. The dimensions and characteristics identified can be explained in depth, verified, validated and, if necessary, expanded deductively through further research initiatives in the form of an "empirical-to-conceptual approach". Theoretical classifications can thereby be enriched, for example, through the construction of empirical case studies. From these limitations, the need for new research approaches can be derived. Existing business models can mostly be reduced to certain patterns (e.g., Gassmann *et al.*, 2013). The present reference model, in the form of the taxonomy of digital business models, can serve as a starting point for developing digital business model trajectories and structuring digital business models into archetypal clusters.

The present structured literature review, in conjunction with the development of a taxonomy, fundamentally strengthens the conceptual basis for further investigation of the digital transformation of industrial value creation. Classifications open up the possibility of organizing abstract, complex concepts. Rich taxonomies are the basis for theory development (Doty and Glick, 1994). Consequently, the present research approach provides a solid and promising basis for conducting further qualitative and quantitative research initiatives.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

G. Schuh, M. Riesener, M. Kuhn, and S. Schümmelfeder, conducted the research and analyzed the data. S. Schümmelfeder wrote the paper. All authors had approved the final version.

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