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Supporting Data-Driven Business Model Innovations A structured Literature Review on Tools and Methods

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Abstract

Purpose: This paper synthesizes existing research on tools and methods that support data-driven business model innovation, and maps out relevant directions for future research.

Design/methodology/approach: We have carried out a structured literature review and collected and analysed a respectable but not excessively large number of 33 publications, due to the comparatively emergent nature of the field.

Findings: Current literature on supporting data-driven business model innovation differs in the types of contribution (taxonomies, patterns, visual tools, methods, IT tool and processes), the types of thinking supported (divergent and convergent) and the elements of the business models that are addressed by the research (value creation, value capturing and value proposition).

Research implications: Our review highlights the following as relevant directions for future research. Firstly, most research focusses on supporting divergent thinking, i.e. ideation. However, convergent thinking, i.e. evaluating, prioritizing, and deciding, is also necessary. Secondly, the complete procedure of developing data-driven business models and also the development on chains of tools related to this have been under-investigated. Thirdly, scarcely any IT tools specifically support the development of data-driven business models. These avenues also highlight the necessity to integrate between research on specifics of data in business model innovation, on innovation management, information systems and business analytics.

Originality/Value: This paper is the first to synthesize the literature on how to identify and develop data-driven

business models, and to map out (interdisciplinary) research directions for the community.

Introduction[1]

Big data and analytics have a transformative aspect in many of today's business models (BMs) (Loebbecke and Picot 2015; Woerner and Wixom 2015) and facilitate the potential for further business growth (Seiberth and Gründinger 2018). A significant portion of companies report to have started investing in innovations based on data and analytics (Gottlieb and Rifai 2017). Empirical research, however, shows that companies mostly utilize big data and analytics for internal optimization (Schüritz and Satzger 2016; Zolnowski et al. 2016).

Simultaneously this field is a very challenging one for traditionally offline established organizations to realize value for their customers and innovate their BM through the use of data and analytics (Schüritz et al. 2017c). Organizations and managers find it difficult to systematically identify relevant opportunities for data as core elements of their business, as well as how to systematically proceed with evaluation, decision-making, and ultimately implementation of the new BM. Nevertheless, there is consensus on the potential of data analytics for new business opportunities. Further, publicly known examples for successful data-driven business models (DDBMs) that could serve as inspiration or blueprint are centred to a great extent on global giants such as Google, Facebook, or Uber. As traditionally offline established organizations differ from these companies, such that inspiration one may gain from those global giants needs significant re-thinking before it can be usefully applied.

The literature recognises and researches tools and methods as support for business model innovation (BMI) processes (Schneider and Spieth 2013). Several established tools and methods already exist, i.e. for designing and evaluating business models (Osterwalder et al. 2014; Osterwalder and Pigneur 2010; Täuscher

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[1] Abbreviations:
BM   Business model
BMI   Business model innovation
DDBM   Data-driven business model
DDBMI   Data-driven business model innovation

and Abdelkafi 2017; Tesch and Brillinger 2017). However, the development of DDBMs requires attention to data as key resource and data analytics as key activities. Thus, in addition to such established generic tools and methods, supporting innovation tools and methods that incorporate the perspectives of data and analytics are required to support traditional offline established organizations. Consequently, in the present paper we ask what prior knowledge is available about tools and methods that incorporate data as a lens of analysis for business model innovation?

We answer this research question with a structured literature review. In this paper we structure existing knowledge from previous research on data-centric tools and methods, identify under-researched fields and provide directions for further research. With respect to literature reviews on tools and methods in BMI in general (for example visual languages for BMs (John et al. 2017), visual tools (Täuscher and Abdelkafi 2017) or evaluation aspects in business model innovation (Tesch and Brillinger 2017)), the present literature review takes the complementary perspective of focusing on data as a lens of analysis in business model innovation. With respect to research on data-driven business models, this review complements existing reviews such as how to realize value with big data (Günther et al. 2017), digital service innovation enabled by big data analytics (Rizk et al. 2017) or data-driven service innovation (Engel and Ebel 2019) by focussing on the aspect of the process of innovation.

The remainder of this paper is structured as follows: Section two provides the conceptual background on tools and methods for business model innovation as well as existing literature on data and analytics enabled business model innovation. Section three follows with a description of the process for the structured literature review. The findings of the review are structured in section four by the concepts *type of contribution*, *type of thinking supported* and the *business model elements studied* in each paper. Subsequently, section five discusses the review and gives an outline for further research. Section six points out the limitations of this research. The paper closes with a conclusion and a

statement on the implications of this research in section seven.

Background and Related Work

Tools and methods in business model innovation

The concept of business models has gained significance in recent years in several disciplines, as information systems (Al-Debei and Avison 2010; Veit et al. 2014), technology and innovation management (Björkdahl 2009; Chesbrough and Rosenbloom 2002; Wirtz et al. 2016) as well as strategic management (Magretta 2002; Wirtz et al. 2016; Zott and Amit 2008). From a widespread high-level view, business models describe how organizations create and capture value (Osterwalder and Pigneur 2010) and explain "how the pieces of a business fit together" (Magretta 2002). With the boom of the internet, an increasing number of companies have thought about innovating their business model in order to keep up with trends such as e-commerce. The business model emerged from a vehicle for innovation in order to commercialize new technologies towards a source of innovation, emerging as a source of competitive advantage (Massa and Tucci, 2013). Skarzynski and Gibson (2008, p. 111) define BMI as "creating fundamentally new kinds of businesses, or about bringing more strategic variety into the business you are already in" (Skarzynski and Gibson 2008, p. 111). Thereby, BMI can be seen as a *process* "the activity of designing - that is, creating, implementing and validating - a new BM" (Massa and Tucci 2013, p. 420). Thus, BMI can be perceived as a creative and collaborative task (Ebel et al. 2016; Eppler et al. 2011). BMI processes can serve as a procedural framework or guidance to structure BMI initiatives (Wirtz and Daiser 2018). Besides the process-oriented view, BMI is also treated as a *result*, the replacement of the existing BM of the company (Mitchell and Coles 2003). In this research paper, we consider BMI from the process perspective, i.e. the activity of designing BMs, as we aim to analyse tools and methods that aim to support that process.

Within the BMI process, individuals and organizations can be supported by different tools and methods (Schneider and Spieth 2013). A *method* is a systematic development approach that follows specific rules, whereas a *tool* supports a part of a development process (Brinkkemper 1996). Tools and methods are used in BMI for idea generation (Eppler et al. 2011) as well

as evaluation and decision making (Tesch and Brillinger 2017). These two opposed activities in BMI relate to the concepts of *divergent* and *convergent thinking* (Kim and Pierce 2013) - on the one hand seeking for alternatives and multiple solutions and on the other hand deciding on the best possible solution.

Tools and methods address specific business model elements or support the BMI process in general. A broad range of tools and methods incorporate all elements of an underlying business model ontology, such as the business model canvas (Osterwalder and Pigneur 2010). Besides, other tools and methods may also incorporate a view on a specific element of the business model, like the value proposition (Osterwalder et al. 2014) or revenue models (Envision 2016).

Several different types of tools and methods are available that support BMI in general: *Visual representations* are one key approach in designing and analysing business models (Täuscher and Abdelkafi 2017). Visual representations support understanding and communicating a firm's business model (Eppler et al. 2011; Osterwalder 2004), support generating and developing new business model ideas (Gassmann et al. 2014; Osterwalder and Pigneur 2010), overcoming organizational innovation barriers (Eppler et al. 2011) or stimulate collaborative innovations (Täuscher and Abdelkafi 2017). Visual representations can incorporate a transactional, a causal and/or a component-based view (Täuscher and Abdelkafi 2017). Furthermore, component-based views are based on ontologies or frameworks (Osterwalder 2004; Osterwalder and Pigneur 2010). *Taxonomies* and morphological boxes of business models from a certain domain list the most relevant dimensions and characteristics of business models and enable the classification of existing business models (Remane et al. 2016). *Business model patterns* describe recurring configurations of certain business model elements (Gassmann et al. 2014) and support idea generation and evaluation via learning from analogies (Gassmann et al. 2014). BMI can also be supported by *software tools* for developing and managing business models (Veit et al. 2014). These tools enable users to digitally represent and change business models and make the process more efficient (Szopinski et al. 2019). Likewise, software tools allow

additional actions like collaborative business model development in distributed teams (Ebel et al. 2016). In summary, tools and methods are relevant and are needed to support BMIs; but specific tools and methods for *data-driven business model innovation* (DDBMI) exist. A systematic synthesis and discussion of such specifics, and gaps in knowledge regarding specific tools and methods for DDBMI is missing to date, and provided in this paper. The existing literature on tools and methods for BMI provides an analysis framework and different viewpoints for identifying and analysing data-related innovation tools and methods for DDBMI in this literature review.

Business model innovation enabled by data and analytics

One important driver for BMI is the increasing amount of data and the advances in analytics. The literature reveals two opposed courses for data-driven business model innovation: refining and improving existing business models with data, and designing totally new business models (Günther et al. 2017; Woerner and Wixom 2015). Besides that, the impact of big data and analytics on business models is highlighted by scholars from different perspectives: Data and analytics is used to enhance decision-making and to improve internal processes (Wixom and Ross 2017); data-as-a-service and analytics-as-a-service as two service-oriented paradigms (Chen et al. 2011); the enrichment of existing core offerings with analytics (Davenport 2013); selling data and information (Wixom 2014; Wixom and Ross 2017); the development of analytics-based products (Davenport and Kudyba 2016); data-driven service innovation (Engel and Ebel 2019); and data-driven business models (Hartmann et al. 2016). Likewise, empirical research shows that data and analytics enable continuous options for organizations in BMI (Schüritz and Satzger 2016).

In line with recent publications, a data-driven business model encompasses the following main characteristics: data is used as a key resource (Engelbrecht et al. 2016; Hartmann et al. 2016), data analytics key activities generate customer value from data (Hartmann et al. 2016; Wixom and Schüritz 2017), data or information is part of the value proposition (Hartmann et al.

2016; Kühne and Böhmann 2018) and can be monetized (Seiberth and Gründinger 2018; Wixom and Ross 2017). In this paper, we understand DDBMI as *the process when an organization adopts a novel approach to commercialize data as its new underlying asset to deliver value to existing or new customers* (Gambardella and McGahan 2010; Hartmann et al. 2016; Seiberth and Gründinger 2018). In other words, we understand DDBMI as the change of the value proposition due to the effect of data and analytics (Schüritz et al. 2017c). This process is different in offline established organizations, than it is for Start-Ups, or genuinely online organisations such as the well-known global disruptors Google, Amazon or Uber. Following existing literature on general BMI, tools and methods can support the innovation process. However, beside generally applicable tools and methods for BMI (as shown in previous subsection), organizations require specialized or adopted tools and methods that incorporate the specific characteristics of DDBMs, like data as key resource or data analytics as a key activity. Knowledge on such specific tools and methods has to date not been systematically synthesised and discussed; doing so is the overall contribution of this paper.

Methodology

In order to identify existing research on tools and methods that incorporate data as a lens of analysis and innovation for business models, we conducted a structured literature review adopting the general methodology of Webster and Watson (2002) and the rigorous procedure that Vom Brocke et al. (2009) propose for identifying relevant articles. The following subsections describe the search and selection as well as the analysis and synthesis of relevant literature in detail.

Search and selection process

In order to ensure reproducibility and transparency of the process of searching and selecting relevant literature, we describe the five sequential steps in this subsection.

Step 1 - Initial search: We started the initial search within the AIS Electronic Library using the keywords "business model" AND ("big data" OR "data-driven" OR

"data analytics") to gain an overview of the research field of from an information system perspective, which is described in the background section.

Step 2 - Definition of databases: To identify relevant publications, we conducted a keyword search in the following databases: AIS Electronic Library, Google Scholar, IEEE Xplore, Science Direct, Scopus and Web of Science to cover research from the field of information systems, computer science and innovation and technology management. We did not set a filter by published year due to the infancy of the topic. Publications issued by May 2019 were considered.

Step 3 - Key word search: The selection of the search strings was initially based on first insights on the topic as shown in step 1. As the topic of DDBMI is still in its infancy, we extended the search focus to additional keywords to obtain more results, as publications may incorporate data as a central element, without directly mentioning the phrase "data-driven business model". As we are interested in identifying publications that provide knowledge about tools and methods with data as a central element to support DDBMI in organizations, we used a broad range of keywords to identify innovation tools and methods. We defined the first set of search strings as "tool" OR "method*" OR "canvas" OR "map" OR "process" OR "framework" OR "visualization" based on the conceptual background on tools and methods for business model innovation. In addition, to find tools and methods with a business model and data aspect focus, we defined ("business model" AND ("data analytics" OR "data-driven" OR "data-based")) OR "data-driven service" as the second set of search strings based on the conceptual background on business model innovation enabled by data and analytics; both combined with the logical operator AND. For the search base Google Scholar we used the search string "data-driven business model".

Step 4 - Literature evaluation: The keyword search resulted in a total set of 11443 articles from five databases. To limit the papers to be considered within a manageable size, the first 200 results were examined for each database, through sorting the results by number of citations (or by relevance, if sorting by citations was not offered by the individual search database) to capture the most relevant papers. Our selection process

involved two stages. In the first stage, papers were judged based on their title, abstracts and keywords. The remaining papers were judged by reading the full text, resulting in 37 articles. We included publications that comply with the following criteria: publication that have business model focus or at least one aspect of the business model, like value creation or value proposition; and that have at least a partial focus on data or analytics; and that describe tools and methods with data as a significant focus supporting the innovation processes; and that are available either in English or German. We restricted the keyword search to peer-reviewed publications. In the forward and backward search as well as the list of promising authors we also included non-peer-reviewed publications, such as working papers. In the next stage, numerous duplicates were identified and deleted, leading to 24 relevant articles.

Step 5 - Forward and backward search and reviewing authors publication lists: A subsequent forward and backward search (Webster and Watson 2002) performed through Google Scholar and Web of Science provided an additional set of 5 articles using the same evaluation criteria as stated above. Moreover, we looked up publication lists of the authors identified in the previous steps (Schryen 2015), leading to an additional set of 4 publications. Finally, the search and selection process resulted in a total number of 33 articles.

As shown in Figure 1, the final set of papers to review was found to be published between 2015 and 2019. We observed an increasing publication frequency over the years, except for the year 2019, where we covered
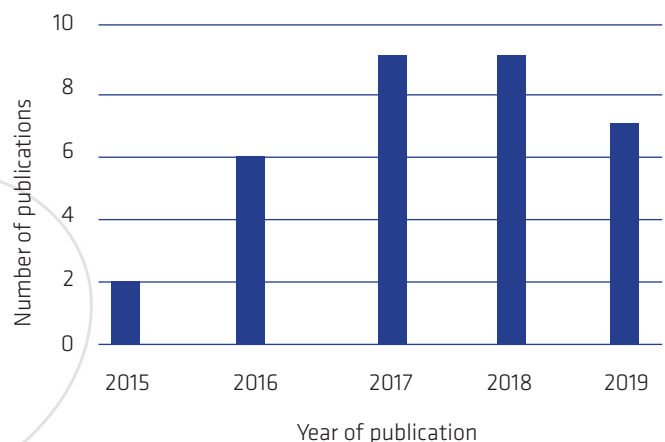

Figure 1: Descriptive analysis of selected literature due to publication year.
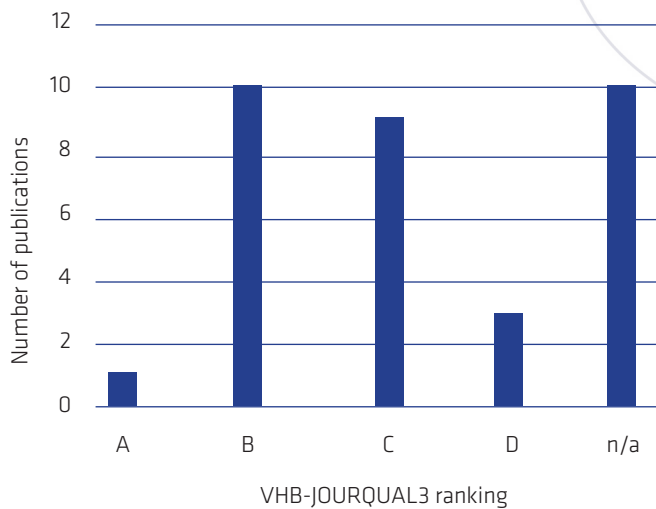
Figure 2: Rating of selected publications according to VHB-JOURQUAL3 ranking.

publications only for the first 5 months. Figure 2 shows the rating of the selected publications according to VHB-JOURQUAL3[2].

Analysis and synthesis process

The aim of the analysis and synthesis step is to summarize and analyse existing research on tools and methods supporting the process of DDBMIs and to identify gaps in the literature. In this regard, the 33 relevant papers are analysed from a concept-centric perspective, as recommended by Webster and Watson (2002). Concepts serve as the organizing framework of the review to synthesize and discuss the literature in the context of each concept as well as for identifying patterns and gaps (Vom Brocke et al. 2009; Webster and Watson 2002). Thus, a concept matrix is created from the literature search results. The concept matrix contains the identified papers in one dimension and the concepts and their characteristics in the other. The concepts we used are the main research question or research goal; the research method of the article; the type of contribution; the type of thinking supported by each tool or method; and the core business model element(s) the article is focusing on.

The type of contribution describes the type of tool or method presented in the research. Categories of this

concept were developed by an inductive approach informed by the literature on tools and methods for BMI (see background section). The type of thinking says what type of cognitive approach in the sense of convergent vs. divergent thinking (Kim and Pierce 2013) the artefact supports, which relates to the activities of ideation and evaluation in BMI. Element of the business model says on what core elements of a business model the article is focusing on. The corresponding categories are value creation, value proposition and value capturing, derived by a deductive approach from existing business model research (Gassmann et al. 2014; Johnson et al. 2008; Osterwalder and Pigneur 2010).

The goal of the concept matrix is on the one hand to derive the distinct perspectives on tools and methods for DDBMI. On the other hand, sparse parts of the concept matrix demonstrate under-researched fields, thus providing avenues for further research (Vom Brocke et al. 2009). In order to show directions for future research, we identify missing or neglected themes in what has been researched, what Alvesson and Sandberg (2011) call gap-spotting.

Results and findings

Table 1 gives an overview over all 33 publications that are included in this literature review and shows how existing work differs significantly across the three concepts 'type of contribution', 'type of thinking supported' and 'element of business model'. The following subsections below synthesize research with respect to the core elements of this concept matrix.

Types of contributions

Six types different types of contribution were revealed in the 33 papers that were reviewed: 'taxonomies and frameworks', 'patterns and types', 'visual tools', 'methods', 'IT tools' and 'processes'. *Taxonomies and frameworks* (Bock and Wiener 2017; Engelbrecht et al. 2016; Hartmann et al. 2016; Schmidt et al. 2018) represent a "basis for the analysis and clustering of big data-related business models" (Hartmann et al. 2016, p. 1400) and list the main elements and characteristics of DDBMs.

Business model patterns and types (Förster et al. 2019; Hartmann et al. 2016; Schmidt et al. 2018; Sprenger

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[2] VHB-JOURQUAL3 is a ranking of journals relevant to business research based on evaluations by the members of the German Academic Association for Business Research. For further information see: https://vhbonline.org/vhb4you/jourqual/vhb-jourqual-3/.

Publication	VHB-JOURQUAL3	Type of contribution						Type of thinking		BM element		
		Taxonomy / framework	Pattern / type	Visual tool	Method	IT-tool	Process	Divergent (ideation)	Convergent (evaluation)	Value creation	Value proposition	Value capturing
Agrawal et al. (2018)	C			●				●		●	○	
Benta et al. (2017)	n/a			●			○	●		○	○	○
Bock and Wiener (2017)	A	●						●		●	●	●
Brillinger (2018)	B			○	●				●	○	●	●
Brownlow et al. (2015)	n/a	○			●			●		●	●	●
Enders et al. (2019)	C	●							●			●
Engelbrecht et al. (2016)	B	●						●		○		○
Exner et al. (2017)	n/a	●		●	○			●		●	●	●
Förster et al. (2019)	C		●	○					●	●		
Hartmann et al. (2016)	C	●	●					●		●	○	●
Hunke et al. (2017)	n/a						●					
Hunke and Wambsganß (2017)	n/a			●				●		●		
Hunke et al. (2019)	B	●						●		●	○	
Hunke and Schüritz (2019)	D			●				●		●	○	
Kammler et al. (2019)	B			○	●			●		●		
Kayser et al. (2018)	n/a				○		○					
Kronsbein and Mueller (2019)	C			●	○			●		●	○	
Kühne and Böhmann (2018)	D			○						●	●	●
Kühne and Böhmann (2019)	B			●				●	○	●	●	
Mathis and Köbler (2016)	n/a			●	○			●		●		
Nagle and Sammon (2017)	B			●	●			●		●		
Rizk et al. (2018)	C	●						●		●	●	
Schmidt et al. (2018)	C		●					●		●	○	●
Schüritz and Satzger (2016)	n/a		●							●	●	●
Schüritz et al. (2017a)	B			○			●			●		
Schüritz et al. (2017b)	C		●					●				●
Spiekermann et al. (2018)	D					●				●		
Sprenger and Mettler (2016)	B		●					●		●	●	●
Terrenghi et al. (2018)	B			●		○		●		●	●	●
Wixom and Markus (2015)	n/a				○				●	●		
Wixom and Schüritz (2018)	n/a				○				●			●
Zolnowski et al. (2016)	B		●					●		●	●	●
Zolnowski et al. (2017)	D				●				●			●

Key: n/a (not available), ● (characteristic fully covered), ○ (characteristic partially covered)

Table 1: Overview of analysed publications along the concepts of three concepts 'type of contribution', 'type of thinking supported' and 'element of business model'.

and Mettler 2016) "can serve as an inspiration and blueprint" (Hartmann et al. 2016, p. 1400) for organizations. In the context of established organizations, data-enabled business model transformation patterns (Schüritz and Satzger 2016; Zolnowski et al. 2016) illustrate what elements of a business model can be affected by data and analytics.

Visual tools mediate collaboration and support ideation for data-driven innovations. Such visual tools can be divided into a component view (e.g., (Exner et al. 2017; Hunke and Schüritz 2019; Kühne and Böhmann 2018, 2019; Nagle and Sammon 2017)), a transaction view (Brillinger 2018; Terrenghi et al. 2018) or a causal view (Förster et al. 2019). Beside such holistic representations of BM, specialized tools emerge (Agrawal et al. 2018; Hunke and Schüritz 2019; Hunke and Wambsganß 2017; Kronsbein and Mueller 2019; Kühne and Böhmann 2019; Mathis and Köbler 2016; Nagle and Sammon 2017) that support the generalized representation of a business model (Kühne and Böhmann 2019) by focusing on central elements of it, such as key resources, key activities or the value proposition. Transaction- or graph-based representations visualize value networks (Brillinger 2018; Terrenghi et al. 2018) or data-driven service systems (Kammler et al. 2019). Causal views visualize the cause and effect relations of data in business models (Förster et al. 2019).

We also revealed the *methods* of use for visual tools (Brillinger 2018; Nagle and Sammon 2017) or certain types of workshops, like "data discovery sessions" (Schüritz et al. 2017a). Furthermore, we identified the description of how "data thinking workshops" are supported by visual tools (Kronsbein and Mueller 2019) to generate ideas. Apart from ideation, the methods also support the evaluation of a business model in terms of a "data value assessment" (Wixom and Markus 2015), a "cost benefit analysis" (Zolnowski et al. 2017) or the measurement of customer benefit and financial success (Wixom and Schüritz 2018).

Two publications comprise an *IT-tool* related contribution. Spiekermann et al. (2018) propose a metadata model for data goods, as the key resource of DDBMs and Terrenghi et al. (2018) states to implement the design elements via a software-reference model.

Process models in DDBMIs shape the last type of contribution. Such processes describe distinct steps or phases of a DDBMI, starting with an "Understand" (Benta et al. 2017) or "Initiation" (Hunke et al. 2017) phase, where the current situation of the organization is analysed and potential data sources are identified. This is followed by an "Ideation" (Hunke et al. 2017), "Idea generation" (Kayser et al. 2018), "Design" (Benta et al. 2017) or "Use case generation" (Schüritz et al. 2017a) phase, to generate different concepts of BMs. Subsequently, a phase of "Proof of concept and evaluation" (Kayser et al. 2018; Schüritz et al. 2017a) or "Prototyping and testing" (Hunke et al. 2017) takes place, to test the BM prototype and to evaluate risks. Finally, an "Implementation" (Benta et al. 2017; Schüritz et al. 2017a), "Realization" (Hunke and Wambsganß 2017) or "Professionalization" (Kayser et al. 2018) phase takes place that aims to operationalize the business model.

Types of thinking

Existing research can also be classified by the type of thinking supported by the artefact for the BMI activity of ideating and evaluating. Idea generation for DDBMI can be supported by frameworks and patterns (Bock and Wiener 2017; Engelbrecht et al. 2016; Förster et al. 2019; Hartmann et al. 2016; Schmidt et al. 2018; Sprenger and Mettler 2016), visual tools (Agrawal et al. 2018; Hunke and Schüritz 2019; Hunke and Wambsganß 2017; Kronsbein and Mueller 2019; Kühne and Böhmann 2019; Mathis and Köbler 2016; Nagle and Sammon 2017) as well as open questions (Brownlow et al. 2015; Exner et al. 2017) facilitating divergent thinking. Fewer publications focus on evaluation and decision making in DDBMI, corresponding to convergent thinking. Such activities encompass the analysis of costs and benefits of data and DDBMI ideas (Wixom and Markus 2015; Zolnowski et al. 2017); the measurement of created customer value and financial success of a DDBMI (Wixom and Schüritz 2018); the reflection on risks (Brillinger 2018; Wixom and Markus 2015); influencing factors for decisions on revenue models (Enders et al. 2019) or decision points in the innovation process (Schüritz et al. 2017a).

Elements of the business model

Tools and methods incorporate either a holistic view or focus on specific elements of the business model. From the perspective of value creation, existing research focuses on elements such as data as the key resource (Mathis and Köbler 2016; Spiekermann et al.

2018) or data analytics as key activities (Hunke and Wambsganß 2017). In the value proposition dimension, research investigates data-driven services (Hunke et al. 2019; Hunke and Schüritz 2019; Kammler et al. 2019; Rizk et al. 2018). From the value capturing dimension, research incorporates revenue models and financial evaluation (Enders et al. 2019; Schüritz et al. 2017b; Wixom and Schüritz 2018; Zolnowski et al. 2017). Other tools and methods combine two aspects of the business model, such as data and value proposition (Kühne and Böhmann 2019) or data as the key resource and analytics as key activities (Nagle and Sammon 2017).

Synthesis of tools and methods towards a toolbox

As tools and methods should support organizations in their activities in business model innovation, we aligned, as shown in Table 2, all identified tools and methods to the corresponding phases and activities of business model management, serving as a toolbox (In contrary, Table 1 above structured the identified papers). We have chosen the business model

management process in offline established organizations based on the empirical work of Terrenghi (2019). As highlighted in Table 2, most research is available for the design phase of DDBMI. Thus, tools and methods are also predominantly available in the design phase. This implies the current focus of research and the specific need for supporting organizations and individuals in the activities of design and idea generation in DDBMI.

Further, tools and methods are clustered based on their origin from different research perspectives. As shown in Table 2, tools and methods emerged from different conceptual backgrounds with diverging focus on the resource data and the business model concept: DDBMs (i.e., full data and business model focus), digital business models (i.e., partial data and full business model focus) or data-driven innovation (i.e., partial business model and full data focus). This implies that no common wording has been established around data-driven business model innovation and that tools and methods are researched from different perspectives (e.g.,

	Analysis	Design	Evaluation	Implementation	Controlling
Data-driven Innovations *(partial business model focus)*	Data value assessment[1] Data innovation board[2] Data value map[3] Data discovery sessions[4]	Data innovation board[2] AI canvas[6] Canvas with key factors for analytics-based services[7] Data value map[3] Taxonomy of data-driven analytics-based services[8]		Graph-based modelling of data driven service systems[21] Meta data model of data goods[22]	Metrics to reflect data wrapping returns[23]
Data-driven business models *(data and business model focus)*	Data map[5]	Taxonomy/Framework[9] Patterns/Types[10] Adopted Business Model Canvas[11] Data Insight Generator[12] Ideation tool for key activities[13] Criteria for selecting revenue models[14]	Causal loop-diagrams[18] Cost-benefit analysis [19]		
Digital business models *(partial data focus)*		Taxonomy/Framework[15] Patterns/Types [16] Design elements for transaction based representation of cyber physical systems business models[17]	Mapping business model risk factors[20]		

[1] Wixom and Markus (2015)
[2] Kronsbein and Mueller (2019)
[3] Nagle and Sammon (2017)
[4] Schüritz et al. (2017a)
[5] Mathis and Köbler (2016)
[6] Agrawal et al. (2018)
[7] Hunke and Schüritz (2019)
[8] Rizk et al. (2018), Hunke et al. (2019)

[9] Brownlow et al. (2015), Engelbrecht et al. (2016), Hartmann et al. (2016), Exner et al. (2017)
[10] Hartmann et al. (2016), Schüritz and Satzger (2016), Zolnowski et al. (2016), Schmidt et al. (2018), Förster et al. (2019)
[11] Benta et al. (2017), Kühne and Böhmann (2018)
[12] Kühne and Böhmann (2019)
[13] Hunke and Wambsganß (2017)
[14] Enders et al. (2019)

[15] Bock and Wiener (2017)
[16] Sprenger and Mettler (2016)
[17] Terrenghi et al. (2018)
[18] Förster et al. (2019)
[19] Zolnowski et al. (2017)
[20] Brillinger (2018)
[21] Kammler et al. (2019)
[22] Spiekermann et al. (2018)
[23] Wixom and Schüritz (2018)

Table 2: Synthesis of tools and methods for DDBMI across the phases of a BMI process.

business model innovation or service innovation), serving the same purpose for practice.

Discussion and Avenues for Further Research

The results show that specific tools and methods are available to innovate a DDBM. We have also demonstrated that many tools are available especially in the design phase of the business model. Those tools that are generally used when innovating the business model, like the business model canvas or the business model patterns, are transferred to DDBMs.

Based on the above results summary, below we discuss gaps and underrepresented facets in existing research fields that highlight avenues for further research in how to support the process of DDBMI. Table 3 summarises the three research streams identified and provides corresponding avenues and recommendations.

Evaluation and decision-making in data-driven business model innovation

Only a few papers (6 out of 33) investigate in convergent thinking (as Table 1 shows) compared to divergent thinking, i.e. ideation (20 out of 33). Existing research tends to focus on the ideation through taxonomies,

patterns or visual tools, thus supporting divergent thinking. Besides divergent thinking, BMI also requires evaluation and decision making (Casadesus-Masanell and Ricart 2010; Tesch and Brillinger 2017), for instance to evaluate and select ideas for further elaboration, or to decide between options, and on further procedure. Existing research on that direction is focusing on financial evaluation (Wixom and Schüritz 2018; Zolnowski et al. 2017). Evaluation of BMs also involves identifying and managing risks (Brillinger 2018; Tesch and Brillinger 2017). Wixom and Markus (2015) suggest bringing in not only costs and benefits, but also risks in data monetization. Brillinger (2018) identified data as critical value streams and risk factors in value networks of business models. As often pointed out, data ownership, data security, privacy and data protection law are challenging factors in DDBMI (Brownlow et al. 2015; Dremel et al. 2017). Few evaluation methods incorporate such aspects.

In that sense we frame our first avenue for further research as *designing tools and methods for evaluation, decision support and risk management in data-driven business model innovation.* Further research could identify data and analytic specific decision and evaluation criteria and success factors and critical elements

Research Field	Research Direction	Recommendations
Tools and methods that supports convergent thinking (i.e. evaluation and decision making)	Designing tools and methods for evaluation, decision support and risk management in DDBMI.	Identifying data and analytics specific evaluation criteria and success factors through in-depth literature review and expert interviews or surveys Developing decision support tools for DDBMI through design-oriented research in combination with design-oriented research Developing data-specific risk assessment methods for business models
Overarching perspective on how single tools and methods link together	Designing a toolbox and a repeatable procedure for the combination of specialized tools and methods towards the development of a data-driven business model.	Study interrelation of tools and creation of a toolbox and assignment to BMI phases through in-depth case studies Develop a repeatable process design for DDBMI through design-oriented research
Software tools to support the DDBM innovation process	Designing software tools as an IT support for developing, evaluating and managing DDBMIs based on information systems design methods.	Software implementation of DDBM representations Combination and integration of tools in software tools to enable data consistency across representations Implementation of data-driven methods

Table 3: Research fields, research directions and recommendations for further research.

of DDBM through in-depth literature review and expert interviews or surveys. Based on that, further research could develop decision support and evaluation tools to support and inform the decision-making process. Further research could also develop decision support tools for specific business model elements, e.g. for the choice of appropriate revenue model or pricing mechanism, both through design-oriented research in combination with in-depth case studies. Furthermore, as decision-makers have to find a balance between acceptable risk and estimated return (Tesch and Brillinger 2017), further research could investigate in methods for identifying and managing novel risk factors in DDBMIs through case studies, expert surveys and design-oriented research. Such evaluation and decision support tools can inform and help managers in their decisions for a certain business model design and balance risks and benefits to ensure the profitability and sustainability of the business model. This line of future research necessitates the integration of research on DDBMI, decision-making and risk analysis in BMI, and technology-oriented research as e.g., business analytics to consider knowledge on characteristics specific to data and data analytics.

Tool-chain and overarching methodology for innovating data-driven business models

In the reviewed literature we see a range of tools and methods for special purposes that are still not related to each other which is the second research field we identified. Tools and methods either incorporate all elements (e.g., (Exner et al. 2017; Hartmann et al. 2016)), or focus on a distinct element of the business model (e.g., (Mathis and Köbler 2016; Schüritz et al. 2017b). Thus, several tools and methods proposed are specialized for supporting the innovation process for a certain task, like identifying data sources (Mathis and Köbler 2016), connecting data with the value proposition (Kühne and Böhmann 2019) or ideating on analytics key activities (Hunke and Wambsganß 2017). Specialized tools support the generalized representations of a business model (Kühne and Böhmann 2019; Mathis and Köbler 2016; Osterwalder et al. 2014). Likewise, existing research on processes (e.g., (Benta et al. 2017; Hunke et al. 2017)) does not provide information on detailed activities as well as tools in each process phase and lacks of empirical evaluation.

To these terms we frame our second avenue for further research as *designing a toolbox and procedure for the combination of specialized tools and methods towards the design and evaluation of a data-driven business model*. Further research could thus study such interrelations between specialized tools to develop a toolbox and tool chain for DDBMI and assign tools and methods to distinct phases of the innovation process as also suggested by Hunke et al. (2017) with the aid of (in-depth) case studies. A first endeavour was made in the synthesis of this literature review, as shown in Table 2. Second, further research could develop a repeatable process design for developing data-driven business models, e.g. as suggested by Simmert et al. (2019) for continuous business model improvements through design-oriented research. Such a clearly defined process with a toolbox assigned to each phase of the process can help managers to overcome hurdles when it comes to designing and evaluating a data-driven business model due to a lack of structured procedure. This line of future research necessitates the integration between research on DDBMI and innovation management.

IT-support for data-driven business model innovation

The third research field identified is the lack of software tools to support the DDBMI process. Only two out of 33 reviewed research papers involve IT to support DDBMI. In complete contrast to the digital nature of DDBMIs, the underlying innovation process still appears to be fragmented and paper-based with very little IT support. Only Terrenghi et al. (2018) indicate a software-based reference model of their tool and the research endeavour of Spiekermann et al. (2018) points to an IT-related tool. On the other hand, there exist numerous software tools implementing generic BMI representations, such as the business model canvas (Szopinski et al. 2019). Much research effort is also going on in the information systems discipline to develop IT tools for other types of business models, like the Internet of Things (Athanasopoulu et al. 2018) or sustainable business models (Schoormann et al. 2018).

In that sense we frame our third research avenue as *designing software tools as an IT support for developing, evaluating and managing data-driven business model innovations* in line with the call for research for IT support for developing and managing BMs (Veit et al.

2014) using methods for information systems design. First, DDBM representations can be implemented in software tools to digitally track results and changes. Likewise, combining specialized and generic BM tools within an IT system to enable consistency and transfer of information across tools seems another fruitful path for further research. In addition, data-related software tools could also be developed, like a meta-database of available data sources within an organization. To further advance the field, not only the business model, but also the corresponding innovation process could be data-driven. Augenstein and Fleig (2017) suggest the use of data from organizational information systems to enable bottom-up creation of a business model, as the underlying process of business model creation is manual and prone to error, time-consuming and subjective. Further research could develop data-driven methods to support DDBMI (Szopinski et al. 2019). For managers, IT-tools can support the results of the innovation process in such a way that they are visualized for presentation and communication. Furthermore, IT-tools can support the business model design process by delivering important data that is needed. This line of research necessitates further integration between research on DDBMI, design-oriented research in information systems, and research in business analytics related to the specific characteristics of data and data analytics in business models.

Limitations

The search and selection for relevant literature as well as the analysis and synthesis process expose the research contribution to certain limitations. *Firstly*, the focus of the literature search and selection was on tools and methods that specifically incorporate data as a central element. Generic BMI tools and methods were not included in this research, even though these are also helpful for supporting the innovation process. Furthermore, organizational measures, such as a data strategy, data-driven culture, or analytics competence centre in the organizational structure endorse the DDBMI process but are excluded in that research. *Secondly*, due to the novelty of DDBMI research, the database search sometimes resulted in comparatively few results, and some of these were not rated B or above according to the VHB JOURQUAL3. This highlights the emergent character of research on supporting the process of DDBMI, and the timeliness of providing a structured overview and synthesis into relevant future research directions. *Thirdly*, although we have documented the research procedure as accurately as possible and discussed uncertainties within the team of researchers, the selection and analysis still remain subjective as this is the case with all structured literature reviews.

Conclusion

In this paper we have argued that the development of tools that support decision-making in the process of DDBMI, the development of a complete procedure including tool chains, and the development of IT tools that can support the process are promising avenues for research, and of practical relevance. For researchers, these three avenues also correspond to opportunities and necessities to integrate knowledge across slightly different research fields, such as research in business models, innovation management, information systems, and business analytics. For practitioners who are in charge of developing a data-driven business model, the challenge is therefore to still use generic overarching BMI processes, but to specify and concretise these by focussing on data as a key resource and data analytics as a key activity within this process. The present paper can support this approach by providing

a structure to the available knowledge in terms of available concepts and tools as useful elements in the overall innovation process.

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